The Relationship between Environmental Degradation, Economic Development and Corruption: A Panel Data Cointegration Analysis of Asian Emerging and Developing Countries

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Abstract

This paper analyzes the relationship between CO_2 emission, economic development and control of corruption for 25 Asian emerging and developing countries in the period from 1998 to 2014. Building upon an Environmental Kuznets Curve (EKC) model, recently developed second generation panel data cointegration methods that account for a number of estimation problems such as unobserved heterogeneity, cross-sectional dependence and endogenous regressors are applied. First results confirm the inverted U-shaped relationship between CO_2 emissions and economic growth as stated by the EKC hypothesis. Furthermore, the finding of a statistically significant relationship between control of corruption and CO_2 emissions emphasizes the importance of good institutional quality for a sustainable growth path in one of the fastest growing regions in the world.

Keywords: Environmental Kuznets Curve, CO2 emissions, Control of Corruption, second generation panel data cointegration methods

JEL classification:

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1. Introduction

According to the International Monetary Fund (IMF, 2017), the share of Asian emerging and developing countries in the world's gross domestic product (GDP) doubled from about 16% in 1998 to about 32% in 2017.[2] Within the same period the annual average growth in real GDP of Asian emerging and developing countries amounted to about 7.43 %, whereas the world's average growth in GDP was only about 3.78% (IMF, 2017). These numbers show that within the last 20 years the economic development in emerging and developing Asia significantly increased. Projections suggest that this trend will hold at least for the next five years (IMF, 2017).

Unfortunately, in line with this development, the amount of climate-damaging carbon dioxide (CO_2) emissions also increased. While in 1998, CO_2 emissions from burning of fossil fuels and the manufacture of cement in emerging and developing Asia amounted to about 4.91 million kilotons, this number increased to about 13.67 million kilotons in 2014. Overall, Asian emerging and developing countries were responsible for about 38 % of the world's CO_2 emissions in 2017 (World Bank, 2017).

A potential solution to this problem is given by the theoretical concept of the so called Environmental Kuznets Curve (EKC) hypothesis. The hypothesis states an inverted U-shaped relationship between environmental degradation and economic development. That is, initially environmental degradation increases with economic development, but after a certain level of economic development environmental degradation turns to decrease (Grossman and Krueger, 1991).

Numerous studies in the area of developing and environmental economies have studied the relationship between economic growth and environmental degradation in the context of the EKC hypothesis (see e.g. Stern (2004), Dinda (2004) and Kaika and Zervas (2013)) for extensive reviews). However, only a few have empirically analyzed the impact of corruption on this relationship. Among the first is Welsch (2004), who investigated the relationship between per capita income, corruption and a number of pollution indicators such as sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) emissions. In particular, he accounted for the direct effect of corruption on pollution as well as for the indirect effect via corruption's impact on per capita income. Overall, he finds a positive relationship between corruption and pollution. However, as Welsch uses cross-sectional data, he does not account for unobserved heterogeneity across

[2]By definition of the IMF, Asian emerging and developing countries are: Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Fiji, India, Indonesia, Kiribati, Lao P.D.R., Malaysia, Maldives, Marshall Islands, Micronesia, Mongolia, Myanmar, Nauru, Nepal, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, Vietnam (IMF 2017).

countries. Furthermore, his estimation procedure does not control for any endogenity issues between economic development and corruption.

Two follow-up studies by Cole (2007) and Leitao (2010) tackle these problems by using panel data and instrument variable estimation procedures. While Cole finds a positive direct impact of corruption on SO_2 and CO_2, his results also indicate a larger negative indirect effect in absolute value for the majority of the sample income range. Consequently, in contrast to Welsch (2004), he concludes that the effect of corruption on emissions is negative, except for countries with very high income levels. Following the theoretical model of López and Mitra (2000), Leitao (2010) investigates the relationship between corruption and the turning point of the EKC hypothesis in context of sulphur dioxide emissions. She finds that the per capita income at the turning point increases with a country's degree of corruption.

In addition, more recent studies by Goel et al. (2013), Apergis and Ozturk (2015), Zhang et al. (2016) and Abid (2017) utilize instrumental variable, generalized method of moment sand quantile regression estimation procedures to investigate the economy-environment-corruption nexus. While the latter three indicate a positive relationship between corruption and CO_2 emissions, the findings of Goel et al. (2013) are in line with Coel (2007), indicating a negative relationship.

