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INSTITUTIONAL GOVERNANCE AND CLIMATE CHANGE NEXUS: A Panel Data Analysis

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Abstract

This study presents the insightful and comprehensive empirical evidence on the impact of income and institutional governance on climate change based on panel data of 203 countries for time series of 1996 to 2017. We have divided the countries into sub-samples of 34 low-income, 101 middle-income and 68 high-income countries by following the World Bank country classification. Econometric analysis is carried out by employing the fixed-effect model in order to incorporate the unobserved heterogeneity among countries, and instrumental variable technique generalised method of moments is applied to tackle the issue of endogeneity. The major contribution of this study involves providing the new empirical evidence on the non-linear impact of institutional governance on CO_2 emissions (a proxy of climate change) and conditional impact of income and institutional governance on these emissions. Findings of the present study indicate that there is a robust inverted-U shape relationship between institutional governance and CO_2 emissions in all income groups of countries. We have termed this curve as Environmental Governance Curve (EGC).

Keywords: Climate Change, Institutional Governance, CO_2, Environmental Governance Curve, Fixed Effect.
JEL Classification: B52, C23, Q50, Q56.

I. Introduction

The objective of an economic and social policy is to achieve economic growth and development accompanied with low poverty, inequality, stable prices, good health and education standards. Hence, it is a matter of great concern about how an economy can achieve high growth and development. Enormous literature discusses the determinants of growth and development, for instance [Solow (1956), Lucas (1988), Romer

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(1989), Acemoglu and Robinson (2001), Siddique, et al. (2016), Khan and Khan (2018)]. Till the 1980s, development economists have been emphasising on sustainable and inclusive growth, reducing poverty and inequality [Anand, et al. (2013)]. However, since last three decades, there is a major focus on environment-friendly growth which can promote green global economy [Grossman and Krueger (1995), Beckerman (1992), Soytas and Sari (2006)].

In the current era of the industrial boom, greenhouse gas emissions are continuously damaging the ozone layer, which is resulting in a rise in the average temperature of the earth. Weather variability and severity is causing uncertainty for the agriculture sector, as highlighted by Nelson, et al. (2009). Climate change and resulting issues of food security, health, poverty, and employment are directly linked with the process of development. So, whether every country is in a position to tackle climate change is the question of grave concern. Developing countries have no financial and institutional strengths to pursue strong policies. However, the global issue of climate change can be tackled with collective action by all the countries.

Sea Level Rise (SLR) will cause severe economic and ecological damage, and tens of millions of people may displace in developing countries within this century. Under the scenario of one per cent SLR, approximately 0.3 per cent (194,000 km square) of the territory and 56 million people of 84 developing countries would be impacted. Similarly, Sergienko (2008) argued that addressing global warming effectively requires generating more power from environmentally friendly resources; solar and wind power and kinetic, wave and tidal hydroelectric power. Without rules defining who owns these resources and expectations, they may lawfully have with regard to permitted and prohibited use, the wide-spread expansion and implementation of environmentally friendly technologies will be severely handicapped. The growing environmental concern has led the researchers to go beyond the testing of conventional EKC hypothesis, such as Halkos and Tzeremes (2013) examined that whether increasing the quality of various governance indicators lead to lower CO_2 emissions?

Above discussion indicates that sustainable growth and development largely depends upon the global environment. This direction of research is the motivation of this study. The present study has analysed the impact of institutional governance on and climate change. Institutional governance index is constructed by taking the average of control over corruption, the rule of law, regulatory quality, voice and accountability, government effectiveness, and political stability and absence of violence. In contrast, CO_2 emissions per capita[1] have been used as a proxy of climate change [Rehman, et al. (2012), Cole and Elliott (2003)].

There are large numbers of studies which examine the EKC hypothesis. But, there is limited literature on the impact of institutions and governance on pollution/climate change. Most of the work on institutional governance and climate change lacks the

[1] According to IPCC (2007) CO2 emissions are considered as primary source of global warming.

comprehensive empirical insights, though provides very useful theoretical framework, for instance [Bulkeley and Betsill (2005), Granberg and Elander (2007)]. This study complements the literature in three ways; first providing the conditional impact of institutional governance and Gross Domestic Product (GDP) on CO_2 emissions. Second, the empirical analysis takes into account the income levels of sample countries, since countries with different levels of income are expected to behave differently, Halkos and Tzeremes (2013). Third, this study tests whether there is an inverted U-shape relationship between institutional governance and CO_2 emissions, and we have termed it an Environmental Governance Curve (EGC). The rationale behind testing this non-linearity is that institutions are driving force of GDP. Hence, at the initial stage of institutional evolution, pollution is expected to increase and decline upon attaining threshold level of institutional quality.

Furthermore, Griffiths, et al. (2007) argued that institutional governance systems influence the ability of public policies and private sector to transform the doing of business in order to curb climate change. An empirical investigation of the above relationships is conducted by employing a fixed effect, system Generalised Method of Moments (GMM). These techniques are selected to take into account the unobserved heterogeneity across the countries and endogeneity, respectively. This is the first study which has used the comprehensive and most recent dataset of 203 countries for the period of 1996 to 2017. We have also divided the countries into sub-samples of 34 low-income, 101 middle-income and 68 high-income countries by following the World Bank country classification. List of countries is given in Appendix A.

After giving the brief introduction in Section I, Section II consists of a review of literature, Section III deals with the theoretical framework of the study while, Section IV presents the data and econometric methodology, Section V contains empirical results in detail, and Section VI gives conclusion and policy Implications.

II. Literature Review

The literature review gives insights to institutions, climate change and economic growth, such as how institutions affect economic growth, climate change and how does climate change, in turn, determine the growth pattern of an economy [Catrinescu, et al. (2009), Siddique, et al. (2016), Fankhauser and Tol (2005), Meadows, et al. (1992)]. According to Greif (2006), institutions are indispensable for an economy and regulate social behaviour as a system which includes rules, customs and traditions. Empirically the role of institutions is explored by Acemoglu, et al. (2001). This study investigates the impact of institutions on comparative development of economies using the average data of 1985 to 1995 for 64 countries that had been colonies in the past. It was found that there is a strong positive impact of institutions on GDP per capita.

Baliamoune (2011) empirically examined the relationship between social capital, institutions and economic development, employing Arellano-Bond GMM estimator and Fixed Effect Model. He has shown that social capital and institutions positively affect the income of countries, and social capital has a positive effect on the effectiveness of human capital. Likewise, Hall, et al. (2010) conducted the study to examine the relationship between institutions, capital and economic growth. Purpose of the study was to investigate whether an increase in human and physical capital foster economic growth in the presence of good institutions and hamper economic growth in the presence of bad institutions? The empirical analysis is based on 98 countries for time period of 1980-2000. Findings point out that when the risk of expropriation is 4.90, increase in human and physical capital leads to a fall in economic growth. When the risk of expropriation is between 4.90 and 7.33, increase in physical capital leads to an increase in economic growth, but schooling has a negative effect on economic growth. Countries, where the risk is above of 7.33, an increase in human capital and physical capital lead to an increase in economic growth.

