Environmental Science and Pollution Research (2021) 28:53781–53792
https://doi.org/10.1007/s11356-021-14430-3

RESEARCH ARTICLE

Environmental quality: examining role of financial development, institutional capacity, and corruption

Ameet Kumar[1] · Muhammad Ramzan Kalhoro[1] · Rakesh Kumar[1] · Niaz Ahmed Bhutto[1] · Ruqia Shaikh[2]

Received: 24 December 2020 / Accepted: 11 May 2021 / Published online: 26 May 2021

Abstract

This study aims to investigate the influence of institutional capacity on the relationship between financial development and environmental quality and also examines the moderating role of corruption on the link between institutional quality and environmental quality. By using yearly data from 33 developing countries for 7 years from 2011 to 2017, this paper applies a dynamic technique system GMM. The results suggest that financial development increases environmental degradation due to possible higher energy-intensive investment. However, institutional capacity moderates its impact on environmental quality by channelizing the funds to energy-efficient investment. The findings of this study suggest that financial development improves the environmental quality when institutional capacity is higher than 3.5 on the scale of 0 to 6. Interestingly, institutional capacity is unable to control environmental degradation in the presence of corruption. The results propose that financial development has a positive relation with environmental degradation in the presence of corruption. Nevertheless, relationship between institutional capacity and environmental degradation turns to negative when corruption improves in the economies. Furthermore, the findings show that institutional capacity may only control environmental degradation when corruption improves to 40 or higher on a scale of 0 to 100. The policy implications of this study are useful for policy departments, environmental regulatory bodies, and financial institutions.

Keywords Institutional capacity · Environmental quality · Financial development · System GMM · Corruption

Introduction

In the course of the last few decades, environmental degradation and global warming have emerged as the two foremost threatening and controversial worldwide issues. The greenhouse gas (GHG) emissions are considered the main cause of these two problems. CO_2 emissions, among other greenhouse gases, are most tarnished because of negative influences on human health and environmental quality around the world. Change (2014) reported that it accounted for about 76.7% of total greenhouse gas emissions. Therefore, mitigating CO_2 emissions has become the main concern for economists and policymakers because carbon emissions create numerous hindrances in means of economic growth. It has become very essential to recognize the way to hold such economic growth while lowering CO_2 emissions. The solution to this problem lies in strong financial development (Lahiani 2020; Yuxiang and Chen 2011).

Yuxiang and Chen (2011) theoretically believe that financial development will affect CO_2 emissions across numerous channels. A well-developed financial system along with environmental protection regulations may decrease the funding cost and encourage innovative technological advances in the energy sector and may subsequently positively contribute towards environmental quality (Tamazian et al. 2009; Abbasi and Riaz 2016; Corsatea et al. 2014). For instance, a sound and efficient financial system promote higher investment in green technology (Anton and Afloarei Nucu 2020), which may ameliorate the environmental quality. Moreover, a well-developed and efficient financial system may support the firms in reducing the liquidity risk and raise funds for developing energy-efficient technologies at a lower cost of capital. Hence, higher investment in energy-efficient

Responsible Editor: Nicholas Apergis

✉ Muhammad Ramzan Kalhoro
ramzan.kalhoro@iba-suk.edu.pk

[1] Department of Business Administration, Sukkur IBA University, Airport road Sukkur, Sindh, Pakistan

[2] Zhengzhou University of Economics and Law, Zhengzhou, China

technologies, i.e., renewable energy, may reduce environmental degradation. Nonetheless, if financial development is largely supporting the traditional industries rather than green technology, then that may increase the GHG emissions. There are three channels through which financial development may negatively affect the environmental quality. First, strong financial system provides funding for manufacturing industries and higher manufacturing activities would increase the concentration of CO_2 in the environment (Jensen 1996). Second, financial development may attract foreign direct investment FDI and may boost the economic growth. That boost in economic growth has negative consequences for environmental quality (Frankel and Romer 1999). Last, an efficient financial system is conducive to customer loan activities and facilitates the customer in purchasing durable items such as automobiles, refrigerators, and air conditioners, and then increase the GHG emissions in the environment (Sadorsky 2010).

