Will be there New CO2 Emitters in the Future? Evidence of Long-run Panel Co-integration for N-11 Countries

Nasre Esfahani, Mohammad and Rasoulinezhad, Ehsan

Kharazmi University, Saint Petersburg State University

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Will be there new CO_2 emitters in the future? Evidence of long-run panel co-integration for N11 countries

Abstract: This article tries to explore the long-run nexus between oil consumption, GDP and carbon dioxide (CO2) emissions in the Next eleven (N-11) countries over the period 1980-2013, by using the panel c-ointegration, the panel Dynamic OLS and the panel Fully modified OLS approaches.The empirical findings indicate that there is a bidirectional long-run linkage between oil consumption – GDP per capita and oil consumption- CO2 emissions. Moreover the inverted U-shaped linkage between the square of GDP per capita and CO2 emissions, supports the existence of Environmental Kuznets Curve (EKC) hypothesis. These findings prove the negative contribution of non-renewable energy (oil) consumption per capita to GDP per capita in the N-11 group. Furthermore, due to the bidirectional long-run relationships between oil consumption and CO2 emissions, these 11 countries should find the efficient energy policies which are in line with CO2 mitigation and reaching a higher GDP per capita growth.

Keywords: Oil consumption per capita, GDP per capita, CO2 emissions per capita.
JEL classifications: E21, Q54, Q56.

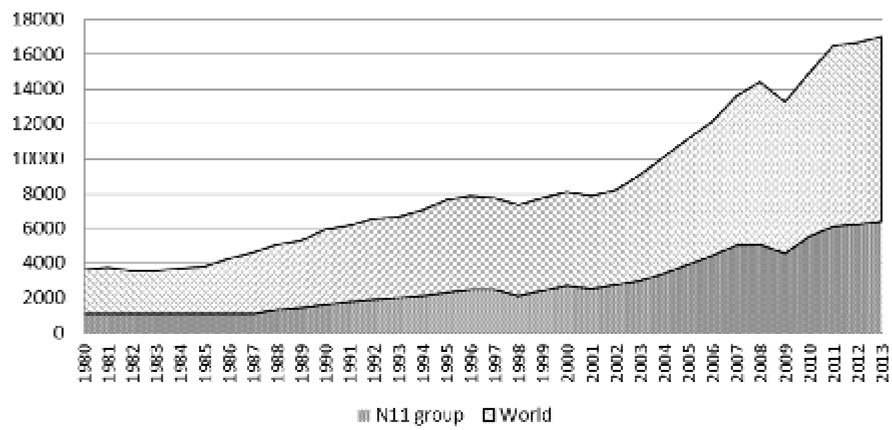
1. Introduction

Over the past few decades, based on the increasing threat of global warming and climate change, the CO_2 emissions-related issues have been attracting the scholars in the world. The findings of a high number of these studies such as Saboori & Sulaiman (2013), Saboori et al. (2014), Al-mulali & Binti Che Sab (2012), Al-mulali (2011), Ozturk & Acaravci (2010), Kasman & Y.S. Duman (2015), Apergis & Payne (2010), Yildirim & Aslan (2012), Hannan (2015a) and Hannan (2015b) have reported a strong connection between economic growth and CO2 emissions. In fact, many countries that experience high economic growth, account for a considerable contribution of global CO2 emissions. But an interesting question that may be raised is what is the relationship between CO2 emissions, economic growth and energy consumption in countries which have the potential to experience a high economic growth in the future. Since it is hard to predict which nation can reach to a high economic growth, a proper group countries is N-11 (Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, the Philippines, Turkey and Vietnam) which was introduced by Goldman Sachs in 2005 and have a major potential to become next emerging countries.

It should be noted that the authors did not find any study incorporating all of the eleven nations in this group together (However, we have found some studies which considered one or some of these nations, i.e. (e.g. Alam et al. (2011) for India, Cheng (1997) for Mexico, Glasure and Lee (2002) for South Korea, Lotfalipour et al. (2010) for Iran, Shahbaz et al. (2013b) for Pakistan, Wolde-Rufael (2009) for Egypt and Yildirim and Aslan (2012) for Turkey)). Hence this research is different from the earlier literature and would be considered as the first attempt applying the panel approach for investigating the relationship between oil consumption per capita, CO2 emissions per capita and GDP per capita in the N-11 group. Furthermore, the findings of this study can shape an interesting picture of the problem of CO2 emissions in the future. Policy makers will find out whether a group of countries like N-11 can become a new CO2 emitters group in the future.

