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The Effects of Rule of Law, Regulatory Quality, and Renewable Energy on CO_2 Emissions in South Asia

Haider Mahmood[1]*, Shafiqul Hassan[2], Muhammad Tanveer[3], Abdul-Rahim Ahmad[4]

[1]Department of Finance, College of Business Administration, Prince Sattam Bin Abdulaziz University, 173 Al-Kharj 11942, Saudi Arabia, [2]College of Law, Prince Sultan University, Riyadh 11586, Saudi Arabia, [3]College of Economics and Administrative Science, Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia, [4]Department of Decision Sciences, School of Business and Leadership, Karachi, Pakistan. *Email: h.farooqi@psau.edu.sa

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ABSTRACT

Governance can help in regulating the environmental quality of any economy. Hence, the present study explores the effects of rule of law and regulatory quality on the CO_2 emissions in four South Asian economies from 1996 to 2019, controlling renewable energy and income level in the model. The results corroborate the Environmental Kuznets Curve (EKC) hypothesis in the long-run analysis of four South Asian economies but renewable energy could not affect the CO_2 emissions. Moreover, regulatory quality helps reduce CO_2 emissions and shows the technique and/or composition effects in these economies. However, the rule of law has a pre-dominant scale effect in these economies and increases CO_2 emissions. Based on the results, we recommend South Asian countries to strengthen the regulatory quality to support a clean environment. Moreover, rule of law needs attention and modifications to have pleasant environmental effects.

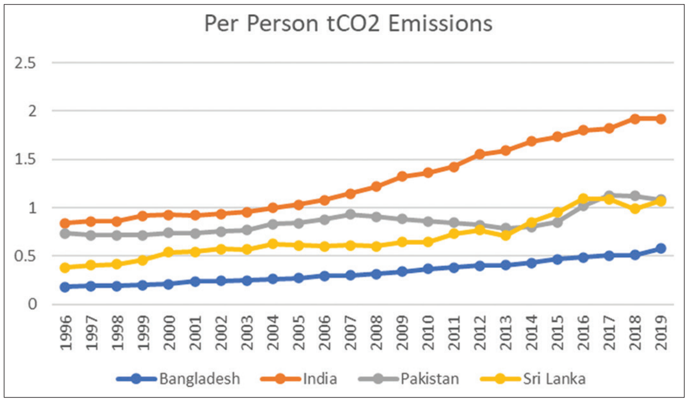
Keywords: CO_2 Emissions, Rule of Law, Regulatory Quality, Renewable Energy, Economic Growth
JEL Classifications: E02, O43, Q53

1. INTRODUCTION

South Asia has encountered many natural disasters, classified among the most vulnerable regions of the globe, and faced extreme climate changes in recent years (Mahmood et al., 2021). Therefore, South Asian economies could have environmental consequences of their economic growth (Ozturk et al., 2021). However, governance and renewable energy could play their active roles in the environment and would be helpful in cutting CO_2 emissions (Rehman et al., 2021a,b). Moreover, governance could accelerate technological innovation, which would help reduce emissions (Ullah et al., 2021). Hence, quality of governance indicators could help reduce CO_2 emissions (Mahmood and Alanzi, 2020). Particularly, control of corruption could facilitate a clean environment (Muhammad and Long, 2021). Figure 1 reflects the environmental profile of South Asia during 1996-2019. Per person tCO_2 emissions have almost positive trends in India, Bangladesh, and Sri Lanka on average during 1996-2019. In the case of Pakistan, the trend of per person tCO_2 emissions is positive during 1996-2007, which declines during 2008-2013. However, this trend is mixed and is positive from 2014 to 2017, which declines during 2018-2019.

In the growth and environment relationship, we cannot ignore the Environmental Kuznets Curve (EKC) testing. There are a number of studies testing this EKC hypothesis. However, we focus on the studies caring for renewable energy and governance indicators in analyses. For instance, Mahmood (2022b) investigated the EKC in nuclear-producing countries. The author validated the EKC in high income economies and the monotonic positive effects of economic growth in lower and middle income nations. Moreover, nuclear energy helped reduce emissions in high-income nations.

