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The Impact of Foreign Trade, Energy Consumption and Income on Co_2 Emissions

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ABSTRACT: The aim of this study is to investigate the impact of energy consumption economic growth and especially trade openness on CO_2 emissions. In this frame, determiners of the CO_2 emissions are questioned by panel data cointegration analysis. In the scope of this study, 85 countries' data are contributed to the analysis for the period of 1990-2011. According to the results positive relationship is found between CO_2 emissions and energy consumption, per capita income and trade openness. On the other hand, trade openness can reduce CO_2 emissions in the long run. Findings indicate that in the short run unidirectional causality from CO_2 emissions to trade openness (TRD). Also there is unidirectional causality from per capita income (GDP) to CO_2 emissions and energy consumption (EN). Short run dynamics suggest bidirectional causality from GDP to TRD and TRD^2. According to the coefficient on the lagged ECT, implying that there are two long-run panel causality links that run from LGDP, LTRD and LEN, to LCO_2 and from LGDP, LTRD and LCO_2 emissions to LEN.
Keywords: CO_2 emissions; Trade Openness; Panel Cointegration Analysis; Panel causality analysis.
JEL Classifications: C33; O13; Q43

1. Introduction

Because of the reason that the global warming has increased for 30 years and the impacts of global warming and climate change on the world economy have been assessed intensively by academics and researchers (Ozturk and Acaravci, 2010). The most important reason behind the global warming is Green House Gas (GHG) and this gas is totally exposed by human activities. CO_2 gas which is exposed by the fossil fuel usage is constitutes more than 60% of the GHG (IEA, 2013).

One of the prominent reasons for the level of increase in CO_2 emission are the increasing amount of production which is called growth, adding up with the amount of energy used in production. In questioning the reasons behind the CO_2 emission increase and environmental degradations, the secondary factors upon this emission are also questioned. Especially foreign trade can also affect the level of CO_2 emission level of countries the in globalization process.

The interaction between growth and CO_2 emission is mainly founded by the EKC hypothesis, and the three interaction mechanisms between production and environmental degradation. These are the scale effect, the composition effect and the technology effect (Brock and Taylor, 2004). The effect of scale has negative effect on the environment by increasing the emission of CO_2 due to the increasing volume of production. Direction of composition effect can be variable. If the environmental factors were taken into the consideration in the new composition of product, the environmental degradation could be decreased. When the technology effect is analyzed, it is thought that the development of technology will decrease the environmental degradation (Kumbaroglu et al., 2008). The source of technological development is R&D researches and the transfers of technology. The formation of the discussed transfers is realized with the way of foreign trade, the environmental degradation can be decreased by using the sources of technological development more effectively (Ma and Stern, 2007).

In this study, economic growth, energy consumption and the trade openness which was subject to Pollution Heaven Hypothesis and technology transfer hypothesis, is questioned with panel data analysis. Apart from the previous studies, long run impact of trade openness on CO_2 emissions investigated with by help of EKC hypothesis to help to find a clean cut answer. In order to question the long term relations, the panel cointegration tests, which was developed by Pedroni (1999), Kao

(1999) and Fisher (Maddala and Kim, 1998) were performed. Then the estimation methods, FMOLS and DOLS is applied in order to test is strong relationship between CO_2 and independent variables, In addition, to investigate the causality relations in short and long terms, the vector error correction model was used.

According to the results obtained, the increase of energy consumption and trade openness affect the emission of CO_2 positively, on the other hand the increase of long term trade openness decrease the emission of CO_2. The short-run dynamics indicate that unidirectional causality from CO_2 emissions to TRD and TRD^2. Also there is unidirectional causality from GDP to CO2 and energy consumption. Another unidirectional causality is found from energy consumption to TRD^2. Short run dynamics suggest bidirectional causality GDP to TRD and TRD^2. Findings also indicate that there are two long-run panel causality links that run from LGDP, LTRD and LEN, to LCO_2 and from LGDP, LTRD and LCO_2 emissions to LEN.

