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A Panel Data Approach for Investigation of Gross Domestic Product (GDP) and CO_2 Causality Relationship

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ABSTRACT

One of the current challenges and complications in the world is the climate change and global warming, which has numerous and varied effects and consequences in different regions. In this regard, the effects of economic activities on the increase in greenhouse gases and also the effects of greenhouse gases on economic activities have become increasingly controversial. In this study, an investigation was done upon the bidirectional causality relationship between real gross domestic product per capita and carbon dioxide emissions per capita in different countries. For this purpose, the Vector Auto-Regression Model with the micro panel application was used and the World Bank member countries were divided into different groups. Results indicated bidirectional causality relationship between Gross domestic product (GDP) and CO_2 for three groups of countries. In addition, there was a one-way causal relationship from GDP o carbon dioxide volume for subgroups of countries with high average economic growth rate (HGR) and the rest of the world countries (ROW). This means that, to accomplish the international goals of decreasing the emissions of pollutant gases, collaboration between HGR and ROW group of the countries with industrial countries is indispensable. Moreover, heterogeneous non-causality test for Iran suggests that the economic activities are having increasingly negative environmental impacts on the country.

Keywords: Carbon dioxide, Causality test, Gross domestic product, Micro panel, Vector auto-Regression.

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) reported that since 1850, the year when systematic temperature-keeping began (IPCC, 2007), eleven of the 12 warmest years occurred during 1995 to 2006. This, along with other evidence of this warming such as the number of shrinking mountain glaciers, thawing permafrost, earlier breakup of rivers and lakes ice, lengthening of mid- to high-latitude growing seasons, shifts of plants, insects, and animal ranges, earlier tree flowering, insect emergences and egg laying in birds and changes in precipitation patterns indicate that the trend of global warming is virtually certain (IPCC, 2007).

With the start of the industrial revolution in the second half of the nineteenth century and the human beings' ever-increasing need for energy and fossil fuels such as coal, oil, and natural gases, the earth has encountered an increase in polluting gases in the atmosphere (e.g. carbon dioxide and methane). In this period of time, the amount of the present carbon dioxide and methane in the earth's atmosphere has increased 13% and 151%, respectively (IPCC, 2007).

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Therefore, one of the current challenges and complications in the world is the climate change and global warming, which has numerous and varied effects and consequences in different regions. Since almost 60 percent of the greenhouse effects are related to human activities in CO_2 emissions, this gas is considered the most important greenhouse gas in regard to global warming (IPCC, 2007).

Two different theories have been proposed about the effects of economic activities on the environment. Some researchers believe that since economic growth requires a greater use of raw material and energy, the economic activities will unavoidably cause vast environmental damage (Perman *et al*., 2003; Acaravci and Ozturk, 2010; Hossain, 2011; Pao and Tsai, 2011; Wang *et al*., 2011). Some, in contrast, insist that since economic growth brings about an increase in products and services and promotes welfare, it will gradually encourage and improve motivations for supporting the environment and, thus, will be prioritized in the policy programs of countries; therefore, economic growth is a need for qualitative improvement of the environment. The World Bank study (1992) and Everett *et al.* (2010) are among the studies which are in this group.

On the other hand, some empirical evidence attest to the possibility of the impact of the environmental effects on economic efficiency. Pigou (1920) is one of the pioneers of this theory. Other investigations, which have focused upon the relationship between greenhouse gases and the economic index, are those done by Dinda and Coondoo (2006), Azomahou *et al.* (2006), Liu (2006), Masih *et al*. (2010), Maddison and Rehdanz (2008), Ferda (2008), Lee (2009), Pao and Tsai(2010), Moghadasi and Golriz (2011), and Hatzigeorgiou *et al.* (2011) have also focused on the bidirectional causal relationship between gross domestic product and the volume of greenhouse gases or, in particular, carbon dioxide. Therefore, the effect of economic activities on the rise of the volume of greenhouse gases and the effect of greenhouse gases on economic activities has been highly controversial.

After frequent warnings given by environmental specialists about the effect of greenhouse gases on global warming, representatives from more than 160 countries ratified the Kyoto Protocol with the aim of obliging different countries to lower the emissions of these gasses. (It might be noticed that the performance of the protocol was launched in February 2005 after Russia joined.)

