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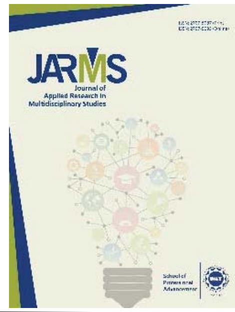

Title: **Article Impact of Foreign Direct Investment on CO2 Emissions in South Asian Countries: The Moderating Role of Institutions**

Author (s): Arslan Tariq Rana, Iqra Shabbir, Muhammad Ilyas Ansari

Affiliation (s): University of Central Punjab, Lahore, Pakistan

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Impact of Foreign Direct Investment (FDI) on Carbon dioxide (CO_2) Emissions in South Asian Countries: The Moderating Role of Institutions

Arslan Tariq Rana*, Iqra Shabbir, and Muhammad Ilyas Ansari

Faculty of Humanities and Social Sciences, University of Central Punjab, Pakistan

Abstract

The current study attempted to investigate the influencing role of the quality of institutions on the long-run effects of Foreign Direct Investment (FDI) on Carbon dioxide (CO_2) emissions for a panel of South Asian countries for the period 1996-2019. The literature on Pollution Haven Hypothesis (PHH) is extensive; however, the literature regarding the influencing role of institutions affecting PHH is relatively limited, especially in the context of South Asian economies. The unit root tests confirmed the stationarity of variables, whereas Pedroni panel co-integration test established the existence of cointegration in the estimation model. The Dynamic OLS (DOLS) methodology was used for the estimation of long-run effects. A significant moderating effect of institutions was observed on the association between F D I and CO_2 emissions. Firstly, the effects of FDI were examined on CO_2 emissions and it was found that FDI increases CO_2 emissions. Hence, the presence of PHH was established for South Asian countries. Afterwards, the institutions were introduced to analyze their moderating effects. The results showed that the mediating role of institutional quality was crucial in the nexus between FDI and CO_2 emissions. In the presence of quality institutions, FDI significantly decreases the level of CO_2 emissions.

Keywords: carbon dioxide (CO_2) emissions**,** foreign direct investment (FDI)**,** institutions, South Asia

Introduction

The economy of the world is presently facing significant challenges of globalization through trade openness and Foreign Direct Investment (FDI) along with climate change.

* Corresponding Author: arslan.tariq@gmail.com

South Asia is an interesting case study to investigate the relationship between FDI and Carbon dioxide (CO_2) emission. Many developing countries need FDI to facilitate economic growth. FDI showed improvement in technology and brought efficiency along with improving living standards by creating the job opportunity in emerging markets.

Nevertheless, FDI may be harmful for environment as it could quickly raise the economic growth and production which is responsible for carbon emissions. It could be negated if the foreign investors bring clean technologies that do not deteriorate the environment. According to the Emission Database for Global Atmosphere Research (EDGAR), the emerging economies and OECD countries account for 85% of Worldwide Carbon emission since 1970 (Bakhsh et al., 2021). Therefore, regarding the impact of FDI on increasing CO_2 emission, pollution is fundamental issue worldwide (Hao & Liu, 2015).

The foreign firms in the developed world are confronted with increased costs at home countries, as the rules regulating the environmental pollution are stringent. The pollution haven hypothesis (PHH) indicates that the FDI increases Carbon dioxide emissions, as these foreign firms relocate their carbon emitting production facilities through FDI in those developing countries where the environmental regulations are not strict. However, there are factors that may play an indirect role to mitigate these PHH effects. The quality of institutions is an important factor that might play a moderating role in the relationship between FDI and CO_2 emissions.

South Asian countries are facing the challenges of increased CO_2 emissions. Climate variation is considered as the main issue at present and it also carries adverse impact on the environment. Foreign Direct Investment played a constructive and important role in the CO_2 emissions of South Asia. This creates environment of competition among manufacturers and service providers. It also encourages the firms towards the betterment of quality of the products. However, FDI could play a negative role in the context of environment. For this, the role of institutions is also very important. Institutions and governance have dimensions, such as government effectiveness, political stability, voice, accountability, control of corruption, rule of law, and regulatory quality. The institutions decrease environmental degradation by playing their role in affecting the relationship between the pollution increasing FDI and CO_2 emissions. The environmental quality improves when government institutions adequately enforce regulations and environmental standards.

The institutions control for the negative externalities of the Foreign Direct Investment projects that are welcomed into the host country. Institutions may indirectly help to force the foreign investors in order to follow the rules and regulations regarding the control of CO_2 emissions from the manufacturing plants. Therefore, they play an influencing role to determine the effects of FDI on pollution. At the same time, institutions also need to force the concerned authorities regarding the FDI projects inflows to make sure of the implementation of rules and laws in order to reduce the side effects of business plants in terms of CO_2 emissions. On the other hand, if the host country lacks strong institutions, they may not make the foreign investors to follow the steps which are necessary to reduce carbon emission from the installed manufacturing plants.

Therefore, this study carries twofold objectives. Firstly, it analyzes the impact of FDI inflows on CO_2 emissions in the selected South Asian countries whether it pollutes or not for instance, to test the PHH for South Asian countries. Secondly, it analyzes the role of institutions on the linkage between FDI and CO_2 emission in South Asia.

There is extensive literature on PHH; however, the influencing role of institutions in affecting the impact of FDI on CO_2 emissions is relatively scant, especially in the context of South Asian economies. The current study attempts to fill this gap in the literature.

The rest of the paper is structured as follows: Section 2 two presents the review of literature on PHH and on the role of institutions. Section 3 provides econometric methodology in order to obtain results. Section 4 presents and discusses the results, whereas section 5 is based on conclusion.

Literature Review

In order to address the Pollution Haven Hypothesis (PHH) or Pollution Halo Hypothesis, it was deemed necessary to ascertain the effects of FDI on Carbon dioxide (CO_2) emissions. Furthermore, the institutions need to be studied for their potential role to mitigate FDI-led CO_2 emissions in case. In this section, existing literature on FDI, institutions, and CO_2 emission was examined. Firstly, the effects of FDI on CO_2 emissions were discussed. Secondly, institutional quality's role was reviewed to mitigate CO_2

emissions directly and indirectly through moderating the FDI-led CO_2 emissions.