The rest of the paper is organized as follows. Section 2 summarizes related literature; Section 3 describes the variables and presents the empirical model. Section 4 presents the empirical findings of the study. Final section gives the conclusions and policy recommendations.

2. Determinants of CO_2 Emissions

Basically three research strands in literature on the relationship between economic growth, energy consumption and environmental pollutants (Zhang and Cheng, 2009). The first strand focuses on the environmental pollutants and economic growth nexus. This strand tests the validity of Environmental Kuznets Curve (EKC) hypothesis, which postulates an inverted U-shaped relationship between the level of environmental degradation and income growth. The second strand of the research is related to energy consumption and output nexus. The third strand is a combined approach of these two methods which is implied to investigate validity of both nexuses in the same framework. This approach investigates the dynamic relationships between economic growth, environmental pollutants and energy consumption altogether (Ozturk and Acaravci, 2010).

One of the branches of these strands which were executed in this movement is the interaction between foreign trade and environmental degradations. Two separate views exist to present the interaction between foreign trade and environmental degradation. One of them is the Pollution Heaven Hypothesis and the other one is technology transfers view.

In the emerging economies, the demand for environmental quality is increase via the growing income. The internalization of the negative externalities by the state via legal regulations increases the costs of production. The firms which cause the environmental degradation transfer the production facilities towards to the undeveloped countries instead of institutional regulations. This mobility which was named as Pollution Heaven Hypothesis can increase via the freedom of foreign trade, environmental degradation of the countries which have lower income level. On the other hand, the increase of trade openness can accelerate the capital mobility for new technologies via technology transfer and ease the facility of environment-friendly technologies. This situation can decrease the environmental deterioration in long term.

There is also growing literature which examines the causality relationship between energy consumption and economic growth and institutional factors and CO_2 emissions. It is important for policymakers to understand the causality relationship in order to design effective energy and environmental policies (Ozturk, 2010). Studies which investigate relationship between environmental degradations and Economic growth, energy consumption and trade openness is presented in Table 1.

Table. 1. Related Literature About Effect of Trade on Environment

Author	Countries	Year	Method	Finding and Results
Ben Aissa et *al.* (2014)	24 Sub-Saharan Africa Countries	1980-2010	Panel Data analysis	In the long-run GDP per capita and real imports per capita both have a negative impact on per capita CO_2 emissions
Dritsaki and Dritsaki (2014)	Greece, Spain, Portugal	1960-2009	Panel cointegration method	There is a short-run bilateral causal relationship, in the long run, there is a unidirectional causality between CO2 emissions, energy consumption , and economic growth

Shahbaz and Leitao (2013)	Portuguese	1970 - 2009	Time series analysis	International trade have positive impact on carbon dioxide emissions
Aslan at al. (2013)	47 US States	1997-2009	Heterogeneous panel data Analysis	There is a bidirectional causal relationship between energy consumption and economic growth.
Jayanthakumaran et al. (2012)	China and India	1971 - 2007	Time series analysis	In the short-run international trade will tend to reduce CO_2 emissions
Sharma (2011)	69 Countries	1985-2005	Panel Data analysis	Trade openness has positive impact on CO_2 emissions.
Hossain (2011)	9 Newly industrialized countries (NIC)	1971-2007	Panel cointegration analysis	There is unidirectional short-run causal relationship from economic growth and trade openness to CO_2 emissions
Ozturk and Acaravci (2010)	Turkey	1968–2005	ARDL analysis	Neither carbon emissions per capita nor energy consumption per capita cause real GDP per capita
Acaravci and Ozturk (2010)	Denmark, Germany Greece, Iceland, Italy Portugal, Switzerland	1960-2005	ARDL analysis	This study also explores causal relationship between carbon dioxide emissions, energy consumption, and economic growth
Yan and Yang, (2010)	China	1997-2007	Time series analysis	Scale and composition effect increased the CO_2 emissions embodied in trade.
Nakano et al. (2009)	41 countries	1995-2000	Input output analysis	Increase in global trade intensity has an increasing impact on embodied emissions
Chebbi et al. (2009)	Tunisia	1961 - 2004	Cointegration analysis	Trade openness has positive impact on CO_2 emissions in the short and the long run
Halicioglu (2009)	Turkey	1960 - 2005	Time series analysis	Income is the most significant variable in explaining the carbon emissions in Turkey which is followed by energy consumption and foreign trade
Jalil and Mahmud (2009)	China	1975 - 2005	ARDL	Trade has a positive but statistically insignificant impact on CO_2 emissions.
Antweiler et al. (2001)	44 countries	1975-1994	Panel Data analysis	Free trade is good for environment
Weber et al. (2008)	China	1987-2005	Input output analysis	One third of Chinese CO_2 emissions were due to production of exports