Sergienko (2008) argued that global warming effectively requires generating more power from environmentally friendly resources. The rules and institutions help to implement environmentally responsible technologies. Similarly, Wang, et al. (2012) evaluated the relationship between energy technology patents and carbon dioxide emissions for 30 provinces in China for 1997-2008. The Findings of the study show that patents for fossil-fuelled technologies have no significant impact on CO_2 emissions, while patents for carbon-free technologies leads to a reduction of in CO_2 emissions. Similar findings by Lau, et al. (2014) while exploring the long-run relationship among CO_2 emissions, institutions, exports and economic growth in Malaysia. The empirical results of the study found the existence of the long-run relationship between institutional quality, CO_2 emissions and economic growth.

On the other hand, Halkos and Tzeremes (2013) exposed that there are significant differences in emissions-governance nexus between countries. The differences are due to countries regional and developmental variations. Finally, it is concluded that increasing the quality of various governance indicators does not always lead to lower CO_2 emissions. Similar findings by Midlarsky (1998) pointed out that democracies cause environmental degradation, as the leader's objective function is to get maximum votes, so they do not take action against business interest groups which cause pollution. Similar results were found by [Paehlke (1996), You, et al. (2015)].

The literature gives inconclusive evidence on the relationship between institutions and climate change. Some studies show that institutions can curb environmental degradation, whereas some studies concludes that institutions cause environmental degradation. Most of the studies on the relationship between CO_2 emissions and income support the EKC hypothesis. However, there is also evidence in the literature that there exists a trade-off between CO_2 emissions and income level of countries. Keeping in view the above strand of evidence, the present study focuses on exploring the relationship between institutional governance and climate change in a more comprehensive way, as discussed in the previous section.

III. Theoretical Framework

To find the impact of institutional governance on climate change, we have developed four models. The basic EKC model has been amended by using the level and square term of institutional governance index to analyse the impact of institutions on CO_2 emissions. The idea of EKC can be shown by the Beckerman's view that: 'There is clear evidence that, although economic growth usually leads to environmental deterioration in the early stages of the process, in the end, the best and probably the only way to attain a decent environment in most countries is to become rich' Beckerman (1992).

Panayotou (2003) argued that in the early stage of development, environmental degradation is increased. Still, when the economy attains a certain level of growth, environmental quality is improved through services and technological improvements. Many other studies examined that there is a significant impact of technological progress and structural changes on CO_2 emissions [Kander (2005), Lantz and Feng (2006)].

According to Panayotou (1997), government policy is one of the major factors which affect environmental quality. Suri and Chapman (1998) argued that international trade might be the factor which causes EKC pattern. Dinda, et al. (2000) found that technical progress and structural changes are driving forces of EKC pattern. Furthermore, Tamazian and Rao (2010) considered the institutional quality as part of the solution to environmental degradation. Moreover, this study suggests that Foreign Direct Investment (FDI) and trade openness also play a crucial role in determining the level of environmental degradation. Since inward investment and trade flows can bring environmentally hazardous production, the converse is also expected in a way that countries having more liberal policies can have access to environment-friendly investment and technology. Trade affects the pollution emissions in three ways, such as scale effect; technique effect and composition effect [Antweiler, et al. (2001), Grether, et al. (2007)]. Scale effect means trade openness promotes economic growth as a result of an increase in exports, which leads to an increase in pollution. Technique effect explains that country can import environment-friendly technology which causes pollution to fall. Change in the industrial structure of the economy is termed as composition effect.

1. Institutional Governance and CO_2 Emissions

Anderson (1992) found that there exists a trade-off between economic growth and the quality of the environment. However, some other researchers found that effective policies of government can moderate this trade-off. Institutions affect CO_2 emissions through both direct and indirect channels. Direct channel entails the fact that poor quality of institutions may result in delays in the implementation of environmentally friendly policies and good quality institutions may take effective and collective steps with the global community. On the other hand, institutions can indirectly affect the level of emissions by promoting economic growth which improves the institutional quality and consequently, emissions may fall. race-to-the-bottom hypothesis posits that trade leads to expansion of production scales and hence the emissions, and in countries with weak environmental regulations, production shifts towards pollution-intensive products. Institutional governance, such as control over corruption, regulatory quality set the stage for initiating climate-friendly policies, hence the countries with poor quality governance face hurdles in joining hand with the global community in this regard. Developing countries with long-standing current account deficits, strive to improve their position. Hence they face public and political constraints regarding the implementation of environmentally friendly policies. In light of the above discussion, we can derive that institutional governance plays a vital role in determining the policy agenda and actions regarding climate change. This study tests whether there is an inverted U-shape relationship between institutional governance and CO_2 emissions, and we have termed it an Environmental Governance Curve (EGC). The rationale behind testing this non-linearity is that institutions are driving force of GDP. Hence, at the initial stage of institutional evolution, pollution is expected to increase and decline upon attaining threshold level of institutional quality.

IV. Data and Econometric Methodology

1. Data Sources and Description

This study aims to examine the impact of institutional governance on climate change. The empirical analysis is conducted for 203 countries selected on the basis of income levels classified by the World Bank. Time series of 1996 to 2017 has been selected from World Governance Indicators (WGI) 2018. The data on CO_2 emissions (metric tons per capita), real GDP per capita (in constant US$) Population growth (per cent), Foreign Direct Investment (net inflows per cent of GDP) trade openness (per cent of GDP) and energy consumption (kg of oil equivalent per capita) is taken from WDI (2018). To capture the overall aspects and quality of institutional governance, we have developed an index of institutional governance by taking simple average of six institutional governance indicators, control over corruption, regulatory quality; rule of law; government effectiveness; voice and accountability; and political stability and absence of violence. Each governance indicator has a range of 0 to 100, where 0 means the lowest rank of governance quality and 100 indicates the highest rank.

2. Description Summary of Data

Summary statistics of the variables included in the model is given in Table 1, Table 2, Table 3 and Table 4, which depicts the mean, median, standard deviation, maximum and minimum values for the full sample, 34 low-income, 101 middle-income and 68 high-income countries, respectively.

TABLE 1

Summary Statistics (Full Sample)

	GDC	GOV	CO	EC	PG	TO	FDI
Mean	14555.30	51.517	5.426	2367.496	1.389	89.475	5.812
Median	5770.970	48.052	3.656	1413.496	1.229	79.441	3.029
Maximum	111968.3	99.757	63.354	21959.44	16.332	442.620	451.71
Minimum	209.862	1.182	0.017	9.585	-9.081	0.167	-58.323
Std. Dev.	18954.35	26.773	6.614	2751.553	1.623	54.684	18.250

Source: Authors' estimation.

TABLE 2

Summary Statistics (Low-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
Mean	639.749	25.023	0.266	347.179	2.503	71.206	3.657
Median	570.753	23.375	0.207	353.994	2.669	61.869	2.035
Maximum	1505.601	53.756	1.302	850.801	3.843	175.351	41.809
Minimum	209.862	1.182	0.017	56.929	0.845	23.981	-1.304
Std. Dev.	283.053	14.099	0.224	157.951	0.726	31.767	5.728

Source: Authors' estimation.