An efficient and effective financial system is necessary but not sufficient to improve environmental quality. A sound and effective financial system works as a lubricant for the emerging world, but it can worsen the environment if a handsome portion of capital is invested in the energy-intensive industry (Ganda 2019). This suggests that green investment requires special policies, rules, procedures, structure, and networks, which may boost investments in environmentally friendly projects. The abovementioned components can be best reflected in institutional capacity; hence, we propose that higher institutional capacity may moderate the relationship between financial development and environmental degradation. Institutional capacity is a broad term that focuses on many aspects, i.e., social capital, empowerment, social and cultural values, and power relationships that influence us (Segnestam 2003). Willems and Baumert (2003) states that higher institutional capacity requires integration and motivation from all levels of society: individual, organizational, and macro-level to reduce emissions. At an individual level, if people are motivated and get financial and non-financial perks from the organization, they may work innovatively to reduce the emission; for example, they may produce green products and develop a green process for production. Likewise, organizational performance is also a key factor of overall capacity building. If they have clear, mutually compatible missions, resources, and management practices, then they can develop an organizational structure for green products through environmentally sound technology. Nonetheless, organizational performance is heavily dependent on a macro level institutional setting. The institutions at country level may create network, provide subsidies, and devise policies and regulation to incite public and private firms to get involved in green products and services. In this way, higher networking, availability of policies, rules, provisions of finance, adaptability, and stability of institutional arrangements are key factors in developing the institutional capacity. When all levels of characteristics (individual, organization, and country) will be motivated and have set rules practices, policies, and resources, the country will have more capacity to mitigate disastrous climate change. Adenle et al. (2017) explore the environmental-based institutional variable named country policy and institutional assessment for environmental sustainability and find that institutional capacity is a major impediment in attracting the financing for low carbon development in African countries.

The above underpinning reveals that higher capacity may improve the environmental quality but there can be another side of the story too. Higher capacity may only contribute significantly if a majority of the members (individual or organizations) of the society follow that transformed structure, policies, and rules to mitigate the climate change, but if some of the members circumvent these policies, rules, and procedures for their own economic benefit, then institutional capacity at country level may fail to contribute towards the environmental quality. For instance, some firms may find it costly to incorporate climate-related policies which may decrease their profitability. Then, they may use illegitimate ways, i.e., bribery, nepotism, etc., to the institutional officer and subsequently following the traditional process, which may increase the carbon emissions. These illegitimate ways are components of corruption. Though corruption may be a tiny part of the overall institutional capacity index, its substantial impact on institutional capacity is worth exploring. Yong Kim, the president of the World Bank, also ranked corruption as the number one enemy, especially in emerging countries. Granoff et al. (2016) found corruption to be one of the major impediments towards low carbon infrastructure investments, especially in emerging countries. Hence, corruption may derail and divert the impact of institutional capacity on environmental quality.

The evidence about the conditional impact of corruption on the relationship between institutional capacity and environmental quality, and conditional impact of institutional capacity on the relationship between financial development and environmental quality, do not exist in literature as per our knowledge. Therefore, this study adds to the empirical analysis of the environmental quality by analyzing the moderating role of both environmental-related institutional capacity and corruption in the nexus between finance development and environmental quality, and in the connection between institutional capacity and environmental quality, respectively. The key contributions of this study are summed up in four points. First, it is the first research that explores the conditional effect of environmental-related institutional capacity and corruption in the nexus between finance development and environmental quality, and in the connection between institutional capacity and environmental quality, respectively, thus paying attention to CO_2 emission reduction, unlike previous studies, in view of the sustainable development goals. Second, this study focuses on a panel data analysis in the context of 33 developing countries—where environmental degradation is more intense and pervasive than other developing as well as developed countries—using a more recent database spanning 2004 to 2017. Third, this research looks at the composite index of financial development utilizing four financial variables relating to financial depth, financial efficiency, financial access, and financial stability. Finally, we not only construct a composite index of financial development using the methodology of principal component analysis (PCA) to prevent the issue of multicollinearity and the subjective choice of variables but also to take into account the various dimensions of financial development. This research also utilizes many econometric methods, including two estimators of the generalized moments method (GMMs), i.e., the differential GMM, system GMM, and margins plot, to resolve the endogeneity issue among variables.

The findings of this study suggest that financial development may ameliorate environmental degradation if institutional capacity is high in the country. On the contrary, it may increase the degradation in the environment if institutional capacity is not low. These results are based on the argument that high institutional capacity—proper policies, procedure, rules, regulations, and networks—may incite energy-efficient and green investment which may inhibit carbon emissions. Moreover, higher corruption may divert the role of institutional capacity through bribery, nepotism, and other illegitimate and illegal means. It can be inferred from the results that a sound financial system along with higher institutional capacity may reduce carbon emissions if corruption is lower in the economy.