3. Model and Methodology

In this study to determine the effect of trade openness on CO_2 emissions, panel data method was preferred. The panel data methods are more powerful compared to the time series unit root and cointegration approaches, by combining information from both time and cross-section dimensions.

3.1. Model

In order to capture the impact of determinants of CO_2 emissions, consider the regression model:

$$LCO2_{i,t} = \alpha_i + \beta_1 LGDP_{i,t} + \beta_2 LEN_{i,t} + \beta_3 LTRD_{i,t} + \beta_3 LTRD^2_{i,t} + \varepsilon_{i,} \quad (1)$$

Where t refers to the time period, $LCO2_{it,}$ is the per capita CO_2 emissions, $LGDP_{it}$ per capita income, LEN_{it} energy use per capita and $LTRD_{it}$ is trade openness. $LTRD^2$ is the square of LTRD to test increasing effect of trade volume. Letter "L" indicate that all the variables are expressed in natural logarithms.

In this specification, the impact of the income on CO_2 expected to be positive since for the scale effect. More production requires more energy so it is expected that coefficient of LEN (B_2) is positive. Trade openness effect can vary so coefficient of LTRD (B_3) can be positive or negative. In this study sign of trade openness $LTRD^2$ (B_4) is expected negative because of the PHH and trade openness promotes technology transfer.

3.2 Cointegration methodology

In the empirical analysis, we test for the existences of a long-run relationship among the variables (estimation of Eq. (1), and the utilization of the error-correction model (ECM) captures the short run dynamics of the variables. The analysis is done in four steps (Pao and Tsai, 2011). The first step is unit root tests. The various cointegration tests are valid only if the variables have the same order of integration. Three types of unit root tests, Breitung (2000), Im, Pesaran and Shin (IPS) (2003), and a Fisher-type Augmented Dickey-Fuller tests (F-ADF) (Maddala and Wu,1999: Choi, 2001) are employed.

The second step, when all series are integrated into the same order, Pedroni (1999,2004), Kao (1999) and the Johansen Fisher (Maddala and Wu,1999) methods are used to test the panel cointegration relationship, which are based on the estimated residuals of Eq. (1).

3.2.1. Panel Cointegration Tests

Pedroni (1999) extends his residual-based panel cointegration tests (Pedroni, 1995) for the models, where there is more than one independent variable. Pedroni developed seven cointegration statistics to test for the null of no-cointegration among the variables. The four statistics – within-dimension panel cointegration tests pool the autoregressive coefficients (ϕ_i) across different members for the unit root tests on the residuals. The next three statistics between-dimension panel cointegration tests take the average of the individually estimated coefficients for each cross-section in the panel (Nazlıoglu, 2012).