TABLE 3

Summary Statistics (Middle-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
Mean	4136.923	37.105	2.901	1169.943	1.352	80.746	4.389
Median	3397.41	36.383	1.835	788.064	1.375	77.974	3.113
Maximum	18075.18	81.65	15.646	5167.012	7.786	220.407	55.07
Minimum	346.775	2.109	0.143	9.585	-9.081	0.167	-8.589
Std. Dev.	2995.147	17.299	2.852	962.691	1.209	34.273	5.184

Source: Authors' estimation.

TABLE 4

Summary Statistics (High-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
Mean	33245.86	79.198	10.413	4623.959	1.164	107.912	8.433
Median	31321.89	81.747	8.169	3682.19	0.661	87.317	3.327
Maximum	111968.3	99.756	63.354	21959.44	16.332	442.62	451.71
Minimum	4880.648	35.399	1.383	758.645	-2.258	18.525	-58.323
Std. Dev.	20102.02	14.534	8.112	3309.105	2.125	75.068	29.063

Source: Authors' estimation.

Note: GDC stands for GDP per capita, GOV shows institutional governance index, CO stands for CO_2 emissions, FDI is Foreign Direct Investment, EC represents energy consumption, PG stands for population growth rate and TO is Trade Openness.

Some interesting facts are depicted in terms of mean values and maximum and minimum values and standard deviations of the variables. Table 1 shows the results of the full sample. The standard deviation of GDP per capita is US$ 18954.35, which is a huge deviation from the mean value in sample countries. Similarly, governance also shows large differences which can be seen by the standard deviation. The maximum value of CO_2 emissions is 63.35 metric tons per capita, whereas minimum value is 0.017 with the standard deviation of 6.614 metric tons per capita. These statistics show that there are huge differences among countries in terms of national income, governance, CO_2 emissions and other key indicators. In low-income countries (Table 2), a very low standard deviation in GDP per capita, institutional governance index and CO_2 emissions as compared to findings from the full sample. On the other hand, middle-income (Table 3) and high-income countries (Table 4) show higher mean and standard deviation values than that of low-income countries.

3. Correlation Analysis

Correlation analysis[2] for full and sub-samples are given in Table 5 through 8. These correlation coefficients depict the linear association between the variables. Table 5 shows the results of the full sample based on 203 countries. The coefficient between GDP per capita and institutional governance index is 0.803 with the probability of 0.00, which indicates the rejection of the null hypothesis of no correlation between these two variables. Similarly, GDP per capita is also highly associated with CO_2 emissions.

Furthermore, institutional governance also has a strong and positive correlation with CO_2 emissions in the full sample. These results indicate that both GDP per capita and institutional governance are significantly and positively related to CO_2 emissions. In Table 6, correlation analysis of low-income countries is given. Interestingly in low-income countries, institutional governance has no significant linear association with the GDP per capita and CO_2 emissions. Table 7 shows the results of middle-income countries. The correlation of GDP per capita and institutional governance indicates positive and significant association. But the coefficient is smaller than that of full sample countries.

Similarly, institutional governance also is positively related with CO_2 emissions. However, the magnitude of the coefficient is smaller than that of full sample countries. Finally, Table 8 gives the results of high-income countries. GDP per capita and CO_2 emissions are significantly and positively related. A similar association can be observed for institutional governance and GDP per capita. However, the coefficient of institutional governance and CO_2 emissions is positive but insignificant. Results from each sample indicate entirely different correlation coefficients, which encourage the researchers to investigate the above relationships deeply. Hence, in order to draw more relevant conclusions, this study presents the separate and detailed empirical analysis to examine the linkages among institutional governance, GDP per capita and CO_2 emissions.

[2] Note: In Table 5-8, probabilities are given below the respective correlation coefficients.

TABLE 5

Spearman Rank-Order Correlation (Full Sample)

	GDC	GOV	CO	EC	PG	TO	FDI
GDC	1.000						

GOV	0.803	1.000					
	0.000	------					
CO	0.868	0.621	1.000				
	0.000	0.000	-----				
EC	0.889	0.647	0.959	1.000			
	0.000	0.000	0.000	-----			
PG	-0.349	-0.399	-0.357	-0.366	1.000		
	0.000	0.000	0.000	0.000	-----		
TO	0.206	0.236	0.238	0.227	-0.107	1.000	
	0.000	0.000	0.000	0.000	0.000	-----	
FDI	0.085	0.168	0.083	0.079	-0.089	0.419	1.000
	0.000	0.000	0.000	0.000	0.000	0.000	-----

Source: Authors' estimation.

TABLE 6

Spearman Rank-Order Correlation (Low-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
GDC	1.000						

GOV	0.174	1.000					
	0.013	-----					
CO	0.816	0.093	1.000				
	0.000	0.188	-----				
EC	0.119	-0.019	0.281	1.000			
	0.091	0.778	0.000	-----			
PG	-0.374	0.379	-0.408	-0.211	1.000		
	0.000	0.000	0.000	0.003	-----		
TO	-0.168	-0.365	0.159	0.188	0.079	1.000	
	0.017	0.000	0.024	0.007	0.261	-----	
FDI	-0.309	0.056	-0.165	0.110	0.429	0.402	1.000
	0.000	0.428	0.019	0.119	0.000	0.000	-----

Source: Authors' estimation.

TABLE 7

Spearman Rank-Order Correlation (Middle-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
GDC	1.000						

GOV	0.383	1.000					
	0.000	-----					
CO	0.716	0.182	1.000				
	0.000	0.000	-----				
EC	0.716	0.129	0.934	1.000			
	0.000	0.000	0.000	-----			
PG	-0.219	-0.284	-0.394	-0.369	1.000		
	0.000	0.000	0.000	0.000	-----		
TO	0.065	0.213	0.153	0.133	-0.098	1.000	
	0.028	0.000	0.000	0.000	0.000	-----	
FDI	0.085	0.224	0.102	0.111	-0.164	0.378	1.000
	0.003	0.000	0.000	0.000	0.000	0.000	-----

Source: Authors' estimation.

TABLE 8

Spearman Rank-Order Correlation (High-Income Countries)

	GDC	GOV	CO	EC	PG	TO	FDI
GDC	1.000						

GOV	0.643	1.000					
	0.000	-----					
CO	0.499	0.054	1.000				
	0.000	0.129	-----				
EC	0.646	0.242	0.820	1.000			
	0.000	0.000	0.000	-----			
PG	0.305	-0.114	0.399	0.382	1.000		
	0.000	0.001	0.000	0.000	-----		
TO	-0.047	-0.031	0.047	0.027	0.071	1.000	
	0.188	0.389	0.189	0.446	0.047	-----	
FDI	-0.079	0.119	-0.098	-0.137	0.064	0.466	1.000
	0.027	0.000	0.006	0.000	0.073	0.000	-----

Source: Authors' estimation.