On the basis of this protocol, 36 industrial countries made a commitment to lower their greenhouse gases emissions rate by about 5.2 percent from 1990 levels between 2008 and 2012. In this protocol, it has been mentioned that economic growth and alleviation of poverty, both causing an increase in the emissions of greenhouse gases, are the rights of the developing countries

The countries that signed the protocol pledged to pay the pollution costs to the countries whose greenhouse gas emissions were lower than the permissible level, if the emissions rate of their greenhouse gases, which affects global warming, did not change or increase. However, the US, China, and India did not sign the Kyoto Protocol. The United States believed that lowering the emissions of greenhouse gases, which is done by decreasing industrial activities, would damage the economy of the country. The USA asserts that until countries like China and India, which have experienced rapid economic growth and also produced large amounts of greenhouse gasses, do not sign this protocol, considerable changes in the atmospheric state cannot be anticipated. Hence, it seems that in response to the issues raised, it is necessary to study the economy of countries which are the main sources of emissions of greenhouse gasses as well as the economic communities that are more vulnerable to the rise of greenhouse gases.

Iran is amongst the second group of the countries committed to the Kyoto Protocol, which are mostly developing countries.

According to unpublished information of Iran's Ministry of Energy, more than 75 percent of the emissions of greenhouse gases in Iran is because of high consumption of fuel and cheap energy.

This study tested the hypothesis of the existence of a bidirectional causal relationship between gross domestic product and emissions of carbon dioxide for different countries, with a focus on Iran. In addition, by studying the mentioned concept for three groups of countries, namely, Organization for Economic Co-operation and Development member countries, countries with high rate of average economic growth, and other countries, this study aimed to find out the economy of which group of countries is the main factor in the emissions of carbon dioxide and its consequences and which group is more affected by this phenomenon. The innovation of the current study is the application of the data set of a greater number of countries and the investigation of countries in three main economic groups.

MATERIALS AND METHODS

In the literature, Granger (1969) causality test, which uses the panel data approach, includes two main groups of methods. The first group considers estimation and testing vector autoregression (VAR) coefficient using autoregressive coefficients and regression coefficient slopes as variables in panel data. This approach was applied by Holtz-Eakin *et al*. (1988), Nair-Reichart and Weinhold (2001), Choe (2003), Costantini and Martini (2009), Lean and Smyth (2009), Sinha (2009) and Lau *et al*. (2011). The second group suggests autoregregressive coefficients and regression coefficients slopes as constant values. This method was developed by Hurlin and Venet (2001), Hurlin (2004a, b), Hansen and Rand (2004), Amiri and Gerdtham (2013). The second method is employed in this study, due to its compatibility with our data sets with relatively short time periods compared to large numbers of cross-section units. Following Hurlin and Venet (2001), two covariance stationary variables, marked by x and y were considered for T periods and N cross-section units of observations.

According to Granger (1969) causality procedure, for each individual $i \in [1, N]$, $x_{i,t}$ explains $y_{i,t}$, if the predictive power of $y_{i,t}$ employing the data of all variables including $x_{i,t}$, is greater than when excluding it. Since it is not practically possible to completely apply the optimum predictors, this study considers only the linear ones. Therefore, a VAR model which is to be used for panel data is presented below. For each cross-section unit i and period t, the following model is estimated:

$$y_{i,t} = \sum_{k=1}^{p} \beta_k y_{i,t-k} + \sum_{k=0}^{p} \theta_k x_{i,t-k} + u_{i,t} \quad (1)$$

Where, $u_{i,t} = \alpha + \varepsilon_{i,t}$ and $\varepsilon_{i,t}$ are i.i.d and N $(0, \sigma^2)$. It is assumed that autoregressive coefficients β_k and the regression coefficient θ_k's are constant for $k \in [1, N]$. It is further assumed that parameters β_k are identical for all individual, while the coefficient θ_k could have an individual dimension. In other words, the model employed in this study was panel data model with constant coefficients. Finally, the residuals are assumed to satisfy the standard properties.