Literature review

There is wide-ranging literature available on the relationship between carbon emission and financial development. There are two strands of literature in this area. One strand of the literature suggests that financial development increases carbon emission as it helps a country to expand its economy by facilitating the creditors. For instance, many studies have found the eminent long-run positive connection between economic growth, energy usage, and emission of carbon (Ang 2008; Ozturk and Acaravci 2010). Similarly, Sadorsky (2010) suggested that an effective financial market motivates consumers to take the loan and buy durable goods like electronic appliances and automobiles which increase the emission of CO_2. According to Dasgupta et al. (2001), an efficient stock market reduces the cost of financing and allows listed companies to raise their funds easily which allow them to invest in new projects that ultimately lead to an increase in their output, higher energy consumption, and eventually higher carbon emission. Ma et al. (2015) studied the nexus between several variables (money and quasi money (M2), domestic credit provided by the banking sector and private sector credit, liquid liabilities (M3), and FDI) for South Asia. The results reveal that all these variables will increase the carbon emission in the long run and they have absolutely no impact in the short run. Shahbaz et al. (2015) and Boutabba (2014) also confirm these findings for India that financial development has degraded the environmental conditions.

However, another strand of the literature suggests that financial development will increase the investment in energy-efficient technologies, which help in reducing carbon emission. Frankel and Romer (1999) suggest that an efficient financial sector development increases the FDI in a country which leads to an effective level of research and development (R&D), and eventually results in better environmental quality. Bello and Abimbola (2010), and Talukdar and Meisner (2001), also suggest in their studies that financial development increases the FDI and investment in energy-efficient projects that resultantly reduce the emission of carbon. Similarly, Tamazian et al. (2009) suggest that an efficient financial sector urges the public listed companies to invest more in environment-friendly projects. Shahbaz et al. (2013a), Shahbaz et al. (2013b), and Shahbaz et al. (2013c) studied the impact of financial development on carbon emission for Malaysia. The results revealed that private sector credit reduces carbon emission.

The above underpinnings of literature reveal that there is no consensus among the researchers about the nexus between financial development and CO_2 emission. We surmise that this difference is because of variation in special policies, rules, procedures, structure, networks, individual, and organizations for environmental standards among countries. These components are parts of institutional capacity (William, 2003). Higher environmental-based institutional capacity facilitates the financial system to provide more funding for innovative and energy-efficient projects which have a lower impact on carbon emission and discourage the funding for traditional energy-intensive investment which can worsen environmental quality. In this regard, Aklin and Urpelainen (2014) suggested the institutional capacity (in the form of environment ministries) is one of the key components impacting the environmental policies. Laird and Stefes (2009) also found that superior institutional capacity in Germany through the creation of Nuclear Safety, Federal Ministry for Environment, and Nature Conservation was the key reason for their early success in the installation of renewable energies compare to the USA. Besides, Lipp (2007) also found that institutional capacity, specifically in Germany and Denmark created through the feed-in-tariff scheme, was the key reason for their success in reduction of carbon emission compared to the UK, that higher environmental-based institutional capacity will require huge investments in renewable, energy-efficient project, thereby creating a need for more finance. A sound and well-developed financial system may facilitate the organizations to meet their need for financing. Therefore, we claim that environmental-based institutional capacity may influence the relationship between financial development and environmental quality.