Overall, previous research indicates a three dimensional relationship between environmental degradation, economic growth and corruption. However, findings for the indirect and direct effects within this nexus are mixed. Our study contributes to the empirical literature by analyzing the long-run relationship betweenCO_2 emissions, gross domestic product (GDP) and control of corruption for 25 Asian emerging and developing countries in the period from 1998 to 2014. In order to do so, we apply recently developed second generation panel data cointegration methods that account for a number of estimation problems such as unobserved heterogeneity, cross-sectional dependence and endogenous regressors. Thereby, we are able to provide state-of-the-art research results that account for several limitations in previous studies. Furthermore, by focusing on Asian emerging and developing countries we aim to shed light on the importance of good institutional quality for a sustainable growth path in one of the fastest growing regions in the world.

The remained of this article consists of three sections. Section 2 describes the data and the specification of the EKC model. Section 3 presents the econometric analysis and the result. Section 4 concludes with a discussion of policy implications and suggestions for further research.

2. Empirical model and data

The aim of this specific study is to investigate the link between Co_2 emission, real GDP per capita, GDP^2 and corruption in the context of Environmental Kuznets Curve (EKC) hypothesis for the case of 25 selected Asian developing economies[3]. To describe the EKC hypothesis and long run relationship between the relevant variables, the study use following model:

$$LnCO_{2it} = \beta_1 + \beta_2 \ln Corr_{it} + \beta_3 \ln GDP_{it} + \beta_4 GDP^2_{it} + \varepsilon_i \qquad (1)$$

Where, i represents the cross sections of 25 countries and t denote the annual time series. CO_2 is carbon dioxide (CO_2) emissions measured in metric tons per capita; Corr is denoting the index of control of corruption[4]. GDP is representing per capita real GDP measured in constant 2010 US Dollars and is also a measure of economic growth, GDP^2 is square term of per capita real GDP to measure the validity of EKC hypothesis and. Ɛ is white noise error term. β_1, β_2, β_3 and β_4 are representing the long run elasticity of carbon dioxide (CO_2) emissions with respect to corruption, per capita real GDP and square of per capita real GDP. The coefficient value and signs of β_3 and β_4 will determine the shape of Environmental Kuznets Curve (EKC). If the $\beta_3 = \beta_4 = 0$ it means there is no relationship between per capita GDP and emissions. If $\beta_3 > 0$ and $\beta_4 = 0$ or $\beta_3 < 0$ and $\beta_4 = 0$ it is monotonically increasing and decreasing relationship between dependent and independent variables. But according to the EKC hypothesis, the expected signs are $\beta_3 > 0$ (implies that increase in GDP per capita will cause increase in carbon dioxide emissions) or $\beta_4 < 0$ (indicating after certain point of level increase in GDP per capita will cause decrease in carbon dioxide emissions). The positive sign of β_3 and negative sign of β_4 are supporting an inverted U- shaped EKC. The positive sign of β_2 and negative sign of β_3 are supporting an inverted U- shaped EKC.

To estimate the model annual time series data collected from World development indicators (WDI) and Worldwide Governance indicators (WGI)[5] over the time period of 1998 to 2014. Asian countries are selected on the basis of data availability on all variables. List of Asian Developing countries was retrieved from World Economic Outlook Database 2017. The study is using balanced Panel[6] of 25 countries for empirical analysis. Co_2 emission is considered as dependent variable to measure the environmental degradation. GDP, GDP^2 and corruption are explanatory variables. The Control of Corruption is taken as proxy of institutions (Abid, 2017).

[3] In a panel framework, the study follows the similar methodological approach used by Apergis & Payne, 2009; Lean & Smyth, 2010 and Al-Mulali et al., 2015.

[4] Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests

[5] Data is retrieved from online database 2017

[6] Baltagi (2013) suggested that panel data has advantage over cross-section data and time series, because there is less multicollineriaty among variables.

All variables are in log form except control of corruption. Total numbers of observation are 425 for each variable series in all 25 cross sections[7]. The data description is in Table 1.