There are a lot of advantages in using panel data models. In addition to providing a large number of observations, increasing the degrees of freedom and reducing the co-linearity among explanatory variables, it obviously improves the efficiency of Granger causality tests (Hurlin and Venet, 2001). In testing causality with panel data, the possibility of heterogeneity among cross-section units should be considered. Innate cross sectional disparities is the first source of heterogeneity. A pooled estimation without heterogeneous intercepts results in a bias of the slope estimates and may lead to fallacious inference of causality tests (Hurlin, 2004a). Heterogeneous regression coefficients θ_k are the second basis of heterogeneity and cause more difficulties than the first reason. Furthermore, different heterogeneity sources of the data-generating process should be considered in the causality test using panel data sets. Hence, different kinds of causality hypotheses are to be tested in a panel data set framework. The first test procedure, named as homogenous and instantaneous non-causality hypothesis (HINC), is directed towards testing whether or not the θ_k's of $x_{i,t-k}$ are simultaneously null for all individuals *i* and all lags *k*. The hypotheses are:

$$H_0 : \theta_k = 0 \forall i \in [1, N], \forall k \in [0, p] \qquad (2)$$
$$H_1 : \theta_k \neq 0 \exists (i,k)$$

For testing *Np* linear restrictions (2), the following Wald statistic is calculated:

$$F_{HINC} = \frac{(SSR_r - SSR_u)/(Np)}{SSR_u /[NT - N(1+p) - p]} \qquad (3)$$

Where, SSR_u stands for the sum of squared residuals for model in (1) and SSR_r for the restricted sum of squared residuals under H_o. If individual effects, α_i, are assumed to be fixed, SSR_u and SSR_r are *SSR* obtained from the maximum likelihood (ML) estimation that corresponds in this case to the fixed effects (FE) estimator.

If the HINC hypothesis is rejected, there are two possibilities. The first one is the homogenous causality hypothesis (HC) and takes place if all the coefficients θ_k are identical for all lags *k* and are statistically different from zero. In other words, we are testing whether or not θ_k s in (1) are equal to each other. Therefore, the following hypotheses are tested:

$$H_0 : \theta_k^i = \theta_k^j \, \forall i, j \in [1, N], \forall k \in [0, p] \qquad (4)$$
$$H_1 : \theta_k^i \neq \theta_k^j \, \exists (i, j, k)$$

In order to test (4), the following statistic is calculated:

$$F_{HC} = \frac{\left(SSR_r^{\prime} - SSR_u\right) / [p(N-1)]}{SSR_u / [NT - N(1+p) - p]} \qquad (5)$$

Where, $SSR_r^{\prime}$ is the restricted sum of squared residuals under H_o. As in the case of HINC, if individual effects, α_i, are assumed to be fixed, the *ML* estimator is consistent with the *FE* estimator.

If the HC hypothesis is also rejected, the process is non-homogenous and no homogenous causality relationship can be obtained. Nonetheless, it does not entail rejection of any causality relationships between two variables and for a sub-group of cross-section units it may still be possible that there exist causality relationships and the variable *x* causes the variables *y*. The last step, therefore, is to test heterogeneous non-causality hypothesis (HENC). The hypotheses are:

$$H_0 : \theta_i^k = 0 \forall i \in [1, N], \forall k \in [0, p]$$
$$H_1 : \theta_i^k \neq 0 \forall i \in [1, N], \forall k \in [0, p] \qquad (6)$$

Under this case, the nullity of all the coefficients of the lagged explanatory variable $x_{i,t-k}$ is tested for each cross-section unit. For testing (6), the following statistic is calculated:

$$F_{HENC} = \frac{\left(SSR_r^{\prime\prime} - SSR_u\right) / p}{SSR_u / [NT - N(1+2p) + p]} \qquad (7)$$

Where, $SSR_r^{\prime\prime}$ is sum of squared residuals found in (1), when the nullity of the *k* coefficients associated with the variable $x_{i,t-k}$ are imposed only for the cross-section unit *i*. These N individual tests identify the cross-section units for which there are no causality relationships. If the HENC hypothesis is not rejected, the variable x does not cause the variable y for a sub-group of cross-section units. The causality relationship is relevant only for a sub-group of cross-section units. This hypothesis can be considered as the consequence of data-generating process heterogeneity.