In Pedroni cointegration test, firstly Eq (1) is estimated for each country by using the ordinary least squares (OLS). Then, the following auxiliary regression on the residuals is estimated by the OLS.

$$\varepsilon_{it}=\phi_i\ \varepsilon_{it-1}+v_{it} \qquad (2)$$

The null hypothesis of no cointegration H_0:$\phi_{i=1}$for all i is tested against the alternative of H_1: ϕ_i $_=\phi_i<1$for all “i” in the within-dimension approach and of H1: $\phi_i<1$ for all i in the between-dimension approach. So, an additional source of potential heterogeneity across cross-sections can be adequately captured by the between-dimension approach. The Pedroni and Kao tests are based on the Engle-Granger (1987) two-step (residual-based) cointegration tests. The Kao test follows the same basic approach as the Pedroni tests but specifies cross section specific intercepts and homogeneous coefficients during the first stage. Additionally, the Fisher test is a combined Johansen and Juselius (1990) test. If cointegration exists among the variables, the ordinary least squares (OLS) method is applied to estimate Eq. (1) does not lead to a spurious regression result. Furthermore, the parameters estimated by OLS are super-consistent (Alves and Bueno ,2003) The β_1, β_2, β_3, and β_4 are the long-run energy consumption elasticity, per capita real GDP elasticity, energy consumption elasticity, trade openness elasticity and square of trade openness elasticity, respectively.

3.2.2. Panel Cointegration Estimation FMOLS and DOLS

The third step is panel cointegration estimations. To test long run cointegration vector, Fully Modified Ordinary Least Squares (FMOLS) (McCoskey and Kao, 1998: Phillips and Moon, 1999: Pedroni, 2000) and the Panel Dynamic Ordinary Least Squares (DOLS) (Mc Coskey and Kao, 1998: Kao and Chiang ,2000) methods are used. The selection of methods to test long run cointegration vector is discussed by some researchers (Mc Coskey and Kao, 1998; Kao and Chiang, 2000). The researcher mentioned that the panel DOLS is less bias than the FMOLS estimators in small samples using Monte Carlo simulations and has better sample properties rather than the FMOLS estimators (Kao and Chiang, 2000). In the study both of method is used for robustness.

3.2.3. Granger causality

In the fourth step, the direction of causality between the variables is examined in a panel context. The existence of cointegration indicates that there are long-run equilibrium relationships among the variables and thereby Granger causality among them in at least one direction (Engle and Granger.1987; Oxley and Greasley, 2008). The vector error-correction model (VECM) is used for correcting disequilibrium in the cointegration relationship, captured by the ECT, as well as to test for long- and short-run causality among cointegrated variables. The panel-based VECM is specified as follows (Pao and Tsai, 2011; Belloumi, 2009): where i = 1,.,N denotes the country; t = 1,.,T denotes the time period; ε_{it} is assumed to be serially uncorrelated error term; ECT is the lagged error-correction term derived from the long-run cointegrating relationship. Following Abdalla and Murinde (1997) and

Pao, Tsai (2011) the optimal lag length in each equation for linear system (3) is selected through maximizing the value of the R^2 and AIC criteria

$$\begin{bmatrix}\Delta LCO2_{it}\\ \Delta LGDP_{it}\\ \Delta LEN_{it}\\ \Delta LTRD_{it}\\ \Delta LTRD_{it}^2\end{bmatrix}=\begin{bmatrix}\alpha_1\\ \alpha_2\\ \alpha_3\\ \alpha_4\\ \alpha_5\end{bmatrix}+\sum_{p=1}^{r}\begin{bmatrix}\beta_{11p} & \beta_{12p} & \beta_{13p} & \beta_{14p} & \beta_{15p}\\ \beta_{21p} & \beta_{22p} & \beta_{23p} & \beta_{24p} & \beta_{25p}\\ \beta_{31p} & \beta_{32p} & \beta_{33p} & \beta_{34p} & \beta_{35p}\\ \beta_{41p} & \beta_{42p} & \beta_{43p} & \beta_{44p} & \beta_{45p}\\ \beta_{51p} & \beta_{52p} & \beta_{53p} & \beta_{54p} & \beta_{55p}\end{bmatrix}\begin{bmatrix}\Delta LCO2_{it-p}\\ \Delta LGDP_{it-p}\\ \Delta LEN_{it-p}\\ \Delta LTRD_{it-p}\\ \Delta LTRD_{it-p}^2\end{bmatrix}+\begin{bmatrix}\theta_1\\ \theta_2\\ \theta_3\\ \theta_4\\ \theta_5\end{bmatrix}ECT_{it-1}+\begin{bmatrix}\varepsilon_{1it}\\ \varepsilon_{2it}\\ \varepsilon_{3it}\\ \varepsilon_{4it}\\ \varepsilon_{5it}\end{bmatrix} \quad (3)$$