Table 1: Summary statistics

Variables	Unit of Measurement	Mean	SD	Min.	Max.
CO_2 emissions	metric tons per capita	2.15	3.77	0.098	24.61
Control of Corruption	index	-0.39	0.56	-1.67	1.28
Real GDP per capita	constant 2010 US$ per capita	3697.97	6798.1	281.73	37401.05

*Data source of Co2 Emissions and Real GDP per capita is World Development Indicators (WDI). Data source of Control of corruption is Worldwide Governance Indicators (WGI) Database (last updated 14 December 2017). Total numbers of observations are 425.

According to the country wise data description, Brunei Darussalam is emitting 24.61 metric tons per capita CO_2 which is highest emission in the panel of 25 developing and emerging Asian countries and also having highest per capita GDP by 37401.05 US$ among the panel. Nepal is lowest emitter of CO_2 by emitting 0.098 metric tons per capita CO_2. The index of control of corruption is highest in Bhutan. Myanmar is having lowest per capita GDP by 281.73 US$ and having lowest index of control of corruption among the panel considering for empirical analysis.

3. Econometric analysis and results

The main purpose of our empirical analysis is to estimate the dynamic and causal relationship between CO2 emissions, economic growth and corruption in the context of Environmental Kuznets curve (EKC) for 25 selected Asian developing countries. The analysis procedure is consisting of many steps like cross section dependence CD test, Panel unit root test, Panel cointegration test, Fully Modified OLS (FMOLS) and VECM granger causality.

3.1 Cross- Section Dependence Test

Moscone and Tosetti (2009) defined the cross section dependence as the simultaneous correlation among countries in the panel exist when individual characteristics are controlled. Pesearn (2004) proposed a cross-section dependence (CD) test, it is applicable for both stationary and unit root dynamic panels with small time dimension and large cross section under a different panel data methods. The CD test depends on an average of pairwise correlation estimates of Ordinary Least Square (OLS) residuals from individual regressions in panel. For large cross sections the CD test statistics are standard normally distributed. The null hypothesis of this test is no cross-section dependence across panel. Baltagi (2013) revealed the test is robust in the existence of non-stationary process, structural breaks, and heterogeneity of parameter and valid in small sample size.

[7] The index of control of corruption is having 50 missing values across all cross sections. Each cross section have missing values in the start of series, over the time period from 1998-2000. To approximate these missing values we uses mean substitution method remove the problem of missing data and made balance panel. As control of corruption index is stable over the time so means substitution for two missing value is useful

Table 2 display the results of cross-section dependence for each variable in the model, also shows the average absolute correlation estimates for each country in the panel. According to the p-values, null of no cross-section dependence is rejecting at 1% level. The average correlation is different across the variables; it varies from 0.387 to 0.777, high correlation in real GDP per capita. After finding the strong estimates of cross-sectional dependencies in the panel data, it is rational to apply a panel unit root test and a panel cointegration test. They both account for cross-sectional dependencies in the panel data (Sorge & Neumann, 2017).

Table 2: Results of Pesaran (2004) CD test

Variable in levels			
Variables	CD-test	p-Value	abs(corr)
CE	34.95	0.000***	0.536
CR	10.33	0.000***	0.387
G	42.13	0.000***	0.777
G^2	42.13	0.000***	0.777

***Level of significance at 1%.

3.2 Second Generation Panel Unit Root Test

Examining the stationary properties of the relevant variables is important step before conducting panel cointegration analysis. To check the stationary property of the data, several panel unit root test are available but every test have some statistical deficiency with respect to power of test and sample size Kasman & Duman (2015). The study use Pesaran (2007) unit root test (second generation). It indicated that in the presence of cross sectional dependencies the first generation panel unit root test have size distortions, due to this an over rejection of the null hypothesis can happen. So the study is using second generation panel unit root test to enhance the robustness of the results.

Pesaran (2007) introduce a second generation panel unit root test that is also based on ADF regressions and average of cross section on both, levels and first difference in individual series. it also corrects the cross- sectional dependence existing due to common factor. The null hypothesis is homogeneous for all cross sections as, each country or cross section in panel is having unit root. According to Baltagi (2013), this test has a sufficient size and power for small and large cross section units and time dimensions (Sorge & Neumann, 2017). As Pesaran (2004) CD test confirms the cross sectional dependence in data, rational to use this test is valid.