The following two models are estimated for each of the three groups:

$$GDPP_{i,t} = \sum_{k=1}^{p} \beta_k GDPP_{i,t-k} + \sum_{k=0}^{p} \theta_k CP_{i,t-k} + u_{i,t} \quad (8)$$

$$CP_{i,t} = \sum_{k=1}^{p} \beta_k CP_{i,t-k} + \sum_{k=0}^{p} \theta_k GDPP_{i,t-k} + u_{i,t} \quad (9)$$

Where, GDPP is real gross domestic product per capita and CP is CO_2 emissions per capita. Before estimating Equations (8) and (9), the optimum lag length should be determined for both variables in each country group using Akaike Information Criterion (AIC). Following the adoption of a model with white noise residuals, both homogenous and instantaneous non-causality (HINC) and homogenous causality (HC) hypotheses were tested using (8) and (9). Later, heterogeneous non-causality hypothesis (HENC) was tested for Iran in the other countries group.

Countries were classified into three consistent groups in order to analyze the information of countries homogenously and present appropriate answers to the questions of the study. The questions are: in which group of countries does CO_2 emissions, as the most important greenhouse gas, affect economic growth more, and in which group does it have less impact? On the other hand, in which type of countries, does economic growth affect CO_2 emissions? After eliminating the countries with missing observations, we formed three groups of countries. The first group included thirty countries which were members of OECD. The second group (HGR)was made up of seventeen countries which had a GDP growth rate of more than 4 percent in our study period according to the World Bank's World Development Indicators. The third group (ROW) contained fifty-one countries which were included in neither of the two other groups. All the data were converted into natural logarithms prior to conducting the analysis. The data of this study, which provided for testing the bidirectional causality between GDP and CO_2 in a panel data setting, were derived from the World Bank's data base between the years of 1990-2004.

RESULTS AND DISCUSSION

The first step in exploring the bidirectional causality between CO2 emissions per capita and gross domestic production is to test whether the variables at hand contain unit roots. In this study, we used Levin, Lin and Chu (2002) and PP panel unit root tests proposed by Maddala and Wu (1999). The null hypothesis in these panel unit root tests is that the panel series has a unit root (non-stationary). The results of the panel unit root tests for GDP and CO2 are shown in Table 1. The results of the panel unit root tests indicated that both variables according to LLC and PP unit root tests, are stationary at level. In other words, the test statistics for

Table 1. The results of Panel unit root tests.

Country Group	Variable	Individual intercept		Individual intercept and trend	
		Levin, Lin and Chu	PP	Levin, Lin and Chu	PP
HGR [a]	GDP [d]	-1.90**	47.7***	-2.06**	72.51***
	CO_2	1.96**	37.04***	-1.39***	12.59
OECD [b]	GDP	-4.30*	114.71*	-6.15*	110.25*
	CO_2	-1.29***	85.02*	-5.32*	130*
ROW [c]	GDP	-5.03*	170.7*	-5.83*	263.5*
	CO_2	-5.98*	121.7*	-3.16*	140.6*

[a] High Growth Rate, [b] OECD:Organisation for Economic Co-operation and Development , [c] Rest of Other Word, [d] Gross Domestic Product, ** and ***: Denote statistical significance at the (1%), (5%) and (10%) level, respectively.

the log levels of CO2 and GDP are statistically significant for all country groups with the exception of the PP test applied to CO_2 with existence of trend for HGR country. However, because of the non-existence of a trend for this variable, taken as a whole, the log levels results suggest that both variables are panel stationary in general.

The next step in an attempt to search for causality is to choose the lag lengths for both variables. Table 2 presents AIC figures for each country group. Consequently, for High Growth Rate countries (HGR) and Organization for Economic Co-operation and Development members (OECD), we chose three lags for variables GDP and CO_2. In the case of Rest-Of-the-World group (ROW), the corresponding lag lengths were four.