4. Econometric Methodology

This study aims to analyse the impact of institutional governance in the presence of control variable such as FDI, energy consumption, population growth, on CO_2 emissions for a panel of 203 countries. The separate empirical analysis is conducted for each sub-sample categorised on the basis of income levels, high-income countries; middle-income countries and low-income countries. We have employed fixed effect and random effect models to tackle with the unobserved heterogeneity among countries. However, in both fixed effect and random effects models, the lagged dependent variable is correlated with the error term. This problem pertains even if the assumption of no autocorrelation in the error term is fulfilled. Fixed effect model uses the fixed effect dummies of countries to capture the country-specific effects.

Moreover, it can also be used to find time effects in the panel. An alternative way of estimating the panel data is the random effect model or error component model. This model estimates an additional parameter of a time-variant dummy variable. One of the major differences between fixed effect and random effect model is that the intercept of the fixed-effect model gives a fixed effect time-invariant dummy of each cross-section unit. On the other hand, the random effect model gives the intercept, which consists of time-variant dummy variables. The intercept of the random effect model includes two components; unobservable stochastic part of the error term and the remaining part of the error term, these terms are normally distributed. While estimating these panel data models, we often have to make a choice between random effect and fixed-effect models. These models give different results if a number of cross-sectional units are greater than time series. Moreover, the random effect model gives biased estimates if the individual specific error term is correlated with the independent variables of the model. In this case, the fixed effect model is preferable. As far as the choice between the fixed and random effect models is concerned, this study will choose the fixed effect estimates. Since, when a random effect model is valid, the fixed effect estimator will still provide consistent estimates of the parameters, Johnston and DiNardo (1972). First equation incorporates the conditional impact of institutional governance in conventional EKC model, whereas the second equation is constructed to test the non-linearity between institutional governance and CO_2 emissions. Panel econometric specification based upon discussion given in section III is as follows, Equation (1) is constructed for estimating the EKC hypothesis, and Equation (2) is developed for estimating the non-linear relationship between institutional governance and CO_2 emissions:

$$CO_{2it} = \beta_1(TO)_{it} + \beta_2(PG)_{it} + \beta_3(EC)_{it} + \beta_4(GDC)_{it} + \beta_5(GDC)^2_{it} + \beta_6(GDC)_{it} \times (GOV)_{it} + \beta_7(FDI)_{it} + \varepsilon_{it} \quad (1)$$

$$CO_{2it} = \gamma_1(TO)_{it} + \gamma_2(PG)_{it} + \gamma_3(EC)_{it} + \gamma_4(GOV)_{it} + \gamma_5(GOV)^2_{it} + \gamma_6(GDC)_{it} \times (GOV)_{it} + \gamma_7(FDI)_{it} + \varepsilon_{it} \quad (2)$$

Where, CO_2 shows Carbon dioxide emission per capita in the country *i*, and at time *t*, PG is population growth in country *i*. At time *t*, EC stands for energy consumption in the country *i* and at time *t*, GDC is GDP per capita in the country *i* and at time *t*. We have scaled the GDP and CO_2 as the ratio of population to make the variables comparable. GOV is institutional governance index in the country *i* and at time *t*. In the first equation, $\varepsilon_{it} = \alpha i + \eta_{it}$ and in the second equation, $\varepsilon_{it} = \gamma_i + \eta_{it}$, where, α_i and γ_i are individual effects, and η_{it} is random error term which is assumed to be uncorrelated with explanatory variables.

This study also employs system GMM to control for endogeneity. Since a wide range of empirical evidence has shown that there exists a bi-causal relationship among institutions, GDP and CO_2 emissions. This fact entails the endogeneity of these explanatory variables which may create biasness in the estimates. Nickell (1981) pointed out that this technique gives consistent estimates since it addresses the endogeneity problems arising from the dynamic specification of the model. Meanwhile, the conventional panel models such as pooled ordinary least square (OLS) and least-square dummy variable estimators give biased estimates because of the presence of the lagged dependent variable as an explanatory variable. This technique takes additional instrumental variables from the orthogonal conditions existing between lagged values of explanatory variables. According to Arellano and Bond (1991), instruments used in the technique are two or more lagged values of explanatory variables. The validity of instruments is confirmed by the Hansen test, whereas serial correlation is tested by AR2 test.[3]

Panel data are well suitable for analysing the dynamic effects: i.e. GMM in our first order model:

$$\begin{aligned} CO_{2it} &= X'_{it}\beta + \gamma CO_{2it-1} + \alpha_i + \varepsilon_{it} \\ &= w'_{it}\delta + \alpha_i + \varepsilon_{it} \end{aligned} \tag{3}$$

Where, X'_{it} is a vector of control variables and w'_{it} includes the lagged dependent variable. Introducing the lagged dependent variable is for the sake of adding dynamics to the equation. The Equation (3) with the lagged dependent variable shows the entire history of the right-hand side variables. It is so that any influence of independent variables is conditioned on this history. Any effect of X'_{it} reflects the impact of new information. A general approach has been developed in various stages in the econometric literature. This approach relies on Instrumental Variables estimators, most recently by Arellano and Bond (1991), and Arellano and Bover (1995) on Generalised Method of Moment (GMM) estimators. Endogeneity is swept from the model by taking first differences:

$$CO_{2it} - CO_{2i,t-1} = \delta(CO_{2i,t-1} - CO_{2i,t-2}) + (X_{it} - X_{i,t-1})'\beta + (\varepsilon_{it} - \varepsilon_{i,t-1}) \tag{4}$$

[3] Null hypothesis of Hansen test: set of instruments are valid; Null hypothesis of AR2: No serial correlation.

If the time series is long enough, we can use lagged differences $(CO_{2i,t-2} - CO_{2i,t-3})$ or the lagged levels, $CO_{2i,t-2}$ and $CO_{2i,t-3}$ as one or two instrumental variables for $CO_{2i,t-1} - CO_{2i,t-2}$. The other variables can serve as their instruments. Hausman and Taylor formulation of the random effects model is extended by including lagged dependent variable:

$$\begin{aligned} CO_{2it} &= \gamma CO_{2i,t-1} + X'_{1it}\beta_1 + X'_{2it}\beta_2 + Z'_{1it}\alpha_1 + Z'_{2it}\alpha_2 + \varepsilon_{it} + u_i \\ &= \delta' w_{it} + \varepsilon_{it} + u_i \\ &= \delta' w_{it} + \eta_{it} \end{aligned} \tag{5}$$

Where,

$w_{it} = [CO_{2i,t-1} + X'_{1it} + X'_{2it} + Z'_{1i} + Z'_{2i}]'$ Moment conditions used to formulate Instrumental Variable are;

$$E[\begin{pmatrix} X_{1it} \\ X_{2it} \\ Z_{1i} \\ \bar{X}_{1i} \end{pmatrix}(\eta_{it} - \bar{\eta}\iota)] = E[\begin{pmatrix} X_{1it} \\ X_{2it} \\ Z_{1it} \\ \bar{X}_{1i} \end{pmatrix}(\varepsilon_{it} - \bar{\varepsilon}_i)] = 0$$