Moreover, many developed countries, including the USA, Japan, Sweden, and Germany, have emphasized the strong institutional capacity while setting the environmental policies (Hughes and Urpelainen 2015). The existing literature reveals that developed countries have achieved better environmental quality (Hughes 2012; Aklin and Urpelainen 2014; Laird and Stefes 2009). Similar to developed countries, developing countries also have an impressive number of environmental regulations and policies but some empirical studies including Walter and Ugelow (1979) suggest that environmental policies and regulation are ineffective in developing countries. López and Mitra (2000) found that environmental degradation was more frequent in developing countries with weaker institutions and higher political instability. Developing countries also have relatively well-designed environmental policies but their continuous ineffectiveness may call for other factors, i.e., corruption. Fredriksson et al. (2004) investigated the impact of corruption on energy policy and they found that corruption leads to relaxed environmental policies and lower environmental regulations. In a study by Baksi and Bose (2010), strict environment regulation may stimulate the polluting companies to migrate to the shadow economy to increase their returns. Our study claims that corruption derails the impact of institutional capacity on carbon emission as corruption corrodes the enforcement of environmental regulations, policies, and practices. For example, officials may take the bribe and allow polluter companies to by environmental standards. Corruption is defined by Bardhan (1997) as misuse of public office for personal benefits. Winbourne (2002) also explained that corruption may add fuel to the advancement of the environmentally harming policies. Fredriksson et al. (2004) and Sheng et al. (2016) have found that higher levels of corruption lead to reduction in the stringency of environmental rules and regulations. Hence, one contribution of our study is to examine how corruption derails the impact of institutional capacity on carbon emission in developing countries.

Data and methodology

Data

To study the impact of financial development, environmental-based institutional capacity, and corruption on environmental quality, we use data of 33 emerging countries with a frequency of yearly data from 2004 to 2017. Multiple sources are used to develop this panel data. We obtain the data of CO_2 emissions per capita—that is dependent variable and other variables including institutional capacity, GDP growth, FDI, energy intensity, industrialization, and trade openness from the WDI. Financial development indicators are extracted from the Global Financial Development Database in the World Bank. Transparency International source is used to get the Corruption Perception Index data.

This study uses CO_2 per capita emission to measure the environmental quality, while CPIA policy and institutions for environmental sustainability rating are used to assess the impact of environmental-based institutional capacity. Considering the different dimensions of financial activities, i.e., raising funds for productive activities; creating and disseminating the crucial information, liquidity, risk management, and control; and reduction in transaction cost (Levine et al. 2002), we develop two multidimensional financial development indexes comprising, e.g., financial depth, financial efficiency, financial access, and financial stability. Following Kassi et al. (2020), the first index is devised by using three components including financial access, financial depth, and financial efficiency, while in the second index additional component of financial development "financial stability" is included in addition to those three components. Financial access, depth, financial, and stability is measured through ATMs per 100,000 adults, domestic credit to the private sector (% of GDP), bank net interest margin (%), and bank Z-score respectively. These financial development variables are suggested by Čihák et al. (2013) and Kassi et al. (2020).

Model and econometric specification

This study applies the principal component analysis (PCA) to derive the financial development of composite indexes. This technique shortens the length of the model by eliminating the highly correlated variables which otherwise could raise the multicollinearity issue. Additionally, it also helps to avoid the arbitrary choices of the variables and provides a complete sense of multifaceted variables by narrowing the dimensionality of large datasets to increase their interpretability without loss of information (Semmlow and Griffel 2014). Therefore, the PCA technique does not only resolve the redundancy issue but also lessens the noise as it only selects the principal components with high variability.

In this study, we investigate the impact of financial development and institutional environmental capacity on CO_2 emissions while incorporating the impact of corruption. The existing literature suggests that financial development may negatively affect environmental degradation in three ways. Firstly, a strong financial system bolsters manufacturing activities, which would intensify the concentration of CO_2 in the environment (Jensen 1996). Secondly, financial development may attract foreign direct investment FDI and may boost economic growth. That boost in economic growth has negative consequences for environmental quality (Frankel and Romer 1999). Thirdly, a sound financial system shoots the loan activities and facilitates the customer in purchasing durable items that increase the CO_2 emissions in the environment (Sadorsky 2010).

We follow the following theoretical model as the general function of CO_2 emissions.

$$CO_2 = \alpha_t + \beta_1 Y_t + \beta_2 F_t + \beta_3 E_t + \beta_4 I_t + \beta_5 T_t + \mu$$

where it represents the carbon emission, while Y_t, F_t, E_t, I_t, and T_t measure GDP per capita, FDI, energy intensity, industrialization, and trade openness, respectively, and α_t and μ are the constant and error term respectively.

This study uses three approaches in the analysis. First, we investigate the dynamic impact of financial development and institutional capacity on CO_2 emissions. Additionally, we examine the moderating impact of institutional capacity on the financial development-CO_2 nexus, where we develop two multidimensional financial development indexes comprising, i.e., financial depth, financial efficiency, financial access, and financial stability. Lastly, we see the moderating impact of corruption on institutional capacity—CO_2 emission. We develop the financial development indexes through the below components.