Before showing estimation and statistical inference of regression, it was necessary to determine the method of estimation of consolidated data. In order to choose between methods of common effects (mix regression model) and fixed effects (panel data), an *F*-Limer test was used. As can be seen in the results of Table 3, the compilation data estimation method (common effect method) is rejected. F-Limer test results for all country groups showed that the common effect method for estimating the regression models was not suitable. In other words, the intercept was different for different units or otherwise, there was individual or group effects and should be used fixed effects methods to estimate the models. In the next step, in order to show that model should be estimated by a fixed effects method or a random effects method, the Hausman test was performed. The results of the test are presented in Table 3.

In Table 3, the *P*-value of the Hausman statistics also show that fixed effects method used to estimate the model is a more appropriate option. Therefore, according to the results of the *F*-Limer test and the Hausman test, the most appropriate method to estimate parameters and test hypotheses is

Table 2. Optimum lag length using Akaike Information Criterion. [a]

Country Group	LAG 1	LAG 2	LAG 3	LAG 4	LAG 5
HGR [b]	2.36	2.28	2.16*	2.19	-
OECD [c]	0.69	0.62	0.46*	0.50	-
ROW [d]	1.21	1.19	1.14	1.13*	1.14

[a] Indicates lag order selected by the criterion. Source: Research findings. [b] High Growth Rate, [c] Organisation for Economic Co-operation and Development, [d] Rest of Other Word

Table 3. Results of *F*-Limer Test and Hausman Test.

Test type	Country group	Type of Relationship	Value test result	Probability
F-Limer	HGR [a]	GDP [c] → Co_2	1.61	0.0699
		Co_2 → GDP	2.23	0.0058
	OECD [b]	GDP → Co_2	1.52	0.0437
		Co_2 → GDP	2.12	0.0009
	ROW [c]	GDP → Co_2	2.20	0.0000
		Co_2 → GDP	3.38	0.0000
Hausman	HGR	GDP → Co_2	18.42	0.0051
		Co_2 → GDP	35.49	0.0000
	OECD	GDP → Co_2	41.85	0.0000
		Co_2 → GDP	59.43	0.0000
	ROW	GDP → Co_2	104.48	0.0000
		Co_2 → GDP	160.67	0.0000

Source: Research findings., [a] High Growth Rate, [b] Organisation for Economic Co-operation and Development, [c] Rest of Other Word, [c] Gross Domestic Product

Table 4. Test results for causality hypotheses.

Country group	Test	From GDP to Co_2	From Co_2 to GDP
HGR [a]	HINC [d]	9.60*	25*
	HC [e]	6.12*	1.06
OECD [b]	HINC	6.15*	6.22*
	HC	1.13	1.001
ROW [c]	HINC	6.39*	4.14*
	HC	1.39***	1.14

Source: Research findings. [a] High Growth Rate, [b] Organisation for Economic Co-operation and Development , [c] Rest of Other Word, [d] Homogenous and Instantaneous Non-Causality, [e] Homogenous Causality, *,** and ***: Reject H_0 at 1% , 5%, and 10% levels of significance, respectively.

fixed effects method.

In the next step, Equations (8) and (9) were estimated for each country group in order to test HINC and HC hypotheses. Table 4 demonstrates the results of testing these two types of homogenous causality hypotheses. The results show that homogenous and instantaneous non-causality are rejected at one percent levels of significance for GDP-to-CO_2 and CO_2-to-GDP causality in all country groups. Rejecting the null hypothesis of HINC means that there exists a causality relationship between GDP and CO_2 in these groups. The next step is whether the causality is an overall causality for each country group or sourced from causality relations for individual countries. On the basis of homogeneous causality test results, the existence of HC is rejected. It means that there is a heterogeneous one-way causality relationship from GDP to CO_2 for sub-groups countries with HGR and also for sub-groups of ROW members at 1% and 10% levels of significance, respectively.

A number of studies have been carried out in order to investigate the causality relationship between CO_2 emissions per capita and GDP per capita for sub-groups of countries such as Taskin and Zaim (2000), and Dijkgraaf and Vollebergh (2001). These studies showed an inverse-U-shape relationship between the mentioned variables in their data set. However, studies by Liu (2006), Masih *et al.* (2010), Maddison and Rehdanz (2008), Ferda (2008), and Lee (2009), depending upon the country (countries) they analyzed, indicated different interpretations of the relationship between CO_2 emissions and GDP value.