The above moment condition does not exploit all the information in the sample. Within the T observations in group *i*, the following fact has not been used:

$$E[\begin{pmatrix} X_{1it} \\ X_{2it} \\ Z_{1i} \\ \bar{X}_{1i} \end{pmatrix}(\eta_{is} - \bar{\eta}\iota)] = 0 \text{ for some } s \neq t.$$

Hence, disturbances at time t are uncorrelated with the variables at time t; these are also uncorrelated with the same variables at time *t-1*, *t-2* and possibly *t+1*, and so on. Considering the panel with two periods, we would have the following expression:

$$E[\begin{pmatrix} X_{1i1} \\ X_{2i1} \\ X_{1i2} \\ X_{2i2} \\ Z_{1i} \\ \bar{X}_{1i} \end{pmatrix}(\eta_{i1} - \bar{\eta}\iota)] = E[\begin{pmatrix} X_{1i1} \\ X_{2i1} \\ X_{1i2} \\ X_{2i2} \\ Z_{1i} \\ \bar{X}_{1i} \end{pmatrix}(\eta_{i2} - \bar{\eta}\iota)] = 0$$

V. Empirical Results and Discussion

This section presents the empirical results based on fixed effect (FE) model and GMM for the full sample, low-income, middle-income and high-income datasets. Table 9 to 12 give the results of fixed effect estimates, whereas Table 13 to 16 present the estimates found from GMM technique. In all of the models given below, the dependent variable is CO_2 emissions per capita.

1. Results of the Fixed Effect Model

Table 9 shows the results of the FE model for the full sample. We have used four equations to identify the impact of governance on climate change (CO_2 emissions per capita). The results exposed that energy consumption and population growth has a positive and significant impact on CO_2 emissions [Siddique (2017)]. Trade openness is helpful to decrease CO_2 emissions. Siddique, et al. (2016) and Rehman, et al. (2012) also found an inverse relationship between trade and CO_2 in South Asia. The negative relation between trade openness and CO_2 emissions confirms the technique effect, which has been explained earlier in the theoretical framework.

GDP has a positive relationship with CO_2 in first two equations [Farhani, et al. (2014), Shahbaz, et al. (2013)], but it is negatively correlated with CO_2 in the non-linear equation by using governance square as a control variable. By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on cli-

TABLE 9

Fixed Effect Model (Full Sample)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
EC	0.00135***	0.00132***	0.00142***	0.00143***
	(4.99e-05)	(5.04e-05)	(4.99e-05)	(4.88e-05)
TO	-0.00699***	-0.00693***	-0.00587***	-0.00491***
	(0.00152)	(0.00151)	(0.00153)	(0.00152)
FDI	0.00111	0.00132	0.00154	0.00165
	(0.00147)	(0.00147)	(0.00149)	(0.00148)
PG	0.128***	0.119***	0.125***	0.128***
	(0.0298)	(0.0298)	(0.0301)	(0.0298)
GDC	9.70e-05***	0.000193***	-5.26e-05***	-
	(2.39e-05)	(3.55e-05)	(1.14e-05)	
GDC^2	-1.81e-09***	-1.57e-09***	-	-
	(2.59e-10)	(2.69e-10)		
GOV	0.00628	-	-0.0256*	-0.0339**
	(0.00591)		(0.0140)	(0.0139)
GOV×GDC	-	-1.38e-06***	--	-9.51e-07***
		(3.98e-07)		(1.34e-07)
GOV^2	-	-	0.000445***	0.000632***
			(0.000152)	(0.000154)
Constant	1.961***	2.386***	2.984***	2.989***
	(0.369)	(0.237)	(0.389)	(0.382)
Obs.	2,135	2,135	2,135	2,135
R-squared	0.320	0.323	0.306	0.316

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

mate change, which shows the EKC between CO_2 and GDP, Rehman, et al. (2012) also found EKC for South Asia. GDP, along with governance, has a negative impact on CO_2 emissions, which shows that GDP with institutional governance is a decreasing source of carbon dioxide emissions. Coefficients of the interaction term in all the equations are negative and statistically significant. This finding can be explained in a way that, keeping the level of institutional governance constant, increase in GDP leads to falling in CO_2 emissions and keeping the GDP constant, increase in the level of institutional governance results in decreasing CO_2 emissions.

Equation (1) shows that governance has a positive relationship with CO_2 emissions, which shows that good institutional governance leads to an increase in CO_2 emissions. Since good quality governance focuses on industrial development, it often plays a role in enhancing CO_2 emissions. Extensive literature has shown that good quality governance alone enhances emissions. Equation (3) and (4) are formulated to capture the existence of a non-linear relationship between institutional governance and CO_2 emissions. Since the level term of institutional governance index is negative, and the square term is found to be positive, the results did not find any EGC among CO_2 emissions and institutional governance in full sample estimates. FDI has a positive impact on climate change, but the coefficients are statistically insignificant.

Table 10 shows the result of the FE model for low-income countries by using four equations. The results exposed that energy consumption has a positive and significant impact on CO_2 emissions [Siddique (2017)]. Trade openness is helpful to decrease CO_2 emissions. Siddique, et al. (2016) and Rehman, et al. (2012) also found an inverse relationship between trade and CO_2 in South Asia. The first three equations show that trade has a positive impact on CO_2, which is insignificant.

Table 9 shows that GDP has a positive relationship with CO_2 in Model 3, see for example [Farhani, et al. (2014), Shahbaz, et al. (2013)], but it is negatively correlated with CO_2 in non-linear equations by using GDP square as a control variable. By using the square of GDP, the empirics show a positive role of the non-linear coefficient of GDP on climate change, which does not show the EKC. GDP, along with governance has a positive impact on CO_2 emissions, which shows that GDP with institutional governance is an increasing source of carbon dioxide emissions.

Governance has an inverse relationship with CO_2 emissions which shows that good institutional governance is playing a vital role to decrease CO_2. In non-linear Equation (3) and (4), results found an EGC among CO_2 and governance in lower-income countries. FDI has a mixed (positive and negative) impact on climate change, but the coefficients are insignificant.

Table 11 shows the results of FE model for middle-income countries. We have used four equations to identify the impact of governance on climate change (CO_2 emissions). The results exposed that energy consumption has a positive and significant impact on CO_2 emissions [Siddique (2017)]. Trade openness is helpful to decrease CO_2 emissions [Rehman, et al. (2012)], but the coefficients are insignificant.

GDP and FDI have a positive relationship with CO_2 [Shahbaz, et al. (2013)]. By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on climate change, which shows the EKC between CO_2 and GDP, Rehman, et al. (2012) also found EKC for South Asia. GDP, along with governance, has a positive impact on CO_2 emissions, which shows that GDP with institutional governance is an increasing source of carbon dioxide emissions. Governance has an inverse relationship with CO_2 emissions which shows that good institutional governance is playing a vital role to decrease CO_2. In non-linear equations (3) and (4), results found an EGC among CO_2 and governance in middle-income countries. FDI has a positive and significant impact on climate change.