Generally, Goldman Sachs in 2005 introduced these 11 nations as the future economies like BRICS (Sachs 2007). Figure 1 illustrates the trends of the average of this variable for the N-11 group in comparison with the world trend during 1980-2013. It can be seen from the figure that the average GDP per capita of all countries in the world is around 2514 and 10610 U.S dollars in 1980 and 2013. While, the average GDP per capita in the N-11 group is nearly 1074 U.S. dollars in 1980 and 6383 U.S. dollars in 2013. It can be noted that the growth rate of this variable in the N-11 group which is 4.9% is higher than the growth rate in the world (about 3.2%) during 1980-2013.

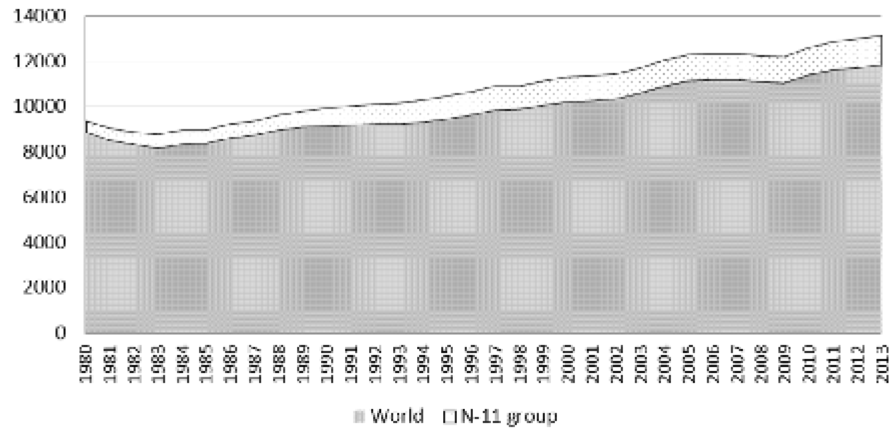
Fig 1. GDP per capita in the N-11 group and World, %, 1980-2013.



Source: Authors' compilation of the World Bank Database

The next variable is Carbon Dioxide (CO_2) emissions from consumption of petroleum in million metric tonnes from 1980 to 2013 (Figure 2). The N-11 countries were responsible for nearly 6.3% in 1980 and 12.1% in 2013 of global CO_2 emissions from consumption of petroleum. The high CO_2 emissions can be explained by a high density of population, dependence of national economies on manufacturing industries, a large share of fossil fuels on electricity generations of these nations.

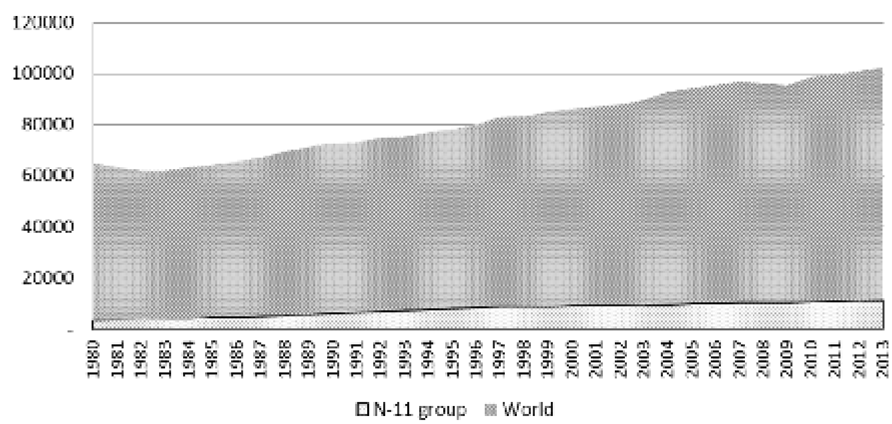
Fig 2. CO_2 emissions the N-11 group and World, in million metric tonnes, 1980-2013



Source: Authors' compilation of the International Energy Statistics

In addition, Figure 3 indicates oil consumption for these eleven countries and the entire world. It can be seen that the world oil consumption has increased over the period 1980-2013 from nearly 61233 thousand b/d to about 91243 thousand b/d. This increase has experienced a growth rate of 49%. In the case of N-11 group, the related oil consumption has boosted up through a 206% growth rate from 3631 thousand b/d in 1980 to nearly 11114 thousand b/d in 2013. It is clear that a higher oil consumption growth has been experienced by the N-11 group rather than the entire world during 1980-2013.