4. Empirical Results

4.1 Data analysis

The multivariate panel framework includes CO_2 emissions, income, energy consumption, and trade. The balanced panel data is collected for the period from 1990 to 2011 for 85[*] countries and obtained from World Bank (2013). The definitions and sources of data are presented in Table 2.

Table 2. Data Definitions and Sources

Code	Name	Source
LCO_2	CO_2 emissions (metric tons per capita)	WDI[a]
LGDP	GDP per capita (constant 2005 US$)	WDI[a]
LEN	Energy use (kg of oil equivalent per capita)	WDI[a]
LTRD	Imports+ exports of goods and services (% of GDP)	WDI[a]
$LTRD^2$	Squared of LTRD	WDI[a]
[a]The World Bank World Development Indicators: http://databank.worldbank.org/data/views/variable Selection/selectvariables.aspx?source=world-development-indicators		

4.2. Panel unit root test results

So in order to examine the relationships among the variables in concern, unit root and cointegration methods are applied to the balanced data set. In the analysis, to ensure robustness for the common components of (LCO_2), (LGDP), (LEN), (LTRD), ($LTRD^2$), Breitung (2000), Im Peseran and Shin (2003) and Fisher ADF unit root test is employed. Unit root test results are presented in Table 3. According to the test results, we have found that all of the series are stationary in first differences.

Table 3. Panel Unit Root Test Results

		Breitung			IPS			F-ADF	
Variables		Level	first dif.		Level	first dif.		Level	first dif.
LCO2		2.8441	-8.72***		1.1635	-13.8***		186.17	501.9***
		(0.997)	(0.000)		(0.877)	(0.000)		(0.187)	(0.000)
LGDP		3.1858	-4.91***		0.5146	-7.88***		191.7	339.7***
		(0.999)	(0.000)		(0.696)	(0.000)		(0.121)	(0.000)
LEN		5.1400	-7.04***		1.5004	-12.2***		157.0	440.0***
		(1.000)	(0.000)		(0.933)	(0.000)		(0.753)	(0.000)
LTRD		-0.4964	-8.03***		-0.3824	-12.1***		173.4	454.7***
		(0.309)	(0.000)		(0.351)	(0.000)		(0.412)	(0.000)
LTRD2		-0.5161	-7.51***		-0.3888	-11.6***		172.8	440.1***
		(0.302)	(0.000)		(0.348)	(0.000)		(0.424)	(0.000)

Notes:
*** Denotes statistical significance at the 1% level.
a) Newey-West bandwidth selection using Bartlett kernel.
b) All variables are tested with intercept and deterministic trend.
c) User specified lag length selection: 1

[*] Country list is given in Annex A

4.3. Panel Cointegration test results

Having verified that the series are non-stationary and same order integration as I(1), it is tested whether there exist any long run equilibrium relationship between the variables using Pedroni and Kao and Fisher Panel Cointegration test. Results are presented in Table 4 and Table 5.

Table 4. Pedroni Panel Cointegration Test Results

Intercept				**Intercept and trend**		
Within-dimension				**Within-dimension**		
	Test Statistic	**Prob.**			**Test Statistic**	**Prob.**
Panel v-Statistic	-0.6236	0.7336		Panel v-Statistic	-4.8338	1.0000
Panel rho-Statistic	-4.3119	0.0000		Panel rho-Statistic	-2.2908	0.0110
Panel PP-Statistic	-23.8670	0.0000		Panel PP-Statistic	-29.4138	0.0000
Panel ADF-Statistic	-1.6211	0.0525		Panel ADF-Statistic	-2.7038	0.0034
Between-dimension				**Between-dimension**		
	Test Statistic	**Prob.**			**Test Statistic**	**Prob.**
Group rho-Statistic	4.6086	1.0000		Group rho-Statistic	6.7887	1.0000
Group PP-Statistic	-13.0298	0.0000		Group PP-Statistic	-20.3841	0.0000
Group ADF-Statistic	-4.6016	0.0000		Group ADF-Statistic	-5.9620	0.0000