Figure 1: Per person tCO_2 emissions trends in four South Asian economies



Therefore, the EKC and positive environmental effects of nuclear are more dominant in high income countries. Shaari et al. (2020) explored the environmental effects of growth and renewable energy and found that renewable sources helped reduce CO_2 emissions. However, population and income showed positive effects on CO_2 emissions. Hence, the effects of affluence are found environmentally unpleasant. Muse (2021) investigated Nigeria and found that oil prices positively affect renewable energy and economic growth also accelerated the demand for renewables. Hence, the economic growth generated the technique and composition effects in the Nigerian economy. Muço et al. (2021) studied the European nations from 1990 to 2018 and energy policies helped to improve green growth. Particularly, energy efficiency and renewables helped reduce CO_2 emissions. Hence, cleaner type of energy along with energy efficiency had environmentally friendly effects in European nations. Alkhateeb et al. (2021) investigated oil abundant economy of Saudi Arabia from 1971 to 2018 and found that oil prices could affect the cyclicality of government policy, which limits the expenditure on renewable production.

Mahmood et al. (2022a) investigated Pakistan from 1996 to 2019 and found that rule of law negatively affected emissions in the short run. However, the effect was found insignificant in the long run, which depicts the policy that governance should be improved for a long time to trace pleasant environmental policies. Moreover, corruption control showed positive long run effects on emissions and negative in the short run. Thus, control of corruption showed dominant scale effects in the long run and dominant technique and composition effects in the short run. Jian et al. (2021) investigated China from 1991 to 2019 and found that law and order and educational attainment helped reduce CO_2 emissions in China. Thus, law and education can improve the environmental profile of China. However, population growth accelerated the emissions. Thus, population control is necessary to avoid environmental degradation in China.

Omri et al. (2021) investigated Saudi Arabia from 1996 to 2016 and found that overall governance and financial development accelerated carbon emissions. However, the interaction effects of both, as per political indicators, reduced the emissions. Thus, political and institutional governance variables remained major institutional factors in reducing pollution emissions. Güney (2022) investigated 35 nations from 2005 to 2018 and found that solar energy reduced CO_2 emissions. Moreover, the interaction of both solar energy and governance helped reduce emissions. Thus, governance along with renewable energy has complementary effects in cutting emissions in the investigated economies. Bakhsh et al. (2021) examined Asian economies from 1996 to 2016 and found that foreign investment boosted CO_2 emissions. It showed that Asia could not attract foreign investment in the clean production process. Moreover, institutional quality helped to moderate this relation, and technological innovation also played a positive role in combating the emissions. Hence, both indicators interacted by foreign investment helped reduce CO_2 emissions. In the same way, Khan and Rana (2021) investigated Asia and observed that institutions' quality reduced the growth of this region but had pleasant environmental effects by reducing CO_2 emissions.

Yuan et al. (2022) explored China from 2005 to 2017 and found that innovations helped in reducing CO_2 emissions. Moreover, institutional quality helped to strengthen the negative effects of innovation on emissions in different subsample time periods. The effects carried different magnitudes but remained negative. Hence, institutional quality helped in the moderation of the environment in China. Acheampong et al. (2021) explored 45 African nations from 1960 to 2017 and found that renewable energy and growth have causality relationships with emissions. Moreover, institutions and renewable energy helped in reducing emissions. Hence, both qualities of institutions and renewable energy use were necessary to have pleasant environmental effects in Africa. Khan et al. (2022) investigated the globe from 2002 to 2019 and found that renewable and foreign investments helped in reducing emissions. However, financial institutions and growth negatively affected the environment. Moreover, institutional quality helped to moderate the effects of all variables and had pleasant environmental effects. Thus, institutional quality augmented the effects of the investigated macroeconomic variables in reducing environmental effects.

Haldar and Sethi (2021) explored thirty-nine developing nations from 1995 to 2017 and found that institutional quality helped reduce energy consumption, which helped in reducing carbon emissions. Moreover, the EKC was validated and renewable sources helped in reducing CO_2 emissions. Li et al. (2021) investigated eighty-six nations from 2003 to 2014 and found that institutional quality moderated the positive environmental effects of foreign aid in the recipient countries. Moreover, green aid along with low corruption helped in the reduction of carbon emissions. However, poor institutional quality accelerated the emissions. Thus, the level of institutional quality does matter in determining carbon emissions. Hussain et al. (2021) investigated fifty-one nations from 1996 to 2017 and found that four indicators of governance helped to boost renewable energy in the economies and trade openness also played its role in this relationship. Thus, increasing renewable consumption would have pleasant environmental effects. Abid et al. (2021) investigated Pakistan from 2000 to 2017 and found that international standards helped in boosting green growth in the economy. Moreover, rule of law helped in mitigating the emissions and in boosting the green environment. Obobisa et al. (2022) explored twenty-five African nations from 2000 to 2018 and found that inventions and renewable energy decreased CO_2 emissions. However, institutional quality, income, and fossil fuels accelerated the emissions in the economies. Thus, poor institutional quality in African economies was the hurdle in the way of a clean environment.