Blanco et al. (2013) analyzed the impact of inward FDI on CO_2 emissions. The panel data for 18 countries from Latin America was obtained for the period 1980-2007. The Granger causality test was applied. In their results, FDI was reported as the cause of more carbon dioxide per capita by developing the pollution-intensive industries in the host country. GDP growth was also found to be a major factor in increasing CO_2 emissions.

Gholipour Fereidouni (2013) conducted the study on the impact of FDI in real estate sector on CO_2. The panel data of 31 emerging countries was used from the year 2000 to 2008. The Gaussian Mixture Model (GMM) techniques were utilized. The empirical results showed that the Foreign Direct Investment in real estate (FDIRE) was not the significant determinant of CO_2 emission.

Omri (2014) examined the impact of causal interaction between pollution (CO_2) emission, FDI, and economic growth. The panel data of 54 countries was employed for the time period of 1990-2011. The dynamic simultaneous- equation model techniques were utilized. The results showed the existence of bidirectional causality between FDI and economic growth. The findings also indicated the presence of causality running from CO_2 emissions to economic growth.

Shaari et al. (2014) inspected the effects of FDI and economic growth on carbon dioxide emission. The panel data was used for the time period 1992-2012. Johansen co-integration techniques were applied. The results signified that there was an association between the GDP, FDI, and CO_2 emission. For this purpose, FMOLS and Vector Error Causality Method (VECM) tests were performed which showed that there was no role of FDI in causing Carbon dioxide emission in the long run. The results further showed that economic growth increases the CO_2 emission.

Zhang and Zhou (2016) identified the effects of FDI inflows in Chinese regions on CO_2 emission which was based on regional and national level emission. The panel data of Chinese regions was used for the time period of 1995-2010. The Stochastic Impacts by Regression on Population Affluence and Technology (STIRPAT) model was applied. The results showed that FDI decreases pollution in China. The FDI significantly mitigates Carbon dioxide emissions in all regions of China, because foreign firms employ advanced technologies which are environmentally friendly. Therefore, the results also suggested that China needs to attract more FDI in order to control emission level through advanced technologies.

Fauzel (2017) investigated the short and long-run impacts of FDI in the sectors of manufacturing and non-manufacturing on carbon dioxide (CO_2) emission. The time series data of Mauritius was employed from the year 1980-2012. The bound testing approach of co-integration and Autoregressive distributed lag (ARDL) models were utilized. The results showed that FDI boosts emission level in manufacturing sector, whereas in non-manufacturing sector it carries no harmful impact on environment. Moreover, the results revealed that the economic growth and energy consumption increases CO_2 emission level in the country.

Kocak and Sarkgunest (2017) explored the effects of FDI on CO_2 emission and environmental Kuznets curve (EKC) hypothesis. The time series data for Turkey was used for the period of 1974-2013. The co-integration and bootstrap approaches were utilized. The results showed that a long run relationship exists among FDI, energy consumption, CO_2 emission, and economic growth. The unidirectional association exists between economic growth and CO_2 emission. The results revealed that the EKC exists in Turkey which indicates that after a sustainable development, economic growth improves environment.

Sung (2017) inquired the possible effects of inward FDI on CO_2. The panel data of 28 subsectors of Chinese manufacturing was obtained from the years 2002-2015. The Generalized Method of Moments techniques were utilized. The results suggested that FDI showed positive effects on pollution levels, while domestic capital stock showed negative effects on environment. The results also indicated that GDP improves the environment quality.

To et al. (2019) scrutinized the effects of FDI on environmental degradation. The panel data of emerging Asia was employed for the time period of 1980-2016. The FMOLS techniques were utilized. These results showed that FDI affects the environment negatively.

Xie et al. (2019) analyzed the impact of FDI on CO_2 emission. The panel data of 11 emerging countries was obtained from the year 2005 to 2014. The Panel Smooth Transition Regression (PSTR) model was used. The results showed that FDI has a significant impact on CO_2 emission.

Pazienza (2019) evaluated the influence of FDI inflows on pollution created by CO_2 emissions. The panel data of 30 OECD countries was employed between 1989-2016. The scale and cumulative effect techniques were utilized. The positive environment was explained by FDI as a driving force of technology innovation, thus confirming the existence of pollution halo hypothesis.

Islam (2020) scrutinized the financial development and FDI nexus using quality of institutions as moderator. The panel data of emerging countries was used for the years 2005-2014. The Pooled Ordinary Least-Squares (POLS), Fixed Effect, and Random Effect model were used. The results showed that the financial market was less attractive to FDI relative to financial institution.

Eriandani (2020) interrogated the effects of FDI on carbon dioxide CO_2 emission. The panel data of 5 Association of South East Asian nations (ASEAN) countries was employed for the time period 1980-2018. The Granger-Causality tests were applied. The results were robust, controlling for other factors associated with CO_2 emission.

Mujtaba and Jena (2021) inspected the impact of FDI and oil price on CO_2 emission. The panel data for OECD countries was employed for the years 1986-2014. The Non-Linear Autoregressive distributed lag (ARDL) model was utilized. The results exhibited that raises in economic growth decline CO_2 emission and a decrease in economic growth would increase Carbon dioxide emissions. Positive shocks and negative shocks to oil prices showed a significant and favorable impact on Carbon dioxide emissions. Additionally, energy consumption with positive shocks showed a significantly positive impact on CO_2 emissions

Tang et al. (2014) studied the effects of energy consumption, income, and FDI on CO_2. The time series data of Vietnam was employed for the years 1976-2009. The Granger Causality tests were performed. The results supported the halo effect hypothesis.

Nadeem et al. (2020) figured out the effects of FDI on carbon emission. The time series of Pakistan was used for the period 1971-2014. The Autoregressive distributed lags (ARDL) were utilized. The results of some of their models exhibited that there was a two-way causal relationship between CO_2 emissions and FDI. However, in other models they found pollution mitigating effects of FDI on SO_2. Additionally, energy consumption was found to be polluting in the long run rather than the short run. Therefore, FDI in clean technology is of great importance to mitigate the country's CO_2 emissions and maintain economic growth.

Essandoh et al. (2020) investigated the short-run and long-run relationship among CO_2 emission, trade openness, and FDI flows. The model used was Pooled Mean Group (PMG)-Autoregressive Distributed Lag (ARDL). The results showed that FDI inflows and CO_2 emissions exhibit positive relationship for developing countries.