Where it measures the domestic credit to the private sector (financial depth), net margin interest (financial efficiency), ATM per 100000 people (financial depth), and Z-score (financial stability).

The following model is developed to assess the causal impact of financial development and institutional capacity on CO_2 emissions as well as the interaction of financial development and institutional capacity.

$$lnCO2_{it} = \alpha_{it} + \beta_1 \; lnCO2_{it-1} + \beta_2 fin_{ijt} + \beta_3 IC_{it} + \beta_4 \left(fin_{ijt}.IC_{it} \right) + \beta_5 Y_{it} + \mu_{it} \quad (1)$$

Here i indicates the country (i = 1… 33) and indicates the annual period (t = 2004…2017). Dependent variable measures the environmental quality, while β_2 is one of the two indexes developed by compiling the different components of financial development, i.e., financial access, depth, efficiency, and stability. β_3 denotes the institutional capacity of the environment and represents the set of core variables containing GDP per capita, FDI (foreign direct investment), energy intensity, industrialization, and trade openness. $\beta_4 < 0$ implies that financial development and institutional capacity may combine to reduce CO_2 emissions, while $\beta_4 > 0$ posits that the combined effect of institutional capacity and financial development increases environmental degradation. β_5 represents the core variables, i.e., GDP (gross domestic product) growth, FDI (foreign direct investment), EI (energy intensity), industrialization, and trade openness.

Additionally, in order to assess the impact of financial development at different levels of institutional capacity, we use marginal impact in the following manner.

$$\frac{\alpha \; CO2_{it}}{\alpha \; fin_{ijt}} = \beta_1 + \beta_3 IC_{it} \quad (2)$$

Then we also see the combined impact of institutional capacity and corruption on environmental quality.

$$CO2_{it} = \alpha_{it} + \beta_1 \; CO2_{it-1} + \beta_2 IC_{it} + \beta_3 Corp_{it} + \beta_4 \left(IC_{it} + Corp_{it} \right) + \beta_5 Y_{it} + \mu_{it} \quad (3)$$

where $\beta_4 < 0$ would suggest that institutional capacity along with control on corruption may reduce environmental degradation, while $\beta_4 > 0$ would posit that the combined effect of institutional capacity and financial development increases environmental degradation.

Lastly, we also explore the impact of institutional capacity on environmental quality at different levels of corruption and we derive the below model.

$$\frac{\alpha \; CO2_{it}}{\alpha \; IC_{it}} = \beta_1 + \beta_3 Corp_{it} \quad (4)$$

Empirical procedure and econometric techniques

The analysis process of the analysis starts with the examination of the distribution of variables. Descriptive statistics, as well as panel unit root tests, are performed. We run four-panel root unit tests, i.e., Dickey and Fuller (1981), Im et al. (2003), Levin et al. (2002), Phillips and Perron (1988). Under the null hypothesis, these tests suppose that there is the unit root, while the alternative hypothesis suggests that data is stationary.

Next, we use the system GMM for our panel data of different countries. Panel data mostly face heteroscedasticity, endogeneity, and serial correlation problems, which may hamper the reliability of the model that may lead to spurious results. The serial correlation arises when there is a correlation between variable's disturbance term and another variable of the model (Attari et al. 2016), while endogeneity is found when there is the correlation between the independent variables and error term (Bölük and Mert 2015; Attari et al. 2016). Moreover, the heteroscedasticity issue occurs when error variance terms diverge across observations (Simpson 2012). System GMM is the robust and appropriate technique to cope up with this issue (Arellano and Bond 1991; Roodman 2009). Moreover, since we have a data panel of different countries, so System GMM will also cope with the problem of heterogeneity (Maddala and Wu 1999). We use this dynamic technique to examine the impact of financial development, institutional quality, and corruption on environmental quality. This system GMM technique is most suitable for our dynamic model having large pane (N) and small period (T), i.e., N > T.

In order to maintain the reliability of System GMM, it is essential to hold the two important conditions. First, the error term should be free from serial correlation, and secondly, instruments must not be correlated with the error term. The Arellano-Bond test is used to analyze the serial correlation; it analyzes the first-order and second-order auto-correlated disturbance in the differenced equation. Hansen and Singleton (1982) and Sargan (1958) of over-identification restriction are used for the validity of instrument; this test detects the correct specification and having the null hypothesis of instrument validity.