The existing literature showed a mixture of positive and negative relationships between governance indicators and pollution emissions. For instance, some literature found the positive effects of governance indicators and institutional quality on pollution emissions (Yuan et al., 2022; Obobisa et al., 2022). However, some other studies also show the negative effects of governance indicators and institutional quality on pollution emissions (Güney, 2022; Acheampong et al., 2021; Khan et al., 2022; Haldar and Sethi, 2021; Li et al., 2021; Khan and Rana, 2021). Thus, the exact connection between different governance variables and pollution emissions is an empirical question. Some studies have investigated this issue in some South Asian economies (Mahmood et al., 2022a; Bakhsh et al., 2021; Abid et al., 2021). However, a thorough study is lacking in the literature to inquire about this issue focusing on a maximum sample of South Asian economies. Thus, the present study tries to fill this gap by examining the effects of rule of law, regulatory quality, Renewable Energy Consumption (REC), and income level on CO_2 emissions in Bangladesh, India, Pakistan, and Sri Lanka from 1996 to 2019.

2. METHODS

In the relationship between income level and emissions, we should not ignore the testing of the EKC. Because it is not necessary to have linear or monotonic effect of economic growth on pollution emissions. Moreover, governance quality may play an effective role in shaping the EKC. Because governance would shape the economy for cleaner production and energy use. Moreover, it may check those pollution-oriented activities to have lesser environmental effects in a country. Hence, rule of law and regulatory quality indicators are used to gauge the effect of governance on emissions. In addition, cleaner energy is the most desirable with economic growth for a clean environment. Considering all arguments, we regress the effects of economic growth, governance, and REC on CO_2 emissions in the following way:

$$CO2_{it} = f\,(GDPC_{it}, GDPC_{it}^2, REC_{it}, ROL_{it}, RQ_{it}) \quad (1)$$

$CO2_{it}$ is per person tCO_2 emissions. $GDPC_{it}$ is per person Gross Domestic Product (GDP), which reflects the growth of the economy. $GDPC_{it}^2$ is the square of $GDPC_{it}$. REC_{it} is the REC in exajoules. ROL_{it} is the rule of law index, which is one aspect of quality of governance. Lastly, RQ_{it} is regulatory quality, which is another aspect of quality of governance. *i* is showing Sri Lanka, Bangladesh, Pakistan, and India. *t* reflects annual series from 1996 to 2019. Macroeconomic series are sourced from World Bank (2022) and governance variables are obtained from Freedom House.

After data collection, we utilize the panel unit root Im-Pesaran-Shin (IPS) of Im et al. (2003), Levin-Lin-Chu (LLC) of Levin et al. (2002), and Augmented Dickey Fuller (ADF) and Phillip-Perron (PP) tests of Maddala and Wu (1999). Then, we apply Kao (1999) test to validate the panel cointegration, which ensures the stationarity of residual from the regression. Then, Maddala and Wu's (1999) procedures are applied in the following way to check the robustness of Kao results:

$$x = -2_{i=1}^{N} ln(prob_i) \quad (2)$$

After the two pieces of evidence of cointegration mentioned above, we apply Pedroni (2004) test to validate the results of cointegration. This technique used 4 within and 3 between statistics to validate the cointegration. Then, the long and short-run effects will be calculated using Pooled Mean Group (PMG), which is Auto-Regressive Distributive Lag (ARDL) (Pesaran et al., 1999) in nature and may be presented as:

$$\begin{aligned}\Delta CO2_{it} = {} & \alpha_i + \sum_{j=1}^{p-1}\gamma_{1j}\Delta CO2_{i,t-j} + \sum_{j=1}^{p-1}\gamma_{2j}\Delta GDPC_{i,t-j} + \\ & \sum_{j=1}^{p-1}\gamma_{3j}\Delta GDPC_{i,t-1}^2 + \sum_{j=1}^{p-1}\gamma_{4j}\Delta REC_{i,t-j} \\ & + \sum_{j=1}^{p-1}\gamma_{5j}\Delta ROL_{i,t-j} + \sum_{j=1}^{p-1}\gamma_{6j}\Delta RQ_{i,t-j} + \mu_1 CO2_{i,t-1} \\ & + \mu_2 GDPC_{i,t-1} + \mu_3 GDPC_{i,t-1}^2 + \mu_4 REC_{i,t-1} + \\ & \mu_5 ROL_{i,t-1} + \mu_6 RQ_{i,t-1} + e_{1it}\end{aligned} \quad (3)$$

$$\begin{aligned}\Delta CO2_{it} = {} & \alpha_i + \varphi_j u_{i,t-1} + \mu_1 CO2_{i,t-1} + \mu_2 GDPC_{i,t-1} \\ & + \mu_3 GDPC_{i,t-1}^2 + \mu_4 REC_{i,t-1} + \mu_5 ROL_{i,t-1} + \mu_6 RQ_{i,t-1} + e_{1it}\end{aligned} \quad (4)$$

The Wald test will be used to inquire about the cointegration in equation 3 and long run effects will be estimated afterwards. Then, equation 4 will be estimated to find the short run effects.

3. DATA ANALYSES

At first, stationarity and normally of series are tested and Table 1 displays unit root based on the four tests, i.e., LLC, IPS, Fisher-ADF, and PP tests. At levels, all series are non-stationary, except REC_{it} in the LLC test, and RQ_{it} in IPS and PP tests. The level REC_{it} is stationary at 5% significance level and RQ_{it} is stationary at 10% significance level. Moreover, all variables are stationary at their first differences. Though, the integration level is mixed but ARDL may generate unbiased results in this case.

Results show the cointegration in some statistics of the Pedroni test at 1% and 5% levels of significance in Table 2. Moreover, the Kao test also shows the stationarity of residual at 1%. In addition, the Fisher-Johansen technique reveals six cointegrating vectors. In sum, all cointegration tests give strong evidence of the long run relationship in the hypothesized panel model. In addition, the negative parameter of ECT_{t-1} is also provided same evidence, presented in Table 3. Thus, long and short run analyses can be proceeded with this evidence from three cointegration techniques and the negative parameter of ECT_{t-1}.

Table 1: Panel unit root test

Series	LLC		IPS		Fisher-ADF		PP	
	C	C&T	C	C&T	C	C&T	C	C&T
Level								
$CO2_{it}$	0.8126	−1.1253	2.2620	−0.1783	2.8562	1.7206	0.9002	1.3191
	(0.7918)	(0.1302)	(0.9882)	(0.4188)	(0.9431)	(0.8964)	(0.9988)	(0.9152)
$GDPC_{it}$	2.1440	0.0572	3.7236	0.4687	1.0839	7.1783	0.3346	5.4358
	(0.9840)	(0.5228)	(0.9999)	(0.6803)	(0.9977)	(0.5175)	(1.0000)	(0.7101)
$GDPC_{it}^2$	2.5427	0.2686	4.0755	0.7917	0.9644	6.8052	0.2384	4.6803
	(0.9945)	(0.6059)	(1.0000)	(0.7857)	(0.9985)	(0.5578)	(1.0000)	(0.7911)
REC_{it}	−1.6736	0.4647	0.6979	1.4204	4.4642	2.8035	3.8387	2.3137
	(0.0471)	(0.6789)	(0.7574)	(0.9222)	(0.8130)	(0.9461)	(0.8714)	(0.9699)
ROL_{it}	−0.5625	0.0694	−0.5582	−0.2510	9.7772	7.8435	7.3103	7.3709
	(0.2869)	(0.52778)	(0.2884)	(0.4009)	(0.2810)	(0.4489)	(0.5036)	(0.4972)
RQ_{it}	−0.3983	0.6525	−1.4766	−0.1345	13.3548	6.8668	13.7525	7.2654
	(0.3452)	(0.7430)	(0.0699)	(0.4465)	(0.1002)	(0.5512)	(0.0884)	(0.5083)
First difference								
$\Delta CO2_{it}$	−1.7580	−2.0482	−3.5935	−1.9503	27.9984	17.0020	−1.7580	55.1038
	(0.0394)	(0.0241)	(0.0002)	(0.0256)	(0.0005)	(0.0301)	(0.0394)	(0.0000)
$\Delta GDPC_{it}$	−3.6956	−4.7528	−1.5699	−1.3566	15.7476	16.5267	22.5473	14.4682
	(0.0000)	(0.0000)	(0.0582)	(0.0926)	(0.0461)	(0.0362)	(0.0040)	(0.0703)
$\Delta GDPC_{it}^2$	−1.8938	−1.6325	−1.3271	−1.4171	14.2184	17.3641	20.8397	13.4521
	(0.0452)	(0.0874)	(0.0999)	(0.0918)	(0.0762)	(0.0257)	(0.0076)	(0.0972)
ΔREC_{it}	−2.5829	−2.1093	−2.3001	−1.3389	17.9461	32.7353	38.6329	30.6989
	(0.0049)	(0.0175)	(0.0107)	(0.0903)	(0.0216)	(0.0000)	(0.0000)	(0.0002)
ΔROL_{it}	−3.2676	−2.0522	−4.7789	−4.0339	37.0430	30.0746	59.9784	65.4584
	(0.0005)	(0.0201)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0000)
ΔRQ_{it}	−3.2910	−2.1233	−3.6351	−2.2831	27.8451	18.0305	56.6019	42.1591
	(0.0005)	(0.0169)	(0.0001)	(0.0112)	(0.0005)	(0.0210)	(0.0000)	(0.0000)