The final step was to discover the existence of causality in Iran. Since the homogenous hypotheses for GDP-to-CO_2 relationship were rejected for the ROW group including Iran, the heterogeneous non-causality test was carried out. Results of HENC hypotheses for GDP-to-CO_2 for Iran are presented at Table5.

At the 5% significance level, the results show that, for Iran, the null hypothesis indicating that the GDP does not cause CO_2, is rejected. This evidence indicates that there is causal relationship running from GDP to CO_2. It means that GDP strongly (Granger) causes CO_2, which implies that CO_2 is so pervasive in the economy that the economic growth actually increases the CO_2 emissions over time.

Table 6 shows the regression results for the Environmental Kuznets Curve for Iran. We clearly reject the existence of an inverted "*U*" relationship, as long as, the estimated t-ratios of the CO_2 quadratic term is not significant at any significance level tested. Thus, according to the results, the typical

Table 5. Results of HENC hypotheses for Iran.

Country group	Test	From GDP to Co_2	Probability
Iran	HENC [a]	5.322297	0.0298

Reference: Research findings, [a] Heterogeneous Noncausality

Table 6. Environmental Kuznets Curve for Iran.

Variable	Coefficient	*T* -ratio
constant	10.389	0.56
Co_2	64.53	1.08
Co_2^2	23.34	1.45

Source: Research findings.

inverted "U" shape of the EKC is not confirmed yet with our data set for Iran.

The EKC model study also found that squared CO_2 did not contribute significantly to explain changes of GDP. A more appropriate interpretation of the model is that, perhaps, there were some important variables that were not incorporated in the model.

CONCLUSIONS

In order to answer the research question of this study concerning existence of a bidirectional relationship between real GDP per capita and CO_2 emissions per capita, we divided the countries of our data set into three groups according to their economic diversities. Results showed that gross domestic product per capita for three groups of ROW, OECD and HGR countries affects their CO_2 emissions per capita. This means that cooperation of these countries along with the industrial countries in order to achieve international goals of decreasing the pollutant gases is indispensable. In order for these countries to obtain an economic growth rate higher than that of the environmental polluting gases, technology would perform a vital role. Promoting technology and cooperation among countries, especially between the two groups of industrial countries and developing countries, might be a proper response to the challenge of greenhouse gases all around the world. The government and the private sector need to invest in appropriate projects and cooperate as well. As a matter of fact, governments are able to prevent the increasing trend of climatic changes by adopting appropriate policies and supporting the private investors on the basis of a market economy.

On the other hand, for ROW, OECD and HGR, the results revealed that their economy is under the influence of greenhouse gas emissions. Therefore, it seems appropriate that these countries encourage transferring clean technologies to other countries by accelerating the flow of international aids. It is only possible in the long term to develop cleaner and cheaper energy resources in order to guarantee permanent economic growth. Therefore, developing appropriate policies on climate change problems might be an inseparable factor of sustainable development in the near future. Some solutions recommended recently for decreasing greenhouse gases include using solar, wind, and nuclear energy, as well as fossil fuel consumption management and silviculture programs.

In the case of Iran, according to our study, gross domestic product affects CO_2 emissions. It indicates that the economic and human activities are having increasingly negative environmental impacts on the country. Therefore, it seems necessary to implement appropriate policies in order to decrease the destructive effects of climatic change. Besides, with the presence of global markets, it is possible to utilize the available opportunities of new knowledge and technologies in order to decrease greenhouse gases, increase efficiency, improve energy resource productivity, manage consumption properly, and also promote clean and renewable energy resources.

REFERENCES

1. Azomahou, T., Laisney, F. and Van, P. N. 2006. Economic Development and CO_2

Emissions: A Nonparametric Panel Approach. *J. Public Econ.,* **90:** 1347-1363.