Table 3 present the results of the panel unit root tests for all variables of the model. Unit root problem is tested either with or without trend. According to CIPS test, all series are having unit root or non stationary at level with or without trend. After converting the series into first difference all become stationary. So that, the study found each variable is integrated of order one, I (1)[8].

Table 3: Results of panel unit root test		
Variables	**CIPS Test**	
	No Trend	Trend
LnCE	-0.444	0.563
CR	-2.170	-0.905
LnG	0.665	2.028
LnG^2	0.665	2.028
Δ LnCE	-9.713***	-8.126***
Δ CR	-9.120***	-5.791***
Δ LnG	-6.474***	-7.033***
Δ LnG^2	-6.474***	-7.033***

***Level of significance at 1%. ** Level of significance at 5%. * Level of significance at 10%.

3.3 Second Generation Panel Cointegration Test

Pesaran (2004) CD test revealed the cross section dependencies in the data and panel unit root testing has confirmed that all variables are integrated of same order, which allows to implement the cointegration tests. There are many cointegration test are available to examine the long run relationship among the variables. The study is applying bootstrap based Westerlund panel cointegration test, introduced by Westerlund in 2007. This test contains four basic panel cointegration tests (*Gt* , *Ga*, *Pt* ,*Pa*) without having limitation of common factor. The null hypothesis of no cointegration is testing with these four statistics. These four statistics can be divided into two groups. One is panel statistics, comprises of Pt and Pa, is based on pooling information of error correction with cross sectional dimension f panel data. Second group is group mean statistics *Gt* and *Ga*, not depending on pool information. These statistics are having same null hypothesis but different alternative hypothesis. For the panel statistics, rejection of null hypothesis means cointegration of the whole panel. For group mean statistics, rejection of null hypothesis means cointegration for at least one of cross section in the panel. The test is conducted by checking the significance of the error-correction term in a restricted panel error correction model. All the four tests are depends upon normal distribution. Moreover, Westerlund (2007) reported that, by passing through bootstrapping these four tests propose p-values that are robust against cross-sectional dependencies.

The Westerlund (2007) considers the following error-correction

[8] Estimates of unit root test is significant at 1% level.

$$\Delta y_{it} = \delta_i' d_t + \alpha_i (y_{i,t-1} - \beta_i' X_{i,t-1}) + \sum_{j=1}^{J_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{J_i} \gamma_{ij} \Delta X_{i,t-j} + \epsilon_{it},$$

Where i = 1….N denoting each cross section in panel and t = 1….T indicating time. d_t is representing the deterministic components, may be either fixed effects and linear time trend or fixed effects. X_{it} refers to aggregate of exogenous variable used in the model. To estimate the error correction term the weterlund (2007) considered the equation as:

$$\Delta y_{it} = \delta_i' d_t + \alpha_i y_{i,t-1} + \lambda_i' X_{i,t-1} + \sum_{j=1}^{J_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{J_i} \gamma_{ij} \Delta X_{i,t-j} + \epsilon_{it},$$

The parameter of α_i is indicating error correction or speed of adjustment term, meaning that in how much time the system converges back to long run equilibrium relationship after any sudden shock. The least square estimate of α_i is used to test the null hypothesis. Table 4 presenting the four error correction based panel cointegration tests with and without constant and trend. In first model apply without constant and trend, three out of four statistics is rejecting the null of no cointegration on conventional significance level. According to second model estimate with trend and constant, all four statistics are rejecting the null hypothesis of no cointegration. Westerlund (2007) suggested that in the presence of cross sectional dependence P_t and G_t tests have smallest size distortions. So, according to this background our results indicate that all variables are panel cointegrated. Results confirm the existence of long run relationship in the variables of panel of 25 emerging and developing Asian countries.

Table 4: Results of Panel Cointegration Test

Westerlund (2007) ECM panel cointegration tests					
Without Constant & Trend			**With Constant & Trend**		
Statistics	Z- value	Robust Prob.	statistics	value	Prob.
G_t	1.54	0.185	G_t	3.98	0.59*
G_a	5.13	0.823*	G_a	8.99	0.96*
P_t	2.55	0.003***	P_t	8.15	0.010***
P_a	2.86	0.802*	P_a	7.29	0.96*

Note: ***Level of significance at 1%. ** Level of significance at 5%. * Level of significance at 10%. Number of replications to obtain bootstrapped p- values is set to 400.