TABLE 10

Fixed Effect Model (Low-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
EC	0.00104***	0.00105***	0.00104***	0.00109***
	(0.000144)	(0.000144)	(0.000156)	(0.000147)
TO	0.000414	0.000307	0.000393	-0.000194
	(0.000324)	(0.000332)	(0.000341)	(0.000306)
FDI	0.000299	0.000413	-0.000961	-0.000749
	(0.001000)	(0.001000)	(0.001030)	(0.000979)
PG	-0.0309**	-0.0381***	-0.0476***	-0.0331**
	(0.0149)	(0.0146)	(0.0157)	(0.0151)
GDC	-0.000121	-0.860e-05	0.000452***	-
	(0.000134)	(0.000133)	(5.66e-05)	
GDC^2	3.62e-07***	3.24e-07***	-	-
	(7.31e-08)	(7.72e-08)		
GOV	-0.00144	-	0.00588**	-0.000543
	(0.00101)		(0.00291)	(0.00312)
GOV×GDC	-	2.68e-07	-	1.39e-05***
		(1.32e-06)		(1.56e-06)
GOV^2	-	-	-0.000103**	-0.000152***
			(4.80e-05)	(4.48e-05)
Constant	-0.113	-0.133*	-0.352***	-0.107*
	(0.0753)	(0.0744)	(0.0603)	(0.0627)
Obs.	202	202	202	202
R-squared	0.707	0.703	0.675	0.695

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

Table 12 contains the results of the FE model for high-income countries by using four equations. The results exposed that energy consumption and population growth has a positive and significant impact on CO_2 emissions [Shahbaz, et al. (2013)]. Trade openness is helpful to decrease CO_2 emissions. Siddique, et al. (2016) also found an inverse relationship between trade and CO_2 in South Asia.GDP has a positive relationship with CO_2 in the first two equations [Farhani, et al. (2014)]. Still, it is negatively correlated with CO_2 in the non-linear equation by using governance square as a control variable.

By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on climate change, which shows the EKC between CO_2 and GDP,

TABLE 11

Fixed Effect Model (Middle-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
EC	0.00214***	0.00220***	0.00220***	0.00227***
	(7.59e-05)	(7.63e-05)	(7.49e-05)	(6.68e-05)
TO	-0.00168	-0.00142	-0.0011	-0.000929
	(0.00102)	(0.00101)	(0.00102)	(0.00101)
FDI	0.0116***	0.0100***	0.0112***	0.00916***
	(0.00349)	(0.00349)	(0.00352)	(0.00347)
PG	0.0163	0.0202	0.0179	0.0259
	(0.0230)	(0.0228)	(0.0233)	(0.0231)
GDC	0.000274***	0.000173***	0.000125***	-
	(4.16e-05)	(4.84e-05)	(1.85e-05)	
GDC^2	-1.07e-08***	-1.00e-08***	-	-
	(2.67e-09)	(2.64e-09)		
GOV	0.00432	-	0.00835	-0.000525
	(0.00310)		(0.00879)	(0.00888)
GOV×GDC	-	2.16e-06***	-	2.96e-06***
		(5.07e-07)		(3.67e-07)
GOV^2	-	-	-3.05e-05	-5.55e-05
			(0.000113)	(0.000112)
Constant	-0.555***	-0.446***	-0.432**	-0.137
	(0.168)	(0.125)	(0.199)	(0.202)
Obs.	1,145	1,145	1,145	1,145
R-squared	0.637	0.642	0.631	0.637

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

Rehman, et al. (2012) also found EKC for South Asia. GDP, along with governance has a negative impact on CO_2 emissions, which shows that GDP with institutional governance is a decreasing source of carbon dioxide emissions.

Governance has an inverse relationship with CO_2 emissions which shows that good institutional governance is playing a vital role to decrease CO_2. In non-linear Equation (3) and 4, the existence of EGC among CO_2 and governance is not found. FDI and population growth have a positive impact on climate change, but the coefficients of FDI are insignificant.

TABLE 12

Fixed Effect Model (High-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
EC	0.00126***	0.00123***	0.00131***	0.00132***
	(8.00e-05)	(8.08e-05)	(7.92e-05)	(7.81e-05)
TO	-0.0118***	-0.0121***	-0.0108***	-0.00941***
	(0.00342)	(0.00340)	(0.00332)	(0.00330)
FDI	0.000577	0.000688	0.000669	0.000739
	(0.00231)	(0.00231)	(0.00229)	(0.00227)
PG	0.166***	0.154***	0.149***	0.151***
	(0.0547)	(0.0550)	(0.0544)	(0.0538)
GDC	3.81e-05	0.000126*	-6.31e-05***	-
	(4.51e-05)	(7.02e-05)	(1.86e-05)	
GDC^2	-1.17e-09**	-1.18e-09**	-	-
	(4.60e-10)	(4.58e-10)		
GOV	0.0247	-	-0.343***	-0.350***
	(0.0197)		(0.0984)	(0.0976)
GOV×GDC	-	-9.64e-07	-	-9.92e-07***
		(6.95e-07)		(2.16e-07)
GOV^2	-	-	0.00275***	0.00297***
			(0.000705)	(0.000700)
Constant	4.212**	6.140***	16.81***	16.45***
	(1.644)	(0.825)	(3.441)	(3.419)
Obs.	788	788	788	788
R-squared	0.290	0.290	0.298	0.307

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

2. *Results of GMM*

Table 13 shows the results of GMM for full sample. We have used four equations to identify the impact of governance on climate change (CO_2 emissions). The results explored that energy consumption has a positive impact on CO_2 emissions. Similar results were found by Siddique (2017). Trade openness is helpful to decrease CO_2

TABLE 13

Results of GMM (Full Sample)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
Lag of CO_2	0.502***	0.324***	0.958***	0.818***
	(0.104)	(0.097)	(0.067)	(0.114)
P	0.247*	0.139	-0.358**	-0.326***
	(0.148)	(0.193)	(0.139)	(0.120)
FDI	-0.00497	-0.00044	-0.0145	-0.00658
	(0.00414)	(0.00177)	(0.01150)	(0.01310)
TO	-0.0123**	-0.0201**	-0.00592	-0.000723
	(0.00586)	(0.00968)	(0.00521)	(0.00388)
EC	0.00172***	0.00175***	5.62e-05	0.00022
	(0.000282)	(0.000364)	(0.000117)	(0.000213)
GDC	6.68e-05	0.000293**	9.30e-05*	-
	(6.11e-05)	(0.000139)	(5.58e-05)	
GDC^2	-1.20e-09*	-2.67e-10	-	-
	(6.15e-10)	(1.20e-09)		
GOV	0.0962**	-	0.0741*	0.140*
	(0.0420)		(0.0389)	(0.0717)
GDC×GOV	-	-3.42e-06**	-	1.54e-06*
		(1.57e-06)		(8.49e-07)
GOV^2	-	-	-0.00139**	-0.00223**
			(0.000585)	(0.001010)
Constant	0.323	-0.562	0.493	-0.469
	(1.101)	(1.451)	(1.232)	(1.355)
P-value of AR2	0.137	0.181	0.057	0.053
P-value of Difference in Hansen test	0.263	0.144	0.284	0.159

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

emissions. Rehman, et al. (2012) also found an inverse relationship between trade and CO_2 in South Asia. GDP has a positive relationship with CO_2 see, for instance, Shahbaz, et al. (2013). By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on climate change, which shows the EKC between CO_2 and GDP, Rehman et al. (2012) also found EKC for South Asia.