Fig 3. Oil consumption in the N-11 group and World, Thousands b/d, 1980-2013



Source: Authors' compilation of the BP statistical review of world energy

The rest of the article is outlined as follows:. Section 2 considers data description and research methodology. The next explains results and the last section concludes the paper.

2 Material and methods

2.1 Description of the dataset

The six variables used in this study include per capita CO2 emissions from the consumption of petroleum in metric tonnes, GDP per capita and square of GDP per capita in current US dollars, crude oil consumption per capita (as a proxy of non-renewable energy consumption) in barrels per day, trade openness and urbanization growth in percent as control variables (to overcome the omitted variable bias problem). All of the variables are used in the natural logarithmic form to reach a better result. Based on Wooldridge (2013), this form has many advantages such as satisfying the Classical Linear Model (CLM) assumptions than a form using the level of variables. The symbols, definitions and units of the research variables are represented in Table 1.

Table 1: Variables definition

Variable	Definition
LGDPPC	Logarithm of GDP per capita in the selected countries
LGDPPC2	Logarithm of GDP per capita squared in the selected countries
LCO2PC	Logarithm of CO_2 emissions per capita in the selected countries
LOILCONPC	Logarithm of oil consumption per capita in the selected countries
LTRADE	Logarithm of trade openness in the selected countries
LURBAN	Logarithm of urbanization growth in the selected countries

Note: Trade openness is the sum of exports and imports as a share of GDP
Source: Authors' compilation.

Countries in our sample which are known as Next Eleven (N-11) contain South Korea, Indonesia, Iran, Mexico, the Philippines, Turkey, Bangladesh, Egypt, Nigeria, Pakistan, Vietnam. Data on the explained five variables for all these eleven nations are annually from 1980 to 2013.The main sources of the data are "World Bank," (2015), "International Energy Statistics," (2015) and "BP statistical review of world energy 2015," (2015).

The summary descriptive statistics (mean, standard deviation, maximum and minimum) associated with GDP per capita, CO2 emissions per capita, oil consumption per capita, trade openness and urbanization growth can be reported as follows: The mean GDP per capita ranges from 412.58 U.S. dollars in Bangladesh to about 11550.62 U.S. dollars in South Korea. Based on the data, as for the crude oil consumption per capita, South Korea and Bangladesh have the highest and lowest mean of 3590.2 and 48.3 barrels per day from 1980 to 2013. With respect to CO2 emissions per capita, which is measured in metric tonnes has the highest mean in South Korea, Iran and Mexico, respectively. In realizing the trade openness, Vietnam has the highest mean, whereas Bangladesh has the lowest trade openness degree. Finally, in terms of urbanization growth, Nigeria has the highest mean, followed by Bangladesh and Indonesia.

In sum, for all these 11 countries, the mean of GDP per capita, CO2 emissions per capita, oil consumption per capita, trade openness and urbanization growth is nearly 2767.9 U.S. dollars, 1.27 metric tones, 976.6 barrels per day, 52.5 and 3.2 percent,respectively.

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Table 2: Summary statistics for the variables, 1980-2013

Countries	**GDPPC**	**CO2PC**	**OILCONPC**	**Trade**	**Urban**

Total N-11	Mean	2767.94	1.27	976.63	52.54	3.26
	Stdev	4193.77	1.31	1153.48	25.76	1.41
	Max	25997.88	6.06	5205.25	165.09	10.82
	Min	97.15	0.05	31.75	13.77	0.56

Source: Authors' compilation.