a) The 1%, 5%, and 10% critical values are respectively 1.28, 1.645, and 2.33 for the panel-v statistic, and - 1.28, -1.645, and -2.33 for other statistics.
b) User specified with a max lag of 1.
c) Newey-West automatic bandwidth selection and Bartlett kernel.

We have seen from the Pedroni Panel Cointegration test, except panel v statistics and group rho- statistics; five out of seven statistics reject the null hypothesis of no cointegration 1% significance level with intercept and trend. That is, there is a long run relationship between the variables. As well, according to Kao and Fisher panel cointegration test results there is a long run cointegration between variables. The Kao test suggests panel cointegration at a 1% level of significance. In addition, the Johansen Fisher test suggests the existence of five cointegrating vectors at a 1% level of significance. Overall, there is strong statistical evidence in favor of panel cointegration among CO_2 emissions, per capita income, energy consumption and TRD and TRD^2.

Table 5. Kao and Fisher Panel CointegrationTest Results

Kao test		
	t-Statistic	***Prob.***
ADF	-4.4243	0.0000
Hypo.	Fisher Stat.	Fisher Stat.
Fisher Test		
No. of CE(s)	***Trace test***	***Max-eigen test***
None	2373*** (0.000)	1572***(0.000)
At most 1	1177***(0.000)	703.5***(0.000)
At most 2	633.2***(0.000)	423.8***(0.000)
At most 3	373.2***(0.000)	291.6***(0.000)
At most 4	338.2***(0.000)	338.2***(0.000)

1- User specified with a max lag of 1
2- Newey-West automatic bandwidth selection and Bartlett kernel
3- Lag intervals for fisher test:11
4- The numbers in parentheses denote p values.

4.4. Panel cointegration estimation results

In the next step, the fully modified OLS (FMOLS) technique for heterogeneous cointegrated panels is estimated (Pedroni, 2000). Table 6 shows this FMOLS and DOLS results. The system's estimated R^2

value is 0.997. The results in Eq. (1) show that all variables have the expected sign and are statistically significant at the 1% level.

Table 6. Panel DOLS and FMOLS Estimation Results

DOLS				FMOLS				
				Constant			Linear trend	
Variables	**Coeff.**	**t-stat.**		**Coeff.**	**t-stat.**		**Coeff.**	**t-stat.**
LGDP	0.435***	6.127		0.285***	6.0424		0.243685***	3.1936
	(0.000)			(0.000)			(0.0014)	
LEN	0.475***	4.863		0.803***	13.464		0.846381***	11.796
	(0.000)			(0.000)			(0.000)	
LTRD	1.011***	3.460		0.898***	4.4025		0.467624*	1.8652
	(0.006)			(0.000)			(0.0623)	
LTRD2	-0.121***	-3.298		-0.119***	-4.7472		-0.050036*	-1.6567
	(0.001)			(0.000)			(0.0978)	
Adj. R^2	0.997			0.987			0.992	
Num. of count	85			85			85	
Obs.	1700			1700			1700	

Note: *** p<0.01, ** p<0.05, * p<0.1
The numbers in parentheses denote p values.

With this balanced panel data, the long-run panel elasticity of emissions with respect to per capita income, is above unity (0.435), indicating that for every 1% increase in per capita income, the per capita emissions are increasing by 0.435%. Result indicates that 1% increase in energy consumption increases per capita emissions by 0.475%. Also % 1 increase in trade openness increases per capita emissions by 1.011% and % 1 increase in square of trade openness decreases per capita emissions by 0.121%.