GDP, along with governance has a negative impact on CO_2 emissions, which shows that GDP with institutional governance is a decreasing source of carbon dioxide emissions. Governance has a positive relationship with CO_2 emissions. Since, in non-linear Equation (3) and 4, the level term of institutional governance index is positive, and its square term is negative, it confirms the existence of EGC among CO_2 emissions and institutional governance in the full sample. These results indicate that at the initial phase of institutional emergence, pollution is increased. However, after reaching a threshold level of institutional governance, pollution is decreased. FDI has a negative impact on climate change, but the coefficients are found to be insignificant. The negative impact can be explained by the fact of receipt of environment-friendly foreign investment. These foreign investments can decrease pollution, but the magnitude is statistically insignificant for full sample countries.

Table 14 shows the results of GMM for low-income countries by using four equations. The results exposed that energy consumption has a mixed and insignificant impact on CO_2 emissions. FDI is helpful to decrease CO_2 emissions, but trade has a positive impact on CO_2, which is insignificant. GDP has a progressive relationship with CO_2 [Farhani, et al. (2014)], but it is negatively correlated with CO_2 in non-linear equations by using GDP square as a control variable. By using the square of GDP, the empirics show a positive role of the non-linear coefficient of GDP on climate change, which does not show the EKC. GDP, along with governance has a negative impact on CO_2 emissions, which shows that GDP with institutional governance is a decreasing source of carbon dioxide emissions. Governance has a positive relationship with CO_2 emissions which shows that good institutional governance is playing its role to increase CO_2 emissions in low-income countries. In non-linear Equation (3) and (4), results found the existence of EGC among CO_2 and governance.

Table 15 shows the results of GMM for middle-income countries. The results exposed that energy consumption has a positive and significant impact on CO_2 emissions [Siddique (2017)]. Trade openness is helpful to decrease CO_2 emissions in three equations [Rehman, et al. (2012)]. GDP has a positive relationship with CO_2 [Shahbaz, et al. (2013)]. By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on climate change, which shows the EKC between CO_2 and GDP, Rehman, et al. (2012) also found EKC for South Asia. GDP, along with governance has a positive impact on CO_2 emissions, which shows that GDP with institutional governance is an increasing source of carbon dioxide emissions. Governance has a positive relationship with CO_2 emissions in middle-income countries. In non-linear Equations (3) and (4), results found an EGC among CO_2 and governance.

Table 16 exposed that energy consumption is an increasing factor of CO_2 emissions [Shahbaz, et al. (2013)]. Trade openness is helpful to decrease CO_2 emissions. Siddique, et al. (2016) also found an inverse relationship between trade and CO_2 in South Asia.GDP has a positive relationship with CO_2 [Farhani, et al. (2014)]. By using the square of GDP, the empirics show a negative role of the non-linear coefficient of GDP on climate change, which shows the EKC between CO_2 and GDP, Rehman, et

TABLE 14

Results of GMM (Low-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
Lag of CO_2	0.656***	0.744***	0.971***	0.824***
	(0.146)	(0.149)	(0.338)	(0.154)
P	0.288***	0.273***	0.314**	-0.0153
	(0.0902)	(0.0892)	(0.1520)	(0.0442)
FDI	-0.0145**	-0.0137*	-0.0288*	-0.00297
	(0.00711)	(0.00715)	(0.01750)	(0.00315)
TO	0.00129	0.00121	0.00391	0.00227
	(0.00131)	(0.00133)	(0.00280)	(0.00144)
EC	-5.43e-05	-0.000298	-0.000533	0.000242
	(0.000232)	(0.000338)	(0.000573)	(0.000283)
GDC	0.00249**	0.00263**	0.000769**	-
	(0.000982)	(0.001030)	(0.000385)	
GDC^2	-1.26e-06**	-1.18e-06**	-	-
	(5.64e-07)	(5.62e-07)		
GOV	0.00706**	-	0.0377	0.0275**
	(0.0032)		(0.0261)	(0.0130)
GDC×GOV	-	-1.01e-05**	-	-7.30e-06***
		(4.86e-06)		(2.72e-06)
GOV^2	-	-	-0.00104*	-0.000564**
			(0.000633)	(0.000235)
Constant	-1.469***	-1.502***	-1.364**	-0.490*
	(0.467)	(0.481)	(0.613)	(0.252)
P-value of AR2	0.545	0.548	0.807	0.150
P-value of Difference in Hansen test	0.110	0.099	0.943	0.264

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

al. (2012) also found EKC for South Asia. GDP, along with governance has a negative impact on CO_2 emissions, which shows that GDP with institutional governance is a decreasing source of carbon dioxide emissions.

Institutional governance alone has a positive relationship with CO_2 emissions which shows that good institutional governance is playing a vital role to enhance CO_2 emissions. However, in non-linear Equation (3) and (4), the existence of EGC between

TABLE 15

Results of GMM (Middle-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
Lag of CO_2	0.680***	0.0537*	-0.173***	-0.186***
	(0.00845)	(0.02870)	(0.05260)	(0.05210)
P	0.0209***	0.112**	-0.0377	-0.0591
	(0.00773)	(0.04970)	(0.07920)	(0.07990)
FDI	-0.000584	-0.00685*	0.00562	0.00684
	(0.00118)	(0.00409)	(0.00851)	(0.00839)
TO	-0.00200***	0.00371***	-0.0116***	-0.0116***
	(0.00035)	(0.00134)	(0.00356)	(0.00351)
EC	0.000983***	0.00181***	0.00343***	0.00321***
	(2.44e-05)	(0.000131)	(0.000237)	(0.000238)
GDC	1.37e-05*	0.000416***	-3.98e-05	-
	(7.87e-06)	(0.000101)	(4.15e-05)	
GDC^2	-1.71e-09***	-3.33e-08***	-	-
	(4.48e-10)	(4.9e-09)		
GOV	5.36e-05	-	0.106***	0.110***
	(0.000463)		(0.037600)	(0.036900)
GDC×GOV	-	5.01e-07	-	5.30e-07
		(1.18e-06)		(1.30e-06)
GOV^2	-	-	-0.000834*	-0.000935**
			(0.000440)	(0.000439)
Constant	-0.0647**	-1.401***	-1.242**	-0.545*
	(0.0325)	(0.409)	(0.512)	(0.352)
P-value of AR2	0.533	0.951	0.089	0.112
P-value of Difference in Hansen test	0.751	0.338	0.135	0.284

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

CO_2 and governance is found. The null hypothesis of P-value of AR2 test statistic indicates that there is no autocorrelation in the model. In all of the equations, the p-value is found to be significant, which shows that there is no autocorrelation. P-values of difference in Hansen test are also significant, which indicate that subset of instruments is valid.