The following table illustrates the correlation matrix. It can be seen that the correlations between GDP per capita, square of GDP per capita and CO2 emissions per capita are positive. Oil consumption per capita is positively related to CO2 emissions per capita, GDP per capita and square of GDP per capita.The correlation shows a positive correlation between Trade openness and all the four variables CO2 emissions, GDP, square of GDP and Oil consumption per capita. Finally, Urbanization growth is negatively correlated with all the other five variables.

Table 3: Correlation matrix for the variables

Variables \ Variables	CO2PC	GDPPC	GDPPC2	OILCONPC	TRADE	URBAN
CO2PC	1.00	-	-	-	-	-
GDPPC	0.77	1.00	-	-	-	-
GDPPC2	0.61	0.92	1.00	-	-	-
OILCONPC	0.98	0.83	0.71	1.00	-	-
TRADE	0.07	0.21	0.25	0.11	1.00	-
URBAN	-0.49	-0.52	-0.41	-0.50	-0.31	1.00

Source: Authors' compilation.

2.2 Methodology

Following a large number of previous studies where the relationship between energy consumption, GDP and CO2 emissions have been proved (e.g. Alam et al., 2011; Al-Iriani, 2006; Al-mulali, 2011; Bhattacheraya and Bhattacharya, 2015; Bildirici and Bakirtas, 2014; Chang et al., 2009; Huang et al., 2008; Lee and Chang, 2008; Saidi and Hammami, 2015; Shahbaz et al., 2013; Soytas et al., 2007; Squalli, 2007; Zhang and Cheng, 2009), our research model under the Environmental Kuznets Curve (EKC) is proposed as:

CO2 emissions per capita = f(GDP per capita, Square of GDP per capita, Energy consumption per capita, Urbanization growth, trade openness) (1)

Or it can be considered as:

$$CO2PC = \beta_0 GDPPC^{\beta_1} GDPPC2^{\beta_2} OILCONPC^{\beta_3} URBAN^{\beta_4} OPEN^{\beta_5} \quad (2)$$

The above equation shows that CO2 emissions per capita can be a function of per capita GDP and square of GDP per capita, square of GDP per capita, oil consumption per capita, urbanization growth and trade openness. To write the equation (2) in a form of econometric, particularly, a panel data, the following equation in the logarithmic form can be arranged as bellows:

$$lCO2PC_{i,t} = \beta_0 + \beta_1 lGDPPC_{i,t} + \beta_2 lGDPPC^2_{i,t} + \beta_3 loilconpc_{i,t} + \beta_4 lurban_{i,t} + \beta_5 lopen_{i,t} + \varepsilon_{i,t} \quad (3)$$

Where i indicates 11 countries (i.e. South Korea, Indonesia, Iran, Mexico, the Philippines, Turkey, Bangladesh, Egypt, Nigeria, Pakistan, Vietnam), t is a time period that in this research covers 33 years from 1980 to 2013. Other symbols were defined in table 1.

Before implication of the cointegration test, the panel unit root tests should be performed to find out whether all the series can be integrated of the same order. Actually, it is widely believed that the panel unit root tests are better than the unit root tests for the individual time series (Al-mulali & Binti Che Sab 2012). In this study, three types of the panel unit root tests are computed which are LLC (Levin et al. 2002), ADF and PP- Fisher statistics (Maddala & Wu 1999) and (Choi 2001). These three panel unit root tests consider a common (LLC) or individual (Fisher type test using ADF and PP test) unit root across the countries (cross sections). The hypotheses of these three panel unit root tests are as follows:

$$\begin{cases} H_0: \text{Panel dat has unit root} \\ H_1: \text{Panel data has not unit root} \end{cases}$$

If the panel unit root tests prove that the variables are integrated of the same order, then we would perform the panel cointegration test to explore whether there is a long run relationship between the variables of the model. In this research, to analyze the long run relationship between variables, the Pedroni panel cointegration test (Pedroni 1999; Pedroni 2004) is implied for the residuals from the following equations. It can be noted that Pedroni heterogeneous cointegration test extends the Engle-Granger approach to panel data models (Liddle 2012)

$$lCo2pc_{it} = \propto_i + \delta_i t + \beta_{1i} lGDPPC_{it} + \beta_{2i} lGDPPC_{it}^2 + \beta_{3i} loilconpc_{it} + \beta_{4i} lopen_{i,} + \beta_{5i} lurban_{it} + \varepsilon_{it} \quad (4)$$

$$\widehat{\varepsilon_{it}} = \rho_i \hat{\varepsilon}_{it-1} + \epsilon_{it} \quad (5)$$