4.5. Panel causality tests results VECM

The existence of a panel long-run cointegration relationship between CO_2 emissions and LGDP, LEN, TRD, TRD^2 suggests that there must be Granger causality in at least one direction. The balanced panel Granger causality results are presented in Table 7.

Table 7. Panel causality tests results

	Short run causality [Chi-sq]					Long run causality
Variables	**ΔLCO_2**	**ΔLGDP**	**ΔLEN**	**ΔLTRD**	**ΔLTRD2**	**ICT (Φ)**
ΔLCO2	-	8.159* (0.085)	1.982 (0.738)	2.531 (0.639)	2.561 (0.636)	-0.936*** (0.000)
Δ LGDP	3.573 (0.469)	-	4.513 (0.341)	12.633** (0.013)	13.117** (0.011)	-0.018 (0.131)
Δ LEN	4.210 (0.378)	22.01*** (0.000)	-	2.656 (0.616)	4.588 (0.332)	-0.033* (0.064)
Δ LTRD	15.64*** (0.003)	15.82*** (0.003)	3.813 (0.431)	-	36.80*** (0.000)	-0.049 (0.201)
Δ LTRD2	17.18*** (0.001)	15.63*** (0.003)	4.063 (0.397)	30.27*** (0.000)	-	-0.370 (0.254)

Notes: a) The null hypothesis is that there is no causal relationship between variables.
b)The numbers in parentheses denote p values.
c)Δ is the first difference operator.
d)*** p<0.01, ** p<0.05, * p<0.1

The short-run dynamics suggest unidirectional causality from CO_2 emissions to TRD and TRD^2. Also there is unidirectional causality from GDP to CO2 and energy consumption. Short run dynamics suggest bidirectional causality GDP to TRD and TRD^2. According to the coefficient on the lagged ECT, there exists a long-run relationship among the variables in the form of Eq. (1), as the ECT is statistically significant. The coefficients of the ECT are significant in both CO_2 emissions and energy consumption, implying that there are two long-run panel causality links that run from LGDP, LTRD and LEN, to LCO_2 and from LGDP, LTRD and LCO_2 emissions to LEN. Short and long run causality results are presented in Table 7.

Figure 1 and Figure 2 summarizes the panel data Granger short run and long run causality relations respectively.

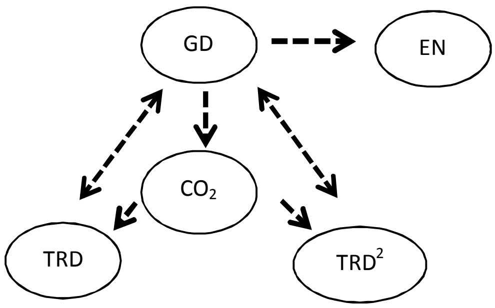

Figure 1. Short run panel causality relation

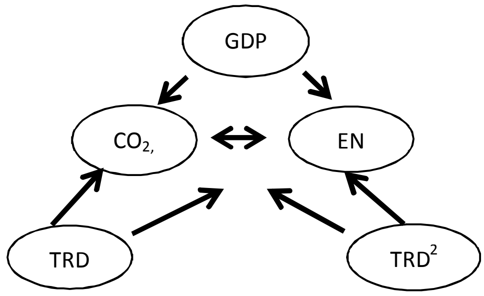

Figure 2. Long run panel causality relation

Based on the causality results, evidence shows that increase of income and requires additional energy usage, which increases emissions. The results are consistent with Ben Aissa at al. (2014). Also findings are consistent with the findings of Pao and Tsai (2011), Belloumi (2009), and Asafu and Mahadevan (2007), who concluded that there is bidirectional causality between GDP and energy consumption. Findings indicate that there is granger causality between GDP and CO_2 emissions. Also there is bidirectional causality CO_2 and trade. The causality results are consistent with the finding of Halicioglu (2009). Cointegration regression results trade openness give rise to increase CO_2 emissions. Findings support Shahbaz and Leitao (2013), Sharma (2011) and Chebbi et al. (2009) but doesn't support Antweiler et al. (2001) and Jayanthakumaran et *al*. (2012).