Results

Descriptive statistics

Table 1 shows the descriptive statistics for the dependent and independent variables used in the multivariate regression model, for our entire analysis. Keeping the focus on the main variables of interest, the average CO_2 concentration in these emerging economies is 0.62 tons per capita, where its highest point in the most polluted region is 9.38 tons per capita. The average institutional capacity is 3.19 which is lower than the middle value (3.5) of the index. Average corruption index (CPI) is 28.85 on a scale of 0–100, which shows that higher corruption is deep and pervasive in emerging countries; even the highest value is 55, which approximately lies in the middle of the scale.

Table 1 Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
CO_2	0.628228	1.536027	.0207304	9.836549
IC	3.198135	.5061734	2.000000	4.00000
Corp	28.85412	8.027805	11.00000	55.00000
Fin _1	−0.002620	1.373271	−3.656500	3.794551
Fin _2	0.045020	1.448898	−3.439950	3.739101
EI	6.854891	3.438725	1.910320	22.87962
GDP	1311.346	1329.823	214.1390	7582.72
FDI	4.015674	6.292173	-6.057209	50.63641
Ind	24.59258	11.89550	2.073170	77.41370
Tro	63.68762	28.50131	19.10080	165.646

This table document the descriptive statistics of all variables. CO_2-dependent variables represents carbon emissions. *IC* and *Corp* show institutional capacity and corruption, while *fin*_1 and *fin*_2 are two indexes of financial development. *EI*, *GDP*, *FDI*, *Ind*, and *Tro* represent energy intensity, GDP growth, foreign direct investment, industrialization, and trade openness respectively

Result of the principal component analysis

Table 2 explains the outcomes of the financial development composite indices developed by using the principal component analysis (PCA) method. This method helps to eliminate arbitrary variables selections, and it also allows the multiple aspects of financial development to create simulated indexes containing their full representation. Thus, three separate indexes of financial development have been created, which includes financial depth, financial inclusion, and financial stability using the PCA process, such as *Findi _* 1, *Findi _* 2, and *Findi _* 3.

Furthermore, the above table shows that *Findi _* 1's first large financial depth factor seems to have an eigenvalue value of 3.13, which reflects a 78.46% variation in the original variables. Likewise, the leading financial development elements, i.e., *Findi _* 2 and *Findi _* 3, express 62.68% and 52.33% of the information found in their components, respectively, with eigenvalue values of 1.88 and 2.09. Therefore, these first major items as substitute financial development measures were selected due to the higher peculiar values over 1 including the reason that these contain most of the original variables' information.

Table 3 represents the stationarity of all variables by applying four tests, i.e., Levin et al. (2002); Im et al. (2003); Dickey and Fuller (1981); and Phillips and Perron (1988). All variables are stationary at a level or first difference at 1% level in

Table 2 Principal component analysis

Principal components	Initial Eigenvalues		
	Total	% of variance	Cumulative %
Financial development index 1: *Findi*_1=*f*(*lndba*,*lndps*,*lnlil*,*lnatm*)			
1	3.13	78.46	78.46
2	0.56	14.01	92.47
3	0.25	6.14	98.61
4	0.06	1.39	100.00
Financial development index 2: *Findi*_2=*f*(*lndps*,*lnnim*,*lnatm*)			
1	1.88	62.68	62.68
2	0.81	27.09	89.77
3	0.31	10.23	100.00
Financial development index 3: *Findi*_3=*f*(*lndps*,*lnnim*,*lnatm*,*lnZscore*)			
1	2.09	52.33	52.33
2	0.88	22.06	74.39
3	0.73	18.13	92.53
4	0.30	07.47	100.00

Table 3 Panel unit root tests

	LLC		Im, Pearson		Dickey-Fuller		PP	
Variables	Level	1st diff	Level	1st diff	Level	1st diff	Level	1st diff
CO_2	−1.460*	−15.273***	2.344	−9.764***	53.129	206.22***	74.092	262.478***
IC	−1.914**	−10.817***	1.1050	−8.183***	35.085	120.31***	51.821	133.125
Corp	−2.983***	−8.601***	−0.2650	−6.837***	48.732	67.647***	76.480***	77.5375***
Fin_1	−7.755***	−125.73***	−1.4578*	−19.731***	94.334	218.684***	137.605	269.983***
Fin_2	−2.362***	−29.882***	−2.362***	−9.680***	101.77***	184.652***	145.79***	229.460***
EI	−6.735***	−11.327***	−0.5450	−5.420***	80.167	151.980***	121.172	187.987***
GDP	4.404	8.303***	6.260	−4.336***	60.922	123.225**	91.028**	135.169***
FDI	−6.374	−18.492***	−4.428***	−13.735***	119.140	275.942***	126.621	347.528***
Ind	−3.484	−16.968***	0.2750	−11.768***	60.554	243.02***	72.840	333.56***
Tro	−2.798***	−16.992***	−5.850	−11.331***	65.184	232.305***	75.0624	293.851***