2. Acaravci, A. and Ozturk, I. 2010. On the Relationship between Energy Consumption, CO_2 Emissions and Economic Growth in Europe. *Energy*, **35:** 5412-5420.
3. Amiri, A. and Gerdthamb, U. 2013. Impact of Maternal and Child Health on Economic Growth: New Evidence Based Granger Causality and DEA Analysis. Newborn and Child Health, Study Commissioned by the Partnership for Maternal, Lund University, Sweden.
4. Choe, J. I. 2003. Do Foreign Direct Investment and Gross Domestic Investment Promote Economic Growth? *Rev. Dev. Econ.,* **7:** 44-57.
5. Costantini, V. and Martini, Ch. 2009. The Causality between Energy Consumption and Economic Growth: A Multi-sectoral Analysis Using Non-stationary Cointegrated Panel Data: Working Paper No. 102. Dipartimento di Economia, Università degli Studi Roma Tre.
6. Dinda, S. and Coondoo, D. 2006. Income and Emission: A Panel Data Based Co-integration Analysis. *Ecol Econ.*, **57**: 167-181.
7. Dijkgraaf, E. and Vollebergh, H. R. J. 2001. A Note on Testing for Environmental Kuznets Curves with Panel Data. Research Centre for Economic Policy (OCFEB), Erasmus University, Rotterdam.
8. Everett, T., Ishwaran, M., Ansaloni, GP. and Rubin, A. 2010. Economic growth and the environment,MPRA Paper 3585, University Library of Munich, Germany. pp.51
9. Ferda, H. 2008. An Econometric Study of CO_2 Emissions, Energy Consumption, Income and Foreign Trade in Turkey. *31st IAEE Annual International Conference*. Istanbul, Turkey, PP. 18.
10. Granger, C. W. J. 1969. Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Econometrica*, **37:** 424-38.
11. Hansen H. and Rand J. 2004. On the Causal Links between FDI and Growth in Developing Countries. Development Economics Research Group (DERG), Institute of Economics, University of Copenhagen, Miméo.
12. Holtz-Eakin, D., Newey, W., and Rosen, H. 1988. Estimating Vector Autoregressions with Panel Data. *Econometrica*, **56:** 1371-95.
13. Hatzigeorgiou, E., Polatidis, H. and Haralambopoulos, D. 2011. CO2 Emissions, GDP and Energy Intensity: A Multivariate Cointegration and Causality Analysis for Greece, 1977–2007. *Appl. Ene*., **88:** 1377–1385.
14. Hossain, M. 2011. Panel Estimation for CO2 Emissions, Energy Consumption, Economic Growth, Trade Openness and Urbanization of Newly Industrialized Countries. *Ene Pol.*, **39:** 6991-6999.
15. Hurlin, C. and Venet, B. 2001. Granger Causality Tests in Panel Data Models with Fixed Coefficients. University Paris IX, Miméo.
16. Hurlin, C., 2004a. Testing Granger Causality in Heterogeneous Panel Data Models with Fixed Coefficients. University Orléans, Miméo.
17. Hurlin, C. 2004b. A Note on Causality Tests in Panel Data Models with Random Coefficients. University Orléans, Miméo.
18. IPCC. 2007. Climate Change 2007: Synthesis Report. Geneva, Switzerland.
19. Lee, C. G. 2009. Foreign Direct Investment, Pollution and Economic Growth: Evidence from Malaysia. *Appl. Econ.*, **41(13):** 1709-1716.
20. Lau, E., Chye, X. and Choong, Ch. 2011. Energy Growth Causality: A Panel Analysis. *International Conference On Applied Economics (ICOAE)*, Greece, pp.355-361.
21. Levin, A., Lin, C. F. , Chu,C. S. J. 2002.Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties. *J.Economet.*, **108**: 1-24.
22. Liu, G. 2006. A Causality Analysis on GDP and Air Emissions in Norway: Discussion Paper No. 447. Research Department, Statistics Norway.
23. Lean, H. H. and Smyth, R. 2009. CO2 Emissions, Electricity Consumption and Output in Asian: Discussion Paper DEVDP 09-13. Development Research Unit, Monash University, Australia. pp.31.
24. Maddala,G. S. and Wu, S. 1999. A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, **61**: 631-652.
25. Maddison, D. and Rehdanz, K. 2008. Carbon Emissions and Economic Growth. "Homogeneous Causality in Heterogeneous Panels": Working Paper No.1437. Kiel Institute for the World Economy, Germany.
26. Masih, M., Al-Sahlawi, M. and DeMello, L. 2010. What Drive Carbon-Dioxide Emissions:Income or Electricity Generation?