Where i represents the number of countries in the panel, t indicates the number of observations over 1980-2013 in the panel and ε shows residuals. To estimate the equation (4) and (5), Pedroni has introduced seven various statistics which contain 4 within dimension statistics and 3 between dimension statistics (These statistics allow for heterogeneity of the variables in cross sections). The null hypothesis of all these statistics are “no cointegration” or “ρi=1 for all i”. In this study, the majority results of these 7 statistics are considered as the final decision.

Furthermore, besides the Pedroni test, the Kao (1999) panel cointegration test is applied which has a similar null hypothesis to the Pedroni test. Based on Kasman and Duman (2015), the main point of this cointegration test is consideration of intercepts in cross section and homogenous coefficients on the first stage regression.

After finding a long run relationship through the Pedroni and Kao panel cointegration tests, the panel fully modified ordinary least squares (FMOLS) and the Panel Dynamic ordinatry least squares (DOLS) approaches are applied to estimate the long run cointegration vector.

3. Results

3.1 Unit root tests

In order to determine the stationarity of all the underlying time series data, we carry out tree panel unit root tests for the variables at levels and first differences including individual intercept and trend. The results for LLC, the augmented Dickey-Fuller (ADF)- and the Phillips-Perron- Fisher type tests are reported in Table 4. It should be noted that the optimal lag length was selected automatically using the SIC (Shwarz Information Criteria) and the Newey-West method.

Table 4: Panel unit root test results

Variable	Levin, Lin & Chu t	ADF-Fisher Chi-square	Philips-Perron – Fisher Chi-square	H0 (majority)	Stationary
LGDPPC	-0.72[0.23]	21.66 [0.48]	15.81[0.82]	Accept	No
D(LGDPPC)	-12.40[0.00]	158.93[0.00]	354.65[0.00]	Reject	Yes
LGDPPC2	-0.30[0.38]	18.60 [0.66]	12.16[0.95]	Accept	No
D(LGDPPC2)	-12.32[0.00]	158.96[0.00]	399.70[0.00]	Reject	Yes
LCO2PC	-0.76[0.22]	38.64[0.01]	3.15[0.09]	Accept	No
D(LCO2PC)	-11.05[0.00]	202.37[0.00]	256.74[0.00]	Reject	Yes
LOILCONPC	-1.07[0.14]	30.56[0.10]	2.39[0.43]	Accept	No
D(LOILCONPC)	-12.24[0.00]	167.56[0.00]	678.88[0.00]	Reject	Yes
LTRADE	2.26[0.98]	45.78[0.00]	34.25[0.06]	Accept	No
D(LTRADE)	-7.74[0.00]	193.33[0.00]	230.79[0.00]	Reject	Yes
LURBAN	-0.05[0.47]	38.54[0.01]	31.00[0.09]	Accept	No
D(LURBAN)	-8.39[0.00]	136.95[0.00]	348.10[0.00]	Reject	Yes

Note: Numbers in brackets indicate p-values at the 5% level
Source: Authors' compilation

According to the reported p-values in the above table, all the series are non-stationary at levels (means accepting the null hypothesis representing that the series contain a panel unit root) and stationary (rejecting the null hypothesis) at their first difference which stands for the integration at I(1).

3.2 Panel Cointegration Test

Since all the variables are cointegrated at I(1), the Pedroni and Kao panel cointegration tests can be applied to find out whether there is any long-run equilibrium relationship between the series. The achieved results are presented in the following Table 5 and 6. From the results, by considering the Pedroni test and all the panel, group and weighted statistics, it indicates that the p-values of eight statistics are less than 0.05 and hence, the majority of the all statistics tests can significantly reject the H0 of no cointegration at the 5% significance level. Furthermore, the Kao panel cointegration test result depicts that all series in our model are cointegrated.