Nguyen et al. (2018) investigated how FDI affected the institutions, trade openness, and credit level in emerging market economies. A Generalized Method of Model (GMM) model was used. The panel data of emerging markets was obtained for the time period 2002-2015. The results showed that FDI affects the economic growth positively when institutions work properly. Trade openness carries significant and positive impact on FDI. Therefore, it was concluded that the institutions help to moderate the effects of trade openness on FDI.

Ahmad et al. (2018) evaluated the effects of institutional quality on sectoral FDI. The sectors comprised services, manufacturing, and primary. The time series data of Pakistan was employed from the year 1980-2010. The Autoregressive distributed lag (ARDL) co-integration techniques were utilized. The results showed that institutions play an important role to boost the FDI in services and manufacturing sector in long-run; however, not in the case of primary sector.

Shahbaz et al. (2019) examined the impact of FDI and carbon emission for the Middle East and the North African (MENA) region. The panel data for the countries situated in MENA region was used for the time period 1990-2015. The Generalized Method of Moments Model (GMM) was performed. The results showed that the presence effect carbon emission and economic growth. The association between biomass energy use and Carbon dioxide emissions also exists.

Ali et al. (2019) reviewed the effects of institutions on environment in the developing economies. The panel data of 47 developing countries was obtained for the time period (1999-2018). The Generalized Method of Moments (GMM) techniques were utilized. The results showed that the institutions have positive and significant impact on environmental quality. Therefore, the results also suggested that quality institutions help to enhance the level of environmental quality. However, Halkos and Tzeremes (2013) argued that not all the institutions have the same impact.

Le et al. (2020) examined the impact of institutional quality on CO_2 emissions. The panel data for 47 Emerging Market and Developing Economies (EMDEs) was obtained for the time period 1990-2014. The error correction techniques were utilized. The empirical results showed that the institutions significantly reduce CO_2 emissions. In EMDEs, the better quality of institutions mitigates CO_2 emissions. It suggests that EMDEs must improve institutional quality to expand trade for the better environment.

Wawrzyniak et al. (2013) tested the impact of economic growth on CO_2 emissions dependent on the institutions. The panel data for 93 emerging and developing countries was obtained for the time 1995-2014. The Generalized Method of Moments techniques were utilized. The results showed that high government effectiveness carry significance in reducing in CO_2 emissions. The control of corruption, political stability, rules, regulations, regulatory quality, and voice and accountability showed no correlation with CO_2 emissions.

Ibrahim and Law (2016) investigated the role of institutional quality, trade, and their interactions in carbon dioxide (CO_2) emission. The panel data of 40 sub- Saharan African countries was obtained for the period 2000 to 2010. The Generalized Method of Moments (GMM) techniques were utilized. The results showed that trade openness is harmful for environment in those countries where institutional quality is poor. In Sub-Saharan Africa (SSA), the better institutional quality and trade openness mitigates CO_2 emissions. It suggests that SSA should improve institutional quality to expand trade for the better environment. Indeed, the environmentally friendly policies were created in the presence of strong institutions and in turn they have a significant impact on the betterment of environmental quality (Ozturk & Al-Mulali, 2015).

Bakhsh et al. (2021) analyzed the role of institutional quality on pollution and FDI inflows. The panel data of 40 Asian countries was used for the time period 1996-2016. The results showed that FDI inflows have significant effects on CO_2 emission. The empirical results indicated that technological innovation and institution quality mitigate CO_2 emission.

These results were helpful for the policy makers to protect environment in short and long run.

Salman et al. (2019) investigated the effects of institutions on economic growth and CO_2. The panel data of three Asian countries was employed from the year 1990 to 2016. The Vector Error Correction Model (VECM) techniques were utilized. There were discussions about the importance of balance between the carbon emissions and economic development. There should be efficient institutions that would help to increase financial growth and decrease carbon dioxide emission. That high green and low carbon would help as a positive economic growth factor. This is synonymous as the feedback hypothesis and both the factors were interdependent and to make it beneficial one factor must be regulated with respect to the other.

Abid (2016) analyzed the significance of economic, financial, and institutional development on carbon dioxide (CO_2) emission in the EKC hypothesis. The panel data of 25 sub- Saharan African (SSA) countries was obtained for the time period of 1996-2010. The Generalized Method of Moments Model (GMM) techniques were utilized. The results validated that government effectiveness, political stability, democracy, and corruption control negatively affects the CO_2 emission. All these factors reduce the CO_2 emissions not only directly; but also indirectly through economic growth and trade openness. Moreover, the financial development and economic growth must not affect the CO_2; however, it could be the part of solution.

It may be summarized from the above discussion that the role of FDI and institutions to impact CO_2 emissions for a country is very important. The literature discusses two main hypotheses in the effects of FDI on pollution caused by CO_2 emissions. First is Pollution Haven Hypothesis and the other is Pollution Halo Hypothesis. If FDI is detrimental to pollution, then haven hypothesis holds otherwise halo hypothesis holds. The results in the literature point towards both directions, that is, in different cases pollution haven hypothesis holds and pollution halo hypothesis exists in other cases. Regarding the impact of institutions, there is a general consensus among researchers that the quality of institutions is important to reduce carbon emissions. Nevertheless, the literature highlights that governance indicators, mentioned above, representing institutional quality, have differential effects and not all of the indicators impact CO_2 emissions uniformly. The good institutions ensure environment friendly policies of businesses and thus, play their role to mitigate CO_2 emissions originating from manufacturing.

Methodology

In order to examine the influencing role of institutions in the effects of FDI on CO_2 emissions for a sample of 7 South Asian countries for the period 1996-2019. The panel data was collected from reliable sources. The variables' definition along with the list of countries on which the analysis was done, is provided in the appendix. The natural log of all the variables was taken except for the institutions.

Carbon dioxide (CO_2) emissions (metric tons per capita), Foreign Direct Investment (FDI) as net inflows (% of GDP), Energy use (kg of oil equivalent per capita), Financial Development, measured as Domestic credit to private sector (% of GDP), Gross Domestic Products per capita (current US$), and Gross Fixed Capital Formation (% of GDP) is obtained from the World Development Indicators (WDI). The data for six institutional dimensions also called governance indicators, such as control of corruption, government effectiveness, regulatory quality, voice and accountability, rule of law and political stability was obtained from the Worldwide Governance Indicators (WGI).