3.4 Fully Modified OLS (FMOLS) Method

After finding the cointegration in the model the study can employ the Fully Modified Least Square (FMOLS) approach rationally introduce by Pedroni (2001). This method is valid to estimate the, Environmental Kuznets curve (EKC) hypothesis based, long run coefficients of heterogeneous co-integrated panel[9]. Estimate of Ordinary Least Square (OLS) works ineffiently due to existence of unit root and cointegration in the model. The method of Vector auto regression (VAR) cannot solve the problem of endogenity in non-stationary series. But FMOLS method takes into account for endogenity arises due to presence of cointegration in explanatory variables. This technique is non- parametric and helps in the corrections of serial correlation between error term and explanatory variables at first difference[10]. It also provides efficient estimates in small size sample and in existence of endogenity and heterogeneity in large size sample[11].

The result estimates of Panel FMOLS are reported in table 5. It shows the long run elasticity of CO_2 emission per capita with respect to control of Corruption, real GDP per capita and squared real GDP per capita in Asian developing and emerging countries. Result shows the long run impact of control of corruption on CO2 emission per capita which suggests as index of control of corruption increases, carbon dioxide emissions will also increase in Asian developing and emerging countries. It also suggests the corruption has indirect affect on CO2 emissions via increasing GDP per capita. This finding is in line with Cole (2007) and Sekrafi & Sghaier (2016) who found indirect impact of corruption on environment. CO_2 emissions per capita is positively related to real GDP per capita and negatively related to square per capita real GDP. The long run elasticity of per capita CO_2 emissions with respect to real GDP per capita of Asian developing countries is 4.70 %. The long run elasticity of per capita CO_2 emissions with respect to squared real GDP per capita of Asian developing countries is -1.99 %. These results are supporting the existence of an inverted U-shaped EKC hypothesis. Results imply that initially an increase in per capita emissions levels with the increase of income and after certain level of income, it starts to decrease Asian developing economies. These findings are in line with Sekrafi & Sghaier (2016); Zhang et al., (2016); Apergis and Payen (2009, 2010). The coefficients of all variables are significant at 1% level.

The finding of inverted U-shape EKC is seemed to be consistent with circumstances in Asian developing and emerging countries with respect to CO_2 emissions and GDP. Panel of Asian countries, analyzed in the study, is including the China and India. Both countries have significant share in emissions and their economic scales are on increasing patterns (emerging phase). Which are not seems to be change in short- run. Emission per capita is likely to increase with the increase in development of country. Corruption is crucial issue of developing economies. Corruption is stimulating the inefficient environmental regulations and governance in

[9] Apergis, N. & Payne, J., E. (2010); ; Hamit-Haggar, M. (2012)
[10] Maeso-Fernandez, F., et al (2006)
[11] Shahbaz et al., (2015)

developing countries. It can affect the environment in two ways. Direct way is by environmental regulations or indirect way is by affecting the economic growth.

Table 5: Results of FMOLS			
Variables	**Coeffients**	**t- statistics**	**Prob.**
Corr	0.0689	13.024	0.0000***
LnGDP	4.7045	984.786	0.0000***
$LnGDP^2$	-1.9957	-93.561	0.0000***

Note: $LnCE_2$ is dependent variable. ***Level of significance at 1%. ** Level of significance at 5%. * Level of significance at 10%.

3.5 VECM Granger Causality

After confirming the long run relationship among carbon dioxide (CO_2) emissions per capita, economic growth and Corruption, further this study is apply granger causality test to have a clear idea of causation for policy makers. According to the panel unit root results all variables are integrated of the same order and cointegration among all variables is also confirmed. In this scenario the vector error correction model (VECM) is appropriate model. VECM granger causality test is used to find out the long run and short run causality between specified variables. In 1987 Engle and Granger have proposed a two step technique to measure the causality. The error correction model can be described as:

$$\Delta CO_{2it} = \delta_{1j} + \sum^{L}_{k=1} \Phi_{1ik}\,\Delta CO_{2it-k} + \sum^{L}_{k=1} \partial_{1ik}\,\Delta Corr_{it-k} + \sum^{L}_{k=1} \Psi_{1ik}\,\Delta GDP_{it-k} + \sum^{L}_{k=1} \Pi_{1ik}\,\Delta GDP^2_{it-k} + ή_{1i} ECM_{it-1} + \varepsilon_{1it} \quad (5)$$

$$\Delta Corr_{it} = \delta_{2j} + \sum^{L}_{k=1} \Phi_{2ik}\,\Delta CO_{2t-k} + \sum^{L}_{k=1} \partial_{2ik}\,\Delta Corr_{t-k} + \sum^{L}_{k=1} \Psi_{2ik}\,\Delta GDP_{it-k} + \sum^{L}_{k=1} \Pi_{2ik}\,\Delta GDP^2_{it-k} + ή_{2i} ECM_{it-1} + \varepsilon_{2it} \quad (6)$$

$$\Delta GDP_{it} = \delta_{3j} + \sum^{L}_{k=1} \Phi_{3ik}\,\Delta CO_{2it-k} + \sum^{L}_{k=1} \partial_{3ik}\,\Delta Corr_{it-k} + \sum^{L}_{k=1} \Psi_{3ik}\,\Delta GDP_{it-k} + \sum^{L}_{k=1} \Pi_{3ik}\,\Delta GDP^2_{it-k} + ή_{3i} ECM_{it-1} + \varepsilon_{3it} \quad (7)$$

$$\Delta GDP^2_{it} = \delta_{4j} + \sum^{L}_{k=1} \Phi_{4ik}\,\Delta CO_{2it-k} + \sum^{L}_{k=1} \partial_{4ik}\,\Delta Corr_{it-k} + \sum^{L}_{k=1} \Psi_{4ik}\,\Delta GDP_{it-k} + \sum^{L}_{k=1} \Pi_{4ik}\,\Delta GDP^2_{it-k} + ή_{4i} ECM_{it-1} + \varepsilon_{4it} \quad (8)$$

Where L is the lag length of the variables in differenced form, lag length is estimated by the Engel- Granger approach. The error correction term in equation 5, 6, and 7 can be estimated by developing the long run relationship in equation (2). Estimated Residuals derived from that model which is called error correction term (ECT) given as,

$$ECT_{it} = \ln CO_{2it} - \Omega_1 - \delta_i t - \partial_2\, Corr_{it} - \Psi_3 \ln GDP_{it} - \Pi_4 \ln GDP^2_{it} \quad (9)$$

Lag of error correction term and all other variable is used in further model to estimate the long run model

$$ECT_{t-1} = \ln CO_{2t-1} - \partial_2\, Corr_{t-1} - \Psi_3 \ln GDP_{t-1} - \Pi_4 \ln GDP^2_{t-1} \quad (10)$$

Value of ECT_{t-1} is interpreted as speed of adjustment toward the long run cointegration relationship and Ω_1, Ω_2 and Ω_3 represent the short run causality or adjustment (Sorge & Neumann, 2017).

The conditions of short- run causal relationship, if the null hypothesis $\partial_{1ik} = 0$ is rejected, *it* indicating that causality is running from $\Delta Corr$ to ΔCO_2. If the null hypothesis $\Phi_{1ik} = 0$ is rejected than there is causality running from ΔCO_2 to $\Delta Corr$. If the null hypothesis $\Psi_{1ik} = 0$ and $\Pi_{1ik} = 0$ is rejected, it supporting that granger causality running from ΔGDP and ΔGDP^2 to ΔCO_2. If the null hypothesis $\Psi_{2ik} = 0$ and $\Pi_{2ik} = 0$ is rejected, it supporting that granger causality running from ΔGDP and ΔGdp^2 to $\Delta Corr$. If $\Phi_{1ik} = 0$, $\Phi_{2ik} = 0$ or $\Phi_{3ik} = 0$ it showing causality is running from ΔCO_2 to $\Delta Corr$, ΔGDP and ΔGDP^2 respectively. All these short run tests can be conducted by using Wald test. This test is also used for long run hypothesis e.g. $\delta_{1j} = 0$, $\delta_{2j} = 0$ and $\delta_{3j} = \delta_{4j} = 0$. Rejection of these hypotheses is in favor of long run causality.