Note: () contains P-values. C shows intercept and T shows trend

Table 2: Panel cointegration

Pedroni test				
Within-dimension	Stat.	Prob.	Weighted-stat.	Prob.
Panel-v	−0.7001	0.7581	−0.9175	0.8206
Panel-rho	1.4126	0.9211	1.2758	0.8990
Panel-PP	−1.5443	0.0613	−1.8381	0.0330
Panel-ADF	−2.5391	0.0056	−2.0577	0.0198
Between-dimension				
Group-rho	2.1832	0.9855		
Group-PP	−2.7675	0.0028		
Group-ADF	−1.8634	0.0312		
Kao residual cointegration test				
ADF	−3.5736	0.0002		
Fisher-Johansen trace test				
No. of CE (s)	Trace test	Prob.	Max-eigen test	Prob.
None	208.00	0.0000	98.15	0.0000
At most 1	131.50	0.0000	56.72	0.0000
At most 2	87.93	0.0000	35.91	0.0000
At most 3	60.27	0.0000	33.80	0.0000
At most 4	37.10	0.0000	30.01	0.0002
At most 5	19.66	0.0117	19.66	0.0117

Table 3 shows the PMG estimations based on the ARDL framework. The coefficient of $GDPC_{it}$ is positive, which means that CO_2 emissions are increasing with the increasing economic growth. However, the coefficient of $GDPC_{it}^2$ is negative, which means that CO_2 emissions would decrease after a threshold point with increasing economic growth. These results validate the EKC in four South Asian economies with a turning point of 6124 USD, which is calculated from the coefficients of $GDPC_{it}$ and $GDPC_{it}^2$. However, both current and average per person GDPs are lesser than 6124 USD in all four investigated countries. Hence, increasing economic growth has a predominant scale effect over technique and composition effects of growth and is responsible for ecological degradation by releasing emissions. In the same way, Mahmood (2022b) also corroborated the EKC in the nuclear-producing nations. The coefficient of REC_{it} is negative but insignificant. So, renewable energy could not help in reducing emissions. It is due to the fact that most South Asian economies rely on fossil fuels mostly and are carrying a meager proportion of renewables in their energy profiles. Thus, these are reasons for the insignificant effect of renewable energy in our estimates. In contrast, literature corroborated the negative effect of REC on emissions (Shaari et al. 2020; Muço et al., 2021). However, our insignificant

Table 3: PMG results

Series	Coefficient	Std. Error	t-Stat.	P-value
Long run				
$GDPC_{it}$	5.4867	1.4129	3.8833	0.0002
$GDPC_{it}^2$	−0.3146	0.0950	−3.3117	0.0015
REC_{it}	−0.0076	0.0134	−0.5707	0.5702
ROL_{it}	0.3087	0.1063	2.9046	0.0051
RQ_{it}	−0.3839	0.0922	−4.1629	0.0001
Short run				
$\Delta GDPC_{it}$	−6.9228	8.7687	−0.7895	0.4328
$\Delta GDPC_{it}^2$	0.4684	0.6832	0.6856	0.4955
ΔREC_{it}	−0.0264	0.0182	−1.4545	0.1508
ΔROL_{it}	0.0059	0.1456	0.0404	0.9679
ΔRQ_{it}	0.0069	0.0157	0.4433	0.6591
ECT_{t-1}	−0.3648	0.1576	−2.3148	0.0239
Intercept	−8.5639	3.7315	−2.2950	0.0251

result shows a low capacity of South Asian economies in the adaptation of renewable energy.