Evidence from Saudi Arabia. *The Journal of Energy and Development*, **33(2)**: 201-213
27. Moghadasi, R. and Golriz, Z. 2011. The Relationship between Carbon Dioxide Emissions and GDP Based on Combined Data. *Agri. Econ. Dev.*, **25(4):** 480-487.
28. Nair-Reichert, U. and Weinhold, D. 2001. Causality Tests for Cross-country Panels: A New Look at FDI and Economic Growth in Developing Countries. *Oxford Econ. Stat.*, **63:** 153-71.
29. Perman, R., Ma, Y., McGilvray, J., and Common, M. 2003. *Natural Resource and Environmental Economics*. 3rd Edition, Pearson Education Limited, Essex, Harlow, PP. 94.
30. Pigou, A. C. 1920. *The Economic of Welfare*. Macmillan and co., limited, London,pp.976.
31. Pao, H. and Tsai, C. 2010. CO2 Emissions, Energy Consumption and Economic Growth in BRIC Countries. *Ene. Pol*., **38:** 7850-7860.
32. Pao, H. and Tsai, C. 2011. Modeling and Forecasting the CO2 Emissions, Energy Consumption, and Economic Growth in Brazil. *Energy*, **36:** 2450-2458.
33. Sinha, D. 2009. The Energy Consumption-GDP Nexus: Panel Data Evidence from 88 Countries: MPRA Paper No. 18446. http://mpra.ub.uni-muenchen.de/18446/,
34. Taskin, F. and Zaim, O. 2000. Searching for a Kuznets Curve in Environmental Efficiency Using Kernal Estimation. *Econ. Lit.*, **68:** 217-223.
35. The World Bank. 1992. *World Development Report*. Washington DC.
36. Wang, S., Zhou, D., Zhou, P. and Wang, Q. 2011. CO2 Emissions, Energy Consumption and Economic Growth in China: A Panel Data Analysis. *Ene. Pol*., **39:** 4870-4875.

رویکرد داده‌های ترکیبی برای بررسی رابطه علیت تولید ناخالص داخلی و دی اکسید کربن

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چکیده

یکی از مشکلات و معضلات فعلی در جامعه جهانی، بروز تغییرات آب و هوایی و گرمایش جهانی است که اثرات و تبعات فراوان و متفاوتی در نقاط مختلف دنیا دارد. در این رابطه، از سویی اثر فعالیت‌های اقتصادی بر افزایش حجم گازهای گلخانه‌ای و از سوی دیگر، تأثیر میزان گازهای گلخانه‌ای بر فعالیت‌های اقتصادی به طور فزاینده‌ای محل مناقشه است لذا، در این مطالعه به بررسی فرضیه ارتباط علی دوسویه میان دو متغیر تولید ناخالص داخلی واقعی سرانه و حجم گاز دی‌اکسیدکربن سرانه کشورهای مختلف پرداخته شده است. برای این منظور، از مدل بردار خودرگرسیونی با کاربرد مایکروپنل استفاده شده و کشورهای عضو بانک جهانی به گروه‌های مختلف تقسیم شده‌اند. نتایج حاکی از وجود ارتباط دوسویه متشابه همزمان برای سه گروه کشور مورد مطالعه، می‌باشد. به‌علاوه، ارتباط علّی یک‌سویه از تولید ناخالص داخلی به حجم گاز دی‌اکسیدکربن برای زیرمجموعه‌ای از کشورهای با رشد متوسط اقتصادی بالا(HGR) و سایر کشورها(ROW) به چشم می‌خورد. این بدان معناست که برای نیل به اهداف بین‌المللی کاهش انتشار گازهای بین‌المللی، مساعدت کشورهای HGR و ROW در کنار کشورهای صنعتی بسیار کارگشاست. علاوه بر آن نتایج آزمون علیت ناهمسان برای ایران بیانگر آن است که فعالیت های اقتصادی دارای اثرات زیست محیطی منفی قابل توجهی بر کشور است.