The econometric investigation starts with the stationarity test of all variables used in the analysis. The two kinds of unit root tests are applied. These tests include Im, Pesaran, and Shin (IPS) along with Augmented Dickey and Fuller (ADF).

Following stationarity tests, the next step was to determine the long-run panel co-integration. For that purpose, the Pedroni (1999) co-integration method was employed.

After the estimation of panel co-integration test of the existence of co-integration between the variables, the log run parameter estimates are analyzed using Dynamic OLS (DOLS) method, suggested by Stock and Waston (1993). DOLS is robust to find the long run elasticity among the independent and dependent variables. Furthermore, the DOLS method employs the parametric adjustment of the error term through the inclusion of the past and future information of the differenced independent variables. The regression equation for the mediating role of institutions on the impact of FDI and CO_2 emissions is as follows:

$$LnCO2emissions_{it} = \beta_0 + \beta_1 lnEnergyuse_{it} + \beta_2 lnFindev_{it} + \beta_3 lnGDPPC_{it} + \beta_4 lnGFCF_{it} + \beta_5 lnFDI_{it} + \beta_6 Institution_{it} + \beta_7 FDI_{it} * Institution_{it} + \varepsilon_{it} \quad (1)$$

As discussed above, there are six dimensions that are used in the current study. Then the Causality Granger rooted on Vector Error Correction Model (VECM) would be employed. VECM is a multivariate co-integation method suggested by (Granger, 1981) and (Engle & Granger, 1987) to examine the convergence of variables towards equilibrium or the long-run causality between variables. The general form of the equation is:

$$\Delta Y_{it} = \alpha_i + \sum_{k=1}^{p} \beta_i \Delta Y_{it-k} + \sum_{k=0}^{q} \delta_i \Delta X_{it-k} + \emptyset_i ECT_{it-1} + \mu_{i,t}$$

Where ECT_{it-1} is the error correction term. that indicates speed of convergence in the log-run.

Results and Discussion

The unit root tests are employed to verify whether the data is stationary at first difference. For this purpose, two-unit root tests are performed for instance, Im, Pesaran and Shin (IPS), and Augmented Dickey-Fuller (ADF). The stationarity tests are performed at level and at first difference including individual intercept and trend for each independent and dependent variable. The test results are reported for IPS and ADF in the Tables 1 and 2 respectively.

Table 1

Im, Pesaran and Shin

Variables	Level		First Difference	
	Intercept	Intercept with trend	Intercept	Intercept with trend
CO_2	4.55038	2.16912	-4.52578***	-3.87458***
Trade	-0.68002	0.99877	-4.76328***	-3.94725***
GDPPC	5.61315	0.99656	-3.36076***	-2.95289***
FDI	-3.12634***	-2.70912***	-7.60797***	-6.21124***
GFCF	-0.61603	0.63198	-3.02155***	-3.38758***
Total Population	1.07039	-6.13740***	-6.09876***	-11.5456***

Variables	Level		First Difference	
	Intercept	Intercept with trend	Intercept	Intercept with trend
FINDEV	0.77447	1.89080	-3.74114***	-2.52013***
Energy use	2.87537	0.91629	-4.29906***	-3.82214***
CC	-1.65281***	-0.70926	-6.49963***	-5.25690***
GE	-1.95592**	-1.71943**	-7.62232***	-6.48500***
PS	-0.30544	0.25587	-5.24773***	-4.36712***
RQ	-0.71281	0.80018	-5.72496***	-4.15626***
RL	-0.46283	-0.08653	-6.399198***	-5.54942***
VA	0.76775	-0.36804	-4.04031***	-2.54280***

Note. In parentheses Standard errors are reported***p<0.001, **p<0.01. All the variables are in logged form except variables of institutions.

Table 2
ADF-Fisher Chi-Square

Variables	Level		First Difference	
	Intercept	Intercept and trend	Intercept	Intercept and trend
CO_2	3.31011	5.23725	50.1776***	44.2941***
Trade	16.2546	9.68848	49.6219***	41.0559***
GDPPC	1.83345	13.3012	43.6841***	38.7104***
FDI	41.0936***	33.7067***	84.1900***	65.6196***
GFCF	20.6437	11.8380	36.0898***	39.6418***
Total Population	16.6722	90.2860***	76.4549***	298.553***
FINDEV	10.7260	7.76609	42.0888***	31.5071***
Energy use	14.1197	9.91553	44.8089***	38.5071***
CC	27.8526**	22.7458	71.7853***	55.9527***
GE	26.6531**	26.8938**	84.1502***	67.8786***
PS	13.0407	14.7126	57.7194***	46.7123***
RQ	17.6502	11.4966	62.2477***	44.7482***
RL	16.4972	13.4620	70.7537***	60.0536***
VA	18.7208	16.8495	44.4915***	30.5959**

Note. In parentheses Standard errors are reported***$p < 0.001$, **$p < 0.01$. All the variables are in logged form except variables of institutions

In both Tables 1 and 2, the test results exhibit that most of the variables are not stationary at level, however, there exists stationarity at first difference for all the variables. Therefore, the criteria to test the co-integration was fulfilled and panel co-integration test was performed. The results of the Pedroni panel co-integration test are presented in Table 3.

Table 3

Pedroni Panel Cointegration Tests

Models	Panel v	Panel rho	Panel PP	Panel ADF	Group rho	Group PP	Group ADF
Model 1	-1.262	1.383*	-8.374***	-5.962***	2.784***	-7.549***	-4.745***
	(0.104)	(0.084)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)
Model 2	-1.26	1.545	-7.292***	-5.278***	2.925***	-7.224***	-3.513***
	(0.10)	(0.621)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Model 3	-0.5866	1.745**	-6.552***	-6.257***	2.819***	-7.272***	-5.804***
	(0.279)	(0.041)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Model 4	1.073	1.92**	-6.975***	-5.568***	3.155***	-6.315***	-4.657***
	(0.142)	(0.02)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Model 5	-0.934	1.386*	-9.801***	-7.662***	2.795***	-8.798***	-5.794***
	(0.1709)	(0.08)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Model 6	-1.209	1.357*	-8.728***	-7.843***	2.765***	-7.89***	-5.586***
	(0.114)	(0.08)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note. In parentheses Standard errors are reported***p<0.01, **p<0.05. All the variables are in logged form except variables of institutions.