In sum, it can be concluded that there is an evidence of a long run relationship between variables in the N-11 countries. These findings are in line with some previous researches such as Abid (2015) in Tunisia; Al-mulali and Binti Che Sab (2012) in the Sub Saharan African Countries; Ang (2008) in Malaysia; Heidari et al. (2015) in Pakistan; Menyah and Wolde-Rufael (2010) in South Africa; Ozturk and Acaravci (2013) inTurkey; Saboori et al. (2014) in OECD; Salahuddin et al. (2015) in GCC countries; Vidyarthi (2013) in India; Wang (2013) in 138 countries and Yang and Zhao (2014) in India.

Table 5: Pedroni Panel Cointegration Test results

Perdroni statistics	Statistic	Prob.	Weighted statistic	Prob.
Panel v-statistic	2.05*	0.02	-0.78	0.78
Panel rho-statistic	-1.73*	0.04	-0.34	0.36

Panel PP-statistic	-6.76*	0.00	-4.20*	0.00
Panel ADF-statistic	-7.38*	0.00	-4.81*	0.00
Group rho-statistic	0.69	0.75	-	-
Group PP-statistic	-6.23*	0.00	-	-
Group ADF-statistic	-5.98*	0.00	-	-

Note: (*) shows statistical significance at the 5% level.
Source: Authors' compilation.

Table 6: Kao Panel Cointegration Test results

Dependent variables	t-satistic	P-value	Result
LCO2PC	-9.10	0.00	Cointegrated

Source: Authors' compilation.

3.3 Panel Cointegration Estimations

Since the Pedroni cointegration test depicts the long run relationship between variables, the cointegrating coefficients of the series can be estimated by using the panel DOLS and FMOLS approaches. The following table summarizes the results of these estimations:

Table 7: Panel FMOLS and DOLS estimations

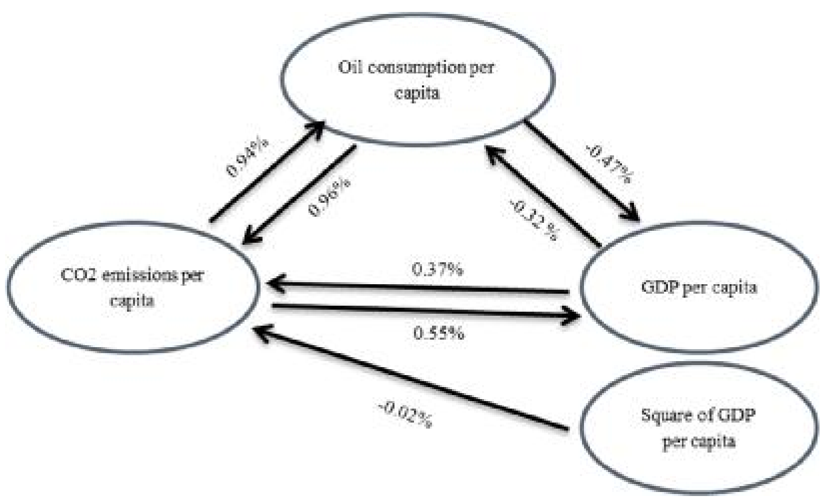
Estimation Approach	Dependent variables	Independent variables	Coefficient	t-statistic	Prob.
FMOLS	LCO2PC	LGDPPC	0.36	11.79	0.00
		LGDPPC2	-0.02	-11.86	0.00
		LOILCONPC	0.95	86.14	0.00
DOLS	LCO2PC	LGDPPC	0.37	3.53	0.00
		LGDPPC2	-0.02	-3.69	0.00
		LOILCONPC	0.96	28.82	0.00
FMOLS	LGDPPC	LCO2PC	0.56	6.79	0.00
		LOILCONPC	-0.51	-6.01	0.00
DOLS	LGDPPC	LCO2PC	0.53	5.24	0.00
		LOILCONPC	-0.44	-4.17	0.00
FMOLS	LOILCONPC	LGDPPC	-0.43	-5.87	0.00
		LCO2PC	0.97	38.18	0.00
DOLS	LOILCONPC	LGDPPC	-0.21	-2.30	0.02
		LCO2PC	0.92	34.64	0.00

Source: Authors' compilation.