TABLE 16

GMM (High-Income Countries)

Variables	Model 1 CO_2	Model 2 CO_2	Model 3 CO_2	Model 4 CO_2
Lag of CO_2	0.866***	0.813***	0.838***	0.559***
	(0.00461)	(0.04270)	(0.05930)	(0.11600)
P	-0.105***	-0.195***	-0.280***	-0.0624
	(0.00792)	(0.04000)	(0.04870)	(0.14300)
FDI	0.00183***	0.00324*	0.0025	-0.00585**
	(9.34e-05)	(0.00167)	(0.00221)	(0.00239)
TO	-0.000571***	-0.000604	-0.00468	-0.0121**
	(0.000162)	(0.001120)	(0.003690)	(0.005290)
EC	0.000188***	0.000294**	0.000974***	0.00244***
	1.83e-05	(0.000118)	(0.000102)	(0.000196)
GDC	4.67e-05***	8.88e-05**	0.000105***	-
	(3.88e-06)	(4.21e-05)	(2.74e-05)	
GDC^2	-1.77e-10***	4.48e-10**	-	-
	(0)	(2.16e-10)		
GOV	0.0318***	-	1.402***	0.813***
	(0.00344)		(0.20400)	(0.30100)
GDC×GOV	-	-1.49e-06***	-	-1.23e-06**
		(5.14e-07)		(5.37e-07)
GOV^2	-	-	-0.0122***	-0.00649**
			(0.00154)	(0.00253)
Constant	1.833***	1.296*	-37.75***	-24.44***
	(0.260)	(0.750)	(6.791)	(5.328)
P-value of AR2	0.066	0.056	0.065	0.304
P-value of Difference in Hansen test	0.440	0.310	0.125	0.331

Source:Authors' estimation.Standard errors are in parentheses. ***, ** and * indicate the statistical significance of variables at 99, 95 and 90 per cent confidence intervals, respectively.

VI. Conclusion and Policy Implications

This study presents the insightful and comprehensive empirical evidence on the impact of income and institutional governance on climate change based on panel data of 203 countries for time series of 1996 to 2017. We have divided the countries into sub-samples of 34 low-income, 101 middle-income and 68 high-income countries by following the World Bank country classification. Econometric analysis is carried out by employing fixed-effect model in order to incorporate the unobserved heterogeneity among countries, and instrumental variable technique generalised method of moments is applied to tackle the issue of endogeneity. The major contribution of this study involves providing the new empirical evidence on the non-linear impact of institutional governance on CO_2 emissions per capita (a proxy of climate change) and conditional impact of income and institutional governance on these emissions.

To investigate the impact of energy and governance on climate change, we have used four data sets, including lower-income countries, middle-income countries, high-income countries and full sample by using four equations. The results of the FE model and GMM exposed that energy consumption and GDP are the increasing factors of CO_2 emissions while GDP along with governance is effective to decline the emission level. Governance and trade are playing a vital role to decrease CO_2. The results also found the EKC among CO_2 and GDP, and between governance and CO_2 emissions. Our results are consistent with the economic literature.

The results of the present study provide different policy implications for each income category of countries. Low-income countries should promote institutional governance, GDP and inward FDI in order to reduce CO_2 emissions. Middle-income countries should promote institutional governance, trade openness, GDP and inward FDI in order to control climate change. On the other hand, high-income countries should promote institutional governance, population growth, trade openness and GDP in order to tackle climate change.

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APPENDIX A

List of Countries

TABLE A-1

LOW-INCOME ECONOMIES ($995 OR LESS)

Afghanistan	Guinea-Bissau	Sierra Leone
Benin	Haiti	Somalia
Burkina Faso	Korea, Dem. People's Rep.	South Sudan
Burundi	Liberia	Syrian Arab Republic
Central African Republic	Madagascar	Tajikistan
Chad	Malawi	Tanzania
Comoros	Mali	Togo
Congo, Dem. Rep	Mozambique	Uganda
Eritrea	Nepal	Yemen, Rep.
Ethiopia	Niger	Zimbabwe
Gambia, The	Rwanda	
Guinea	Senegal	

Source:World Bank.

TABLE A-2

MIDDLE-INCOME ECONOMIES ($996 TO $12,055)

Angola	Indonesia	Papua New Guinea
Bangladesh	Kenya	Philippines
Bhutan	Kiribati	São Tomé and Principe
Bolivia	Kosovo	Solomon Islands
Cabo Verde	Kyrgyz Republic	Sri Lanka
Cambodia	Lao PDR	Sudan
Cameroon	Lesotho	Timor-Leste
Congo, Rep.	Mauritania	Tunisia
Côte d'Ivoire	Micronesia, Fed. Sts.	Ukraine
Djibouti	Moldova	Uzbekistan
Egypt, Arab Rep.	Mongolia	Vanuatu
El Salvador	Morocco	Vietnam
Georgia	Myanmar	West Bank and Gaza
Ghana	Nicaragua	Zambia
Honduras	Nigeria	Albania
India	Pakistan	Algeria
American Samoa	Grenada	Peru
Armenia	Guatemala	Romania
Azerbaijan	Guyana	Russian Federation
Belarus	Iran, Islamic Rep.	Samoa
Belize	Iraq	Serbia
Bosnia and Herzegovina	Jamaica	South Africa
Botswana	Jordan	St. Lucia
Brazil	Kazakhstan	St. Vincent and the Grenadines
Bulgaria	Lebanon	Suriname
China	Libya	Thailand
Colombia	Malaysia	Tonga
Costa Rica	Maldives	Turkey
Cuba	Marshall Islands	Turkmenistan
Dominica	Mauritius	Tuvalu
Dominican Republic	Mexico	Venezuela, RB
Equatorial Guinea	Montenegro	
Ecuador	Namibia	
Fiji	Nauru	
Gabon	Paraguay	

Source:World Bank.

TABLE A-3

HIGH-INCOME ECONOMIES ($12,056 OR MORE)

Andorra	Germany	Palau
Antigua and Barbuda	Greece	Panama
Argentina	Greenland	Poland
Aruba	Guam	Portugal
Australia	Hong Kong SAR, China	Puerto Rico
Austria	Hungary	Qatar
Bahamas, The	Iceland	San Marino
Bahrain	Ireland	Saudi Arabia
Barbados	Slovenia	Seychelles
Belgium	Israel	Singapore
Bermuda	Italy	Slovak Republic
	Japan	Canada
Brunei Darussalam	Oman	Cayman Islands
Chile	Liechtenstein	Sweden
Croatia	Lithuania	Switzerland
Cyprus	Luxembourg	Trinidad and Tobago
Czech Republic	Macao SAR, China	United Arab Emirates
Denmark	Malta	United Kingdom
Estonia	Monaco	United States
Finland	Netherlands	Uruguay
France	New Zealand	Virgin Islands (U.S.)
Korea, Rep.	Norway	
Kuwait	Spain	
Latvia	St. Kitts and Nevis	

Source:World Bank.