The results exhibited that at least five statistics were significant at 5% level of significance which, therefore, rejected the null hypothesis of no co-integration for all the six models. Consequently, the long-run relationship between interaction of FDI and dimensions of Institutions was validated. These results confirmed previous studies that also found a long relationship between Carbon dioxide emission (see Baek & Pride, 2014).

After the co-integration test, the next step was to estimate Dynamic OLS that is another more robust and more recent technique to measure the elasticity of parameters in the long run among the independent and dependent variables. Therefore, DOLS methodology was used to measure the long-term moderating impact of institutions on FDI and CO_2 relationship. The regression results are presented in Table 4.

Table 4
Dynamic OLS Estimates

Variables	CO_2 emissions						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
TRADE	-0.671***	-0.867***	-0.671***	-0.721***	-0.671***	-0.813***	-0.663***
	(0.196)	(0.147)	(0.143)	(0.148)	(0.181)	(0.149)	(0.191)
GDPPC	0.407***	0.365***	0.375***	0.387***	0.400***	0.412***	0.441***
	(0.104)	(0.075)	(0.075)	(0.077)	(0.097)	(0.081)	(0.092)
ENERGY USE	0.837***	0.579***	0.681***	0.850***	0.821***	0.619***	0.779***
	(0.092)	(0.067)	(0.066)	(0.069)	(0.086)	(0.072)	(0.082)
FINDEV	-0.099**	-0.013	0.054*	-0.104***	-0.111***	-0.084**	-0.188***
	(0.043)	(0.032)	(0.031)	(0.033)	(0.042)	(0.036)	(0.042)
GFCF	0.029	-0.026	-0.031*	0.038**	0.050**	0.011	0.065***
	(0.024)	(0.018)	(0.018)	(0.018)	(0.024)	(0.019)	(0.024)
FDI	0.315***	0.278***	0.116***	0.210***	0.386***	0.210***	0.223***
	(0.036)	(0.027)	(0.029)	(0.031)	(0.077)	(0.033)	(0.043)
CC		0.334***					
		(0.109)					
FDI*CC		-0.217***					
		(0.025)					
GE			0.434***				
			(0.135)				
FDI*GE			-0.382***				
			(0.038)				
PS				0.102**			
				(0.047)			
FDI*PS				-0.109***			
				(0.018)			
RQ					0.109		
					(0.128)		
FDI*RQ					0.126		
					(0.110)		
RL						0.395***	
						(0.152)	
FDI*RL						-0.231***	
						(0.043)	
VA							0.237**
							(0.101)
FDI*VA							-0.111**
							(0.049)
Observations	147	147	147	147	147	147	147
R-squared	1.464	1.448	1.292	1.535	1.390	1.342	1.424
Number of countries	7	7	7	7	7	7	7

Note. In parentheses Standard errors are reported***$p < 0.001$, ** $p < 0.05$. All the variables are in logged form except variables of institutions. The abbreviations are: CC=Control of Corruption, GE=Government Effectiveness, PS=Political Stability, RQ=Regulatory Quality, RL=Rule of law, VA=Voice and Accountability

The analysis of the current study started by determining whether PHH exists in the sample or not. Therefore, in model (1), the linear impact of FDI was tested along with other control variables. FDI was found to be the cause of pollution with positive and significant sign. Hence, Pollution Haven Hypothesis (PHH) exists. These results suggested that foreign countries shift their pollution emitting industries in South Asian countries. This may also be the case that FDI in South Asia falls in those sectors where outdated technologies are used. This outcome is in line with Blanco et al. (2013) who found FDI to be pollution intensive and To et al. (2019) who found PHH it for emerging Asian countries.

Afterwards, the institutions and their interactions were introduced in order to examine the moderating role of institutions in estimations (2) to (7). Model (2) shows that control for corruption (CC) reduces the pollution creating effects of FDI. In Model (3) the interaction of FDI and institution of government effectiveness (GE) exhibits significant and negative sign, which shows that 10% increase in quality of GE reduces CO_2 emissions generated through FDI by 4% on average in South Asia. Indeed, the government effectiveness ensures that the environmental policy formulation and government's commitment for its implementation works effectively. This feature would influence the pollution emitting role of FDI and constrain it towards the betterment of environment. These results are in line with Ozturk, Mulali (2015), Deacon, and Norman (2004), who found the pollution mitigating role of government effectiveness and control of corruption for Cambodia. Similarly, political stability (PS) is also effective in decreasing the pollution (estimation (4)). The results of this study complement the outcome of Abid (2017) who studied 41 European Union (EU) countries. The institutional indicator of rule of law (RL) also showed the negative and significant moderating effects signifying that the improvement in rule of law mitigates the adverse pollution creating effects of FDI. The 10% improvement in RL reduces the role of FDI in pollution emissions to about 2 percent. Therefore, the creation and proper enforcement of law helps to promote cleaner technologies in FDI and are thus important in reducing CO_2 emissions.

Among control variables, trade openness significantly helps to reduce Carbon dioxide emissions. This outcome complements the findings of Grossman and Krueger (1991) who analyzed G-20 economies. However, the results contradict Ibrahim and Law (2016) who found trade openness to be detrimental for the environment in Sub Saharan African countries. The variable of financial development showed negative and significant sign in all estimations generally which indicated that the financial development in South Asian countries leads to the betterment of environment. Indeed, financial development mitigates the environmental degradation by making the energy sector more efficient. Furthermore, access to credit makes the green energy projects easier to undertake. Frankel and Rose (2002) also found that financial development leads to improvement in the environment. GDPPC and energy consumption showed significant pollution increase. These results are generally consistent in all the estimations.

On the whole, the results of Dynamic OLS (DOLS) model established that the interaction of Foreign Direct Investment and institutions showed significant and negative effects on CO_2 emissions with reference to South Asian countries. This showed that the presence of quality institutions mitigates the effects of Foreign Direct Investment on CO_2 emissions. Conclusively, these results explained that all South Asian countries need to increase the quality of institutions so that the foreign investor may introduce the modern technology through FDI by which CO_2 emissions could be minimized.