5 . Conclusion

This paper analyzed the main determinants of CO2 emissions by the 85 countries by employing annual balanced data over the period 1991–2011. Panel cointegration techniques FMOLS DOLS were applied to estimate emissions and to examine the per capita GDP energy consumption and trade openness sensitivity issues of both long and short run emissions. An error correction model was used to capture the short run and long run dynamics for countries. Then OLS, FMOLS and DOLS estimation methods are applied in order to test strong relationship between CO_2 energy consumption, per capita income and trade openness

According to the results obtained in the analysis, the increase of production and energy consumption enhance the CO_2 emission. On the other hand, the increase of trade openness affect the CO_2 emission positively in short term, then the increase of trade openness will decrease the CO_2 emission after a threshold level.

As to the results emissions increasing with trade openness, stabilizing and then declining. Shape of curve is similar to EKC. Hence, beyond a threshold level of trade openness may actually reduce emissions. This has reasons more than one. Firstly, the foreign trade volume which was increased by trade openness and higher income may promote demand for environmental quality. Secondly, the high scale production which was achieved by the increase of foreign trade will bring the higher level technology. Finally, reduction of environmental degradation with increasing trade openness threshold level can be explained by PHH.

In order to test the causality of panel data we created the error correction model (ECM) followed by the Granger in order to investigate the short and long-run dynamic relationships. The empirical results suggest that in the short run there is unidirectional causality from CO_2 emissions to TRD and TRD^2. Also there is unidirectional causality from GDP to CO2 and energy consumption. Short run dynamics suggest bidirectional causality from GDP to TRD and TRD^2.

Findings indicate a long run equilibrium relationship between CO_2 emissions and energy consumption for the all countries. Long run energy consumption elasticity is statistically significant. This elasticity suggests high energy consumption responsiveness to changes in emissions. In the long run, the estimated coefficients of energy consumption are statistically significant at 10% for countries, which implies that changes in emissions per capita are partly by short term energy consumption shocks and partly by movements back to long term equilibrium. Finally, whenever a shock occurs in the system, energy consumption and emissions would make short term adjustment to restore long term equilibrium.

For the decrease of the CO_2 emission, the increase the trade openness is an effective policy suggestion for high income countries. Besides, the increase of liberalization of foreign trade will ease the attitude on acting together in the policies upon environment.

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Annex A. Country List

1	Australia	23	Spain	44	Namibia	65	Nicaragua
2	Austria	24	Sweden	45	Panama	66	Nigeria
3	Belgium	25	Switzerland	46	Peru	67	Pakistan
4	Canada	26	United King.	47	South Africa	68	Paraguay
5	Chile	27	United States	48	Thailand	69	Philippines
6	Czech Rep.	28	Algeria	49	Tunisia	70	Senegal
7	Denmark	29	Argentina	50	Turkey	71	Sri Lanka
8	Finland	30	Botswana	51	Venezuela, RB	72	Sudan
9	France	31	Brazil	52	Bolivia	73	Ukraine
10	Germany	32	Bulgaria	53	Cameroon	74	Vietnam
11	Greece	33	China	54	Congo, Rep.	75	Yemen, Rep.
12	Iceland	34	Colombia	55	Cote d'Ivoire	76	Zambia
13	Ireland	35	Costa Rica	56	Egypt, Arab Rep.	77	Bangladesh
14	Israel	36	Dominican Rep.	57	El Salvador	78	Benin
15	Italy	37	Ecuador	58	Ghana	79	Ethiopia
16	Japan	38	Gabon	59	Guatemala	80	Kenya
17	Korea, Rep.	39	Hungary	60	Honduras	81	Mozambique
18	Luxembourg	40	Jordan	61	India	82	Nepal
19	Netherlands	41	Lebanon	62	Indonesia	83	Tajikistan
20	New Zealand	42	Malaysia	63	Mongolia	84	Tanzania
21	Poland	43	Mexico	64	Morocco	85	Togo
22	Portugal						