Table 6 reports the results of panel granger causality for both short run[12] and long run[13]. According to the results estimates there is short run unidirectional causality running from control of corruption to carbon dioxide (CO_2) emissions. It means that increase in control of corruption will leads to increase in CO_2 emissions in Asian developing and emerging countries. There is also short run unidirectional causality from economic growth to control of corruption. Coefficient of ECT in the corruption equation is statistically significant, it suggesting that control of corruption is important adjustment factor as the system departs from long run equilibrium. It also indicates unidirectional granger causality relationship.

Table 6: Panel Causality Test for 25 Asian Countries, 1998-2014

Dependent Variable	Source of Causation/ independent variables				
	short run				long run
	$LnCO_2$	LnGDP	$LnGDP_2$	Corr	ECT
$LnCO_2$	-----	1.21 (0.545)	1.181(0.553)	6.52(0.038)***	6.000007 (0.8)
LnCorr	1.90(0.38)	8.56(0.013)***	8.53(0.014)***	-----	-0.0017(0.070)*
LnGDP	1.12(0.56)	-----	-----	2.78 (0.24)	-0.00011(0.28)
$LnGDP^2$	1.09(0.57)	-----	-----	2.92(0.23)	-0.00017(0.39)

Note: For short run values of Wald chi-square test are reported, p-values are in brackets. For long run t-statistics are reported. ** represent the 5% significance level. * represent the 10% significance level.

4. Conclusion

Since 1990 these emissions are on increasing patterns due to population and economic growth in Asian developing and emerging countries. These Countries are fighting with economic, social and ecological challenges due to lack of energy recourses, food and water insecurity to climate change and pollution. Developing countries are more vulnerable to climate change conditions and more likely to relay on the exploitation of natural resources to attain economic growth. Less develop countries are pathway to attain the green growth globally. So, the impact of institutional and economic activities in context of environmental degradation is important for these countries. Thus, to understand the effect and causal patterns of corruption-growth-

[12] Short run Causality estimates are significant at 1% level.
[13] Long run causality estimate is significant at 10% level.

emissions in Asian developing countries, the study conducted the empirical analysis between these variable.

This study examined the long run dynamic relationship, in the EKC hypothesis context, between carbon dioxide (CO2) emissions, corruption and economic growth in the panel of 25 selected Asian developing and emerging countries over the period 1998- 2014. To conduct an empirical analysis the study used Pesaran (2004) CD test to check the cross- sectional dependencies and second generation panel unit root test. Westerlund (2007) panel cointegration tests are employed to test long-run cointegration relationships. Fully Modified Least Square (FMOLS) is applied to test EKC hypothesis and Vector Error Correction Model (VECM) is used to identify short and long run causalities.

Pesaran (2004) CD test confirmed the cross sectional dependence in the panel data. In the existence of cross sectional dependence, use of second generation Pesaran (2007) unit root test is rational. Results of this test showed that all variables are integrating on same order. Westerlund (2007) panel cointegration test indicated long- run cointegrated relationship among the model variables. Empirical findings supports the evidence of inverted U-shaped EKC curve between carbon dioxide (CO_2) emissions and economic growth. The study found short run unidirectional causality running from control of corruption to carbon dioxide (CO_2) emissions. It means that increase in control of corruption will leads to increase in CO_2 emissions in Asian developing and emerging countries. Results indicate indirect impact of corruption on CO2 emissions via real GDP growth. There is also short run unidirectional causality from economic growth to control of corruption. Long run causality suggesting that control of corruption is important adjustment factor as the system departs from long run equilibrium.

The contribution of the study into scarce panel based literature by using corruption as an explanatory regressor to test its impact on CO2 emissions within Asian developing and emerging countries. The study has incorporating cross sectional dependence in the panel analysis and used second generation unit root test and second generation cointegration test.

As the study found empirical evidence of inverted U- shape EKC, it highlights many important policy recommendations. The implementation of stronger environmental regulations to prevent the future environmental degradation accompanied with economic growth at early stage of development. There should be some policies in favor of sustainable economic growth which improve the environmental quality with respect to CO_2 emissions. Effective environmental policies and regulation implementations can decrease the environmental cost of economic growth. The quality of policies, implementation and quality of institution can accelerate the process to make clean environment and reduce emissions in Asian developing and emerging countries.

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