Based on the two applied estimation approaches and considering CO2 emissions per capita as dependent variable, the coefficients of GDP per capita are statistically significant and positive, while the square of GDP per capita has negative coefficients of about -0.02. According to EKC hypothesis, there is a non-linear linkage between GDP per capita and CO2 emissions per capita which can be interpreted as an inverted U-shaped (It proves the EKC hypothesis). It means that CO2 emissions per capita begins to boost up until a specific level of income and then it goes down. This result is in line with some earlier studies such as Farhani and Shahbaz (2014), Kasman and Duman (2015) and Wang et al. (2011). Moreover, the results in Table 7 report a positive relationship between oil consumption per capita and CO2 emissions per capita. In other words, a 1% increase in the N-11 countries' oil consumption per capita increases CO2 emissions per capita by 0.96%. In the case of considering GDP per capita as dependent variable, the results support statistically positive significant long run CO2 emissions per capita – GDP per capita nexus. In contrast, oil consumption per capita has a negative coefficient of nearly -0.48 which means a 1% increase in the N-11 countries' oil consumption per capita leads to decreasing GDP per capita by 0.48%. In the last case, GDP per capita has a tendency to negatively affect oil consumption per capita, while there is a positive long run linkage between CO2 emissions per capita and oil consumption per capita (The diagram of long run linkage between the variables of our model is shown in Figure 4).

In sum, the long run estimations prove the long run positive effects of non-renewable energy on CO2 emissions per capita and also support the long run linkage between GDP per capita and CO2 emissions per capita. These results are in line with some earlier studies (e.g. Begum et al., 2015; Ben Jebli and Ben Youssef, 2015; Bloch et al., 2012; Chandran Govindaraju and Tang, 2013; Farhani and Shahbaz, 2014; Long et al., 2015; Shafiei and Salim, 2014; Shahbaz et al., 2013; Tang and Tan, 2015 and Yildirim, 2014) who find a positive effect of non-renewable energy consumption on CO2 emissions (deteriorate environment).

Fig 4. Long-run relationships between oil consumption per capita, CO_2 emissions per capita and GDP per capita



Source: Authors' compilation.

4. Concluding remarks and future directions

In this study, we have empirically tried to explore the dynamic long-run linkage between CO2 emissions per capita, oil consumption per capita and GDP per capita for Next eleven countries, i.e. South Korea, Indonesia, Iran, Mexico, the Philippines, Turkey, Bangladesh, Egypt, Nigeria, Pakistan, Vietnam using panel cointegration, the Fully Modified and the Dynamic OLS estimations for a wide range of a set of data from 1980 to 2013. In doing so, we implied various panel unit root tests to seek the variables' order of integration. The long-run relationships among variables CO2 emissions per capita, oil consumption per capita and GDP per capita were analyzed by using the Pedroni panel cointegration test. The long run coefficients were investigated by applying the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS). The empirical results indicated that in these eleven countries over the 33 years (1980-2013), there is long-run relationships between these three variables. Following the standard Environmental Kuznets Curve (EKC) hypothesis, the finding of this research proves an inverted U-shaped relationship between CO2 emissions, GDP per capita and square of GDP per capita. However, according to our estimations, a 1% increase in GDP per capita leads to increase of CO2 emissions per capita by nearly 0.37% in the 11 next countries.

The long-run elasticity of oil consumption per capita to GDP per capita in both the panel FMOLS and the DOLS estimations, is estimated to be around -0.48%. This amount of elasticity depicts the negative linkage between non-renewable energy consumption per capita and GDP per capita in the N-11 countries in the long run. Furthermore, the long run elasticity of oil consumption per capita to CO2 emissions per capita is calculated to be about 0.96%, which is more than the amount of its elasticity to GDP per capita. It can be concluded that the contribution of oil consumption per capita to GDP per capita is in contrast to the contribution to CO2 emissions per capita in all 11 countries under study.

The findings of this research indicate that oil consumption per capita affect GDP per capita and CO2 emissions per capita. Further research should try to explore the best policies to reduce CO2 emissions and increase GDP through some qualitative decision making methods (such as ANP or DNP) or combined qualitative-quantitative methods (such as ANP-VAR model). Furthermore, the various energy sources-CO2 emissions nexus can be further investigated in the N-11 group.

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