The coefficient of ROL_{it} is positive and significant. Hence, rule of law shows a positive influence on CO_2 emissions in South Asia and is responsible for environmental degradation. It is showing a pre-dominant scale effect over technique and composition effects of rule of law in the South Asian economies. Thus, the increasing rule of law is supporting more economic activities and using more fossil fuels, which have environmental consequences by emitting CO_2 emissions in South Asia. Along the same lines, some literature realized the positive effect of control of corruption on emissions in Pakistan (Mahmood et al., 2022a), and the positive effect of governance on emissions in Saudi Arabia (Omri et al., 2021), in Asia (Bakhsh et al., 2021), in China (Yuan et al., 2022) and in African economies (Obobisa et al., 2022). In contrast, some studies found a negative effect of rule of law on emissions (Mahmood et al., 2022a; Jian et al., 2021). Moreover, our results display that the parameter of RQ_{it} is negative. Thus, the technique and composition effects are dominant over the scale effect of regulatory quality in South Asia. So, regulatory quality help in reducing CO_2 emissions in the South Asian region. It reflects that the regulatory quality of this region is perusing the use of cleaner energy and/or technologies. Hence, it is promoting the net effect of technique or/and composition in the region. Consequently, the technique or/and composition effects are helping in reducing CO_2 emissions in the region. In the same way, some studies found the negative effects of governance indicators and institutional quality on emissions (Güney, 2022; Acheampong et al., 2021; Khan et al., 2022; Haldar and Sethi, 2021; Li et al., 2021). Particularly, Khan and Rana (2021) corroborated this negative effect in Asia.

In the short run, ECT_{t-1} is negative. It corroborates a convergence from short-run disequilibrium to a long-run adjustment path at a speed of more than 4 months in a year. However, all factors could not affect the CO_2 emissions in the short-run analysis. It means that all hypothesized factors need a long time to be effective on the CO_2 emissions. Particularly, governance is not a short-run phenomenon, and it needs time to have any kind of effects on the economy and the environment. In the same way, renewable energy needs maturity to have a significant proportion in the total energy mix to be effective in reducing CO_2 emissions. However, economic growth should have immediate effects on the environment. The insignificant effect reflects that the negative environmental scale effect of growth is nullifying by the expected positive environmental effects of technique and composition effects. Hence, the short-run effects of economic growth remain undetermined to have any kinds of positive or negative effects.

4. CONCLUSIONS

We examine the effects of economic growth, rule of law, regulatory quality, and REC on CO_2 emissions in four Asian countries from 1996 to 2019. Panel techniques are utilized and cointegration is corroborated in 3 cointegration tests and with a negative parameter of error correction term. Moreover, the positive effect of the linear and negative effect of quadratic term of economic growth are found, which corroborate the EKC hypothesis in the South Asian region with a turning point of 6124 USD. It means that economic growth after a certain threshold point would have positive environmental consequences in the South Asian region. But all sample economies are facing 1st stage of the EKC and have environmental consequences of growth in their economies. The effect of regulatory quality is found as negative. Hence, improving regulatory quality can improve the usage of clean technologies and would have technique and composition effects to support the environmental quality in the region. However, the positive effect of rule of law is found on CO_2 emissions. It reflects the net scale effect of the improving rule of law in South Asian economies. For instance, the improving rule of law is increasing economic activities and demand for more energy without caring for cleaner types of energy uses. Consequently, rule of law is increasing CO_2 emissions in South Asia. Surprisingly, renewable energy shows an insignificant effect. Thus, the South Asian economies do not reach a certain scale of REC, which could cut CO_2 emissions. Based on the results, we recommend South Asian economies to accelerate the regulatory quality in the region to support a clean environment in the region. Moreover, REC in total energy usage should also be increased to enjoy its positive environmental consequences in the region.

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