The last step of the analysis was to use Vector Error Correction model (VECM) in order to examine the direction of causality in long-run and short-run. The results of Vector Error Correction model analysis are demonstrated in the Table 5.

Table 5
The Results of VECM Granger Causality Test

Model No.	Short run									Long run
	ΔCO₂	ΔTRADE	ΔGDPPC	ΔENERG Yuse	ΔFINDEV	ΔGFCF	ΔFDI	ΔCC	ΔFDI*CC	ΔECT (-1)
Model 1										
ΔCO_2		0.050	-0.106	0.684***	0.114	-0.042	-0.010	0.056	-0.001	-0.16***
		[0.105]	[0.109]	[0.140]	[0.077]	[0.048]	[0.012]	[0.065]	[0.132]	[0.055]
ΔTRADE	0.030		-0.015	0.035	0.221***	0.045	0.003	0.076	0.012	-0.16***
	[0.070]		[0.085]	[0.118]	[0.057]	[0.037]	[0.009]	[0.050]	[0.010]	[0.038]
ΔGDPPC	0.006	0.004		0.328***	0.022	0.030	-0.008	0.011	0.010	-0.018
	[0.072]	[0.083]		[0.118]	[0.064]	[0.038]	[0.009]	[0.052]	[0.010]	[0.025]
ΔENERGY	0.091**	-0.028	0.096**		-0.037	-0.018	-0.003	0.010	-0.006	-0.22***
use	[0.039]	[0.046]	[0.048]		[0.034]	[0.021]	[0.005]	[0.029]	[0.005]	[0.013]
ΔFINDEV	0.137	0.480***	0.047	-0.151		-0.14***	-0.001	-0.02**	-0.042***	-0.001
	[0.101]	[0.111]	[0.124]	[0.171]		[0.053]	[0.014]	[0.072]	[0.014]	[0.020]
Δ GFCF	0.016	0.261*	0.028	-0.027	-0.580***		-0.014	0.002	-0.014	-0.15***
	[0.106]	[0.157]	[0.166]	[0.022]	[0.106]		[0.018]	[0.098]	[0.019]	[0.009]
ΔFDI	0.268	0.270	0.847	-2.045**	-0.133	-0.023		0.479	0.070	-0.72***
	[0.601]	[0.697]	[0.726]	[0.995]	[0.147]	[0.323]		[0.432]	[0.087]	[0.079]
ΔCC	-0.094	-0.156	0.060	-0.007	0.117	0.011	0.321**		0.061	-0.41***
	[0.120]	[0.139]	[0.146]	[0.203]	[0.103]	[0.065]	[0.016]		[0.017]	[0.471]
ΔFDI*CC	1.016*	-1.012	0.570	-1.668*	0.811*	-0.138	0.083	0.589		-0.81***
	[0.547]	[0.636]	[0.670]	[0.199]	[0.471]	[0.297]	[0.076]	[0.396]		[0.079]
Model 2										
ΔCO2		0.086	-0.088	0.693***	0.112	-0.032	-0.010	0.137**	-0.001	-0.18***
		[0.102]	[0.108]	[0.141]	[0.072]	[0.048]	[0.013]	[0.068]	[0.021]	[0.058]
ΔTRADE	0.043		-0.042	0.1388	0.172***	0.049	0.002	-0.009	0.015	-0.16***
	[0.723]		[0.086]	[0.121]	[0.056]	[0.038]	[0.380]	[0.055]	[0.016]	[0.038]

Model No.	Short run									Long run
	ΔCO_2	ΔTRADE	ΔGDPPC	ΔENERG Yuse	ΔFINDEV	ΔGFCF	ΔFDI	ΔCC	ΔFDI*CC	ΔECT (-1)
ΔGDPPC	0.001 [0.731]	0.016 [0.082]		0.350*** [0.119]	0.012 [0.587]	0.031 [0.038]	-0.007 [0.019]	0.005 [0.055]	0.014 [0.017]	-0.027 [0.026]
ΔENERGY Use	-0.524 [0.039]	0.006 [0.444]	0.104** [0.464]		-0.045 [0.315]	-0.022 [0.208]	-0.103* [0.005]	-0.038 [0.030]	-0.025*** [0.008]	-0.24*** [0.013]
ΔFINDEV	0.1493 [0.192]	0.4115*** [0.1183]	0.0363 [0.131]	-0.282 [0.183]		- 0.150*** [0.056]	-0.021* [0.016]	-0.054 [0.083]	-0.045* [0.0253]	-0.001 [0.222]
ΔGFCF	0.053 [0.139]	-0.248 [0.155]	-0.537 [0.139]	-0.057 [0.234]	-0.568*** [0.101]		-0.010 [0.020]	-0.107 [0.106]	-0.003 [0.032]	-0.14*** [0.010]
ΔFDI	0.452 [0.557]	0.539 [0.625]	1.084 [0.660]	-1.927 [0.927]	-0.092 [0.449]	-0.2115 [0.294]		-0.115 [0.427]	-0.128 [0.129]	-0.76*** [0.813]
ΔGE	0.602* [0.334]	-0.049 [0.385]	0.487 [0.407]	-0.553 [0.576]	-0.253 [0.274]	0.487 [0.407]	0.014 [0.051]		-0.037 [0.181]	-0.77*** [0.777]
ΔFDI*GE	0.280*** [0.107]	-0.261* [0.121]	-0.151 [0.130]	0.176 [0.184]	-0.021 [0.884]	-0.015 [0.058]	0.024 [0.016]	0.049** [0.025]		-0.37*** [0.064]
Model 3										
ΔCo2		0.071 [0.101]	-0.075 [0.109]	0.681*** [0.139]	0.098 [0.075]	-0.052 [0.048]	-0.009 [0.013]	0.040 [0.036]	-0.001 [0.101]	-0.20*** [0.053]
ΔTRADE	0.009 [0.069]		-0.020 [0.080]	0.082 [0.121]	0.190*** [0.058]	0.038 [0.039]	-0.002 [0.011]	0.003 [0.029]	-0.000 [0.008]	-0.18*** [0.041]
ΔGDPPC	-0.015 [0.068]	0.011 [0.079]	0.032 [0.038]		0.329*** [0.115]	0.027 [0.059]	0.032 [0.038]	0.002 [0.028]	0.001 [0.007]	-0.039 [0.026]
ΔENERGY Use	0.083** [0.037]	-0.034 [0.044]	0.095** [0.047]		-0.052 [0.033]	-0.012 [0.021]	-0.007 [0.006]	-0.025 [0.016]	-0.007 [0.004]	-0.23*** [0.012]
ΔFINDEV	0.156 [0.099]	0.355*** [0.113]	0.056 [0.126]	-0.302* [0.173]		-0.113** [0.055]	-0.026* [0.015]	-0.043 [0.042]	-0.030*** [0.011]	-0.005 [0.021]

Model No.	Short run									Long run
	ΔCO_2	ΔTRADE	ΔGDPPC	ΔENERG Yuse	ΔFINDEV	ΔGFCF	ΔFDI	ΔCC	ΔFDI*CC	ΔECT (-1)
ΔGFCF	0.040 [0.131]	0.253* [0.151]	0.022 [0.165]	0.0042 [0.229]	-0.52*** [0.105]		-0.008 [0.020]	0.039 [0.055]	-0.000 [0.153]	-0.15*** [0.010]
ΔFDI	0.494 [0.495]	0.260 [0.579]	1.084* [0.618]	-1.819** [0.851]	-0.10 [0.432]	-0.347 [0.276]		-0.199 [0.208]	-0.032 [0.057]	-0.82*** [0.722]
ΔPS	0.140 [0.197]	-0.106 [0.230]	-0.285 [0.248]	-0.231 [0.344]	0.44 [0.172]	0.005 [0.119]	0.001 [0.031]		-0.001 [0.023]	-0.16*** [0.042]
ΔFDI*PS	0.496 [0.715]	-0.382 [0.835]	1.310 [0.895]	-1.273 [1.24]	0.190 [0.624]	-0.565 [0.398]	-0.085 [0.113]	0.248 [0.300]		-0.61*** [0.076]
Model 4										
ΔCO2		0.064 [0.101]	-0.095 [0.108]	0.700*** [0.137]	0.109 [0.073]	-0.048 [0.048]	0.006 [0.026]	0.092 [0.058]	0.022 [0.377]	-0.14*** [0.045]
ΔTRADE	0.031 [0.068]		-0.010 [0.087]	0.091 [0.119]	0.159*** [0.577]	0.048 [0.038]	0.019 [0.021]	-0.042 [0.046]	0.037 [0.030]	-0.18*** [0.068]
ΔGDPPC	0.014 [0.069]	0.008 [0.081]		0.278** [0.118]	0.013 [0.059]	0.022 [0.039]	-0.029 [0.021]	-0.030 [0.047]	-0.031 [0.030]	-0.013 [0.025]
ΔENERGY Use	0.0886** [0.037]	-0.022 [o.045	0.081* [0.048]		-0.033 [0.033]	-0.174 [0.021]	-0.016 [0.012]	0.004 [0.026]	-0.022 [0.016]	-0.22*** [0.012]
ΔFINDEV	0.279*** [0.101]	0.423*** [0.117]	-0.000 [0.131]	-0.243 [0.180]		-0.144** [0.057]	-0.014 [0.032]	- 0.143** [0.069]	-0.007 [0.045]	0.0115 [0.023]
ΔGFCF	-0.018 [0.128]	0.237 [0.150]	0.009 [0.163]	-0.004 [0.224]	-0.548*** [0.100]		0.025 [0.040]	0.0106 [0.087]	0.0544 [0.056]	-0.16*** [0.018]
ΔFDI	-0.105 [0.264]	0.257 [0.311]	-0.251 [0.335]	-0.802* [0.457]	-0.133 [0.228]	-0.114 [0.149]		0.242 [0.179]	-0.490*** [0.108]	-0.63*** [0.076]
ΔRQ	-0.094 [0.128]	0.016 [0.151]	-0.037 [0.163]	-0.013 [0.224]	-0.080 [0.110]	-0.088 [0.725]	0.021 [0.040]		0.053 [0.056]	-0.41*** [0.072]

Model No.	Short run									Long run
	ΔCO_2	ΔTRADE	ΔGDPPC	ΔENERG Yuse	ΔFINDEV	ΔGFCF	ΔFDI	ΔCC	ΔFDI*CC	ΔECT (-1)
ΔFDI*RQ	-0.032 [0.189]	0.035 [0.222]	-0.262 [0.238]	-0.178 [0.327]	-0.054 [[0.163]	-0.048 [0.107]	-0.016 [0.013]	0.171 [0.107]		-0.90*** [0.038]
Model 5										
ΔCO2		0.0729 [0.104]	-0-.117 [0.190]	0.702*** [0.138]	0.097 [0.073]	-0.041 [0.050]	-0.008 [0.014]	-0.006 [0.092]	0.008 [0.021]	-0.16*** [0.053]
ΔTRADE	0.035 [0.070]		-0.003 [0.087]	0.074 [0.119]	0.170*** [0.056]	0.059 [0.039]	0.003 [0.011]	0.110 [0.072]	0.007 [0.017]	-0.153*** [0.039]
ΔGDPPC	-0.026 [0.069]	0.015 [0.081]		0.307*** [0.115]	0.028 [0.057]	0.030 [0.039]	-0.009 [0.011]	-0.023 [0.072]	0.015 [0.016]	-0.044 [0.028]
ΔENERGY Use	0.093** [0.038]	-0.021 [0.046]	0.094** [0.0482]		-0.37 [0.032]	-0.241 [0.022]	-0.005 [0.006]	-0.030 [0.040]	-0.010 [0.009]	-0.23*** [0.013]
ΔFINDEV	0.234** [0.105]	0.419*** [0.120]	0.0452** [0.132]	-0.242 [0.180]		-0.16*** [0.0592]	-0.013 [0.172]	0.002 [0.110]	-0.029 [0.025]	0.001 [0.023]
ΔGFCF	-0.01 [0.030]	0.305** [0.150]	0.015 [0.161]	-0.050 [0.221]	0.538*** [0.097]		-0.031 [0.020]	-0.33** [0.131]	-0.049 [0.031]	-0.14*** [0.01]
ΔFDI	0.453 [0.524]	0.242 [0.613]	0.833 [0.645]	-1.751** [0.877]	-0.329 [0.433]	-0.203 [0.297]		0.386 [0.5411]	-0.034 [0.127]	-0.82*** [0.083]
ΔRL	-0.122 [0.081]	0.171* [0.095]	-0.105 [0.101]	-0.019 [0.1396]	0.0238 [0.068]	-0.866 [0.046]	-0.018 [0.013]		0.185 [0.020]	-0.24*** [0.054]
ΔFDI*RL	0.366 [0.343]	-0.177 [0.408]	0.268 [0.432]	-0.364 [0.592]	-0.140 [0.291]	-0.184 [0.198]	- 0.14*** [0.041]	0.380 [0.353]		-0.49*** [0.067]
Model 6										
Δ CO2		0.1062 [0.131]	-0.032 [0.109]	0.611*** [0.138]	0.093 [0.071]	-0.074 [0.051]	-0.013 [0.017]	-0.109 [0.066]	0.000** [0.023]	-0.18*** [0.437]

Model No.	Short run									Long run
	ΔCO_2	ΔTRADE	ΔGDPPC	ΔENERG Yuse	ΔFINDEV	ΔGFCF	ΔFDI	ΔCC	ΔFDI*CC	ΔECT (-1)
Δ TRADE	0.007 [0.044]		0.004 [0.086]	0.063 [0.120]	0.174*** [0.056]	0.037 [0.042]	-0.010 [0.014]	0.096* [0.053]	-0.014 [0.018]	-0.16*** [0.044]
ΔGDPPC	0.051 [0.064]	-0.030 [0.080]		0.344*** [0.111]	0.003 [0.056]	0.071* [0.040]	-0.005 [0.013]	0.042 [0.052]	-0.002 [0.018]	-0.039 [0.025]
ΔENERGY Use	0.073** [0.036]	-0.010 [0.046]	0.125*** [0.048]		-0.025 [0.032]	- 0.038*** [0.023]	-0.002 [0.007]	-0.009 [0.029]	0.002 [0.010]	-0.24*** [0.0137]
ΔFINDEV	0.250** [0.098]	0.325*** [0.122]	-0.056 [0.133]	-0.139 [0.180]		-0.071 [0.063]	0.003 [0.021]	0.028 [0.081]	0.004 [0.028]	-0.018 [0.025]
ΔGFCF	-0.019 [0.113]	0.378*** [0.139]	0.190 [0.151]	-0.178 [0.204]	-0.41*** [0.093]		- 0.060** [0.023]	-0.135 [0.091]	-0.072** [0.031]	-0.16*** [0.009]
ΔFDI	0.088 [0.378]	0.430 [0.474]	-0.154 [0.505]	0.114 [0.681]	-0.516 [0.327]	0.445* [0.237]		0.230 [0.306]	-0.364*** [0.101]	-0.69*** [0.076]
ΔVA	0.076 [0.105]	0.192 [0.131]	-0.275** [0.139]	0.2035 [0.189]	-0.073 [0.092]	0.094 [0.066]	0.026 [0.022]		0.032 [0.029]	-0.19*** [0.051]
ΔFDI*VA	0.112 [0.283]	-0.572 [0.352]	-0.490 [0.375]	0.864* [0.504]	-0.360 [0.245]	0.430** [0.175]	- 0.24*** [0.056]	0.149 [0.229]		-0.50*** [0.067]

Note. In parentheses Standard errors are reported***$p<0.01$, **$p<0.05$. All the variables are in logged form except variables of institutions.

The results confirmed long-run causality between the moderating role of institutions (along with other controls) and CO_2 emissions. This signified that there exists convergence of the role of institutions to mitigate the polluting effects of FDI. This is equally applicable to all the institutional indicators. For instance, in model 2, the long-run causality exists running from interaction of FDI and GE towards CO_2 emission. The Error Correction Term showed a negative sign with the value of coefficient (-0.182) and significant at 1%. The negative and significant sign of Error Correction Term signified the long run causation between the CO_2 emission and FDI*GE along with other control variables. Therefore, the CO_2 emission tends to converge towards long-run equilibrium in FDI*GE. The results further suggested that the speed of convergence is over 5 years.

Therefore, it may be established that the institutions play an important role indirectly to restrict the harmful impact of FDI on environment. Institutions constrain the manufacturing and polluting FDI with the incorporation of green manufacturing.

Conclusion and Recommendations

The current study examined the relationship between FDI and quality of institutions on CO2 emissions in South Asian countries by applying DOLS. Specifically, the influencing role of institutional quality in the relationship between FDI and CO2 emissions was analyzed for the period 1996-2009. In order to perform empirical analysis, the panel unit root test, Pedroni panel cointegration test, dynamic OLS, and VECM test were conducted.

The current study provided significant insights for institutional quality's mitigating role in the pollution creating impact of FDI. The results suggested that FDI in South Asian countries is pollution creating, however, institutions act as a mediating factor that reduce the FDI-led CO2 emissions.

It is generally proposed that through new FDI, the ability and capacity of production may improve. These are very useful for industries because they help to increase production with the same level of resources and input with innovative technologies at work. However, along with these benefits there are some pitfalls of FDI, especially in emerging economies, for instance, in South Asia where FDI is responsible for pollution. Therefore, in order to mitigate this effect, the institutions may play an indirect role.

This research emphasized the importance of institutions in mitigating CO_2 emissions created by FDI. There is a need that the government and policymakers of the host country must strengthen the governance and introduce certain reforms in institutions. These reforms would ensure proper implementation which. in-turn, would weaken the adverse impact of FDI on the environment. In this way, the institutions may create an environment in which the foreign investors are encouraged to invest in industries and bring in technology through FDI that would be favorable for the environmental sustainability.

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Appendix

A1. List of Countries

Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka

A2. Data definitions and sources

Symbol	Variables	Definition	Source
CO_2	CO_2 emission	Metric tons per	WDI
FINDEV	Financial	Domestic credit	WDI
TRADE	Trade openness	Total trade as %	WDI
GFCF	Gross fixed	GFCF in current	WDI
ENERGY-USE	Government	Government	WDI
GDPPC	Gross domestic	GDP per capita	WDI
FDI	Foreign direct	Net inflow as %	WDI
CC	Control of	Estimate	WGI
GE	Government	Estimate	WGI
PS	Political stability	Estimate	WGI
RQ	Regulatory	Estimate	WGI
RL	Rule of law	Estimate	WGI
VA	Voice and	Estimate	WGI