In this table, four tests, i.e., Levin, Pearson, Dicky, and Fuller and Phillips and Perron, are applied to the full sample of 33 countries. Akaike information criterion (AIC) was used for lag length selection. The null hypothesis represents the unit root, while the alternative hypothesis shows stationarity in the series. 1st diff = first difference ***p < 0.01; **p < 0.05; *p < 0.1. CO_2-dependent variable represents carbon emissions. *IC* and *Corp* show institutional capacity and corruption, while *fin*_1 and *fin*_2 are two indexes of financial development. *EI*, *GDP*, *FDI*, *Ind*, and *Tro* represent energy intensity, GDP growth, foreign direct investment, industrialization, and trade openness respectively

most of the cases. Hence, system GMM can be used reliably to cope with the endogeneity issue.

Table 4 represents the impact of financial development, institutional capacity, and interaction of both variables on the environmental quality. According to the first financial composite index (fin_1) which contains financial depth, access, and efficiency, 1% increase in the development engenders 0.11% growth in CO_2 emission, while another composite index fin_2, which contains an additional component of financial development—financial stability—induces 0.13% change in CO_2 when it changes by 1%, which implies that financial development enhances the environmental degradation. The strong financial depth and access to the public create a conducive loaning environment that helps customers purchasing durable goods and durable goods increase environmental degradation (Sadorsky 2010). Likewise, financial efficiency reduces the cost of capital for the companies and the cheaper cost of capital incites more investments in manufacturing and other economic activities that subsequently enhances the CO_2 emissions. These results are in line with Ganda (2019), who argued that higher financial development may engender higher investment in an energy-intensive industry, which may subsequently increase environmental degradation. Lastly, higher financial stability means lower financial risk and lower risk increase the confidence of financial institutions and they increase the financial facilities for individuals and firms that subsequently incite economic activities and environmental degradation. A positive sign of institutional capacity is unexpected, but it is not worth exploring as it is insignificant. Interestingly, the signs of both interaction terms are negative, which posit that environmental-based policy and institutional capacity significantly negate the negative impact of financial development on environmental degradation. The higher institutional capacity contains not only the proper set of policies, rules, regulation, and networking by the government for decarburization but also motivation, management practices, and resources by organizations. When organizations and individuals will be given awareness about the harmful effect of emissions along with subsidies, tax exemptions, networking, and other required institutional support for clean energy investments, they may utilize the strong financial system to divert funds from energy-intensive projects to clean technology projects. These results are supported by Willems and Baumert (2003) who suggest that institutional capacity may influence the decisions of climate change policies of the organizations, from a formulation of a strategy to monitoring and evaluation of policy performance, which may subsequently reduce emissions in the environment.

All core variables, i.e., GDP per capita, FDI, energy intensity, industrialization, and trade openness, are jointly significant, as F-test P-values are lower than 5% and 10% in both models. Moreover, results do not suffer from over-identification as P values of Hansen and Saran tests are higher than 5% or 10%. Additionally, results are free from the autocorrelation problem as the P-value of AR (2) is also more than 10%, which suggests that we fail to reject the null hypothesis of no autocorrelation of order 2.

Graph 1, as well as Graph 2, show the role of institutional capacity in moderating the role of financial development on environmental quality. The relationship between financial development and CO_2 is positive when institutional capacity is low but turns to negative when institutional capacity increases. More specifically, Graph 1 (fin_1) and Graph 2 (fin_2) posit that on a scale of 0–6 (where the higher number

Table 4 Impact of financial development and institutional capacity on environmental quality

	(Model 1) lnco2	(Model 2) lnco2
lnCO2	0.8310***	0.8426***
	[0.163]	[0.158]
fin _1	0.1189**	
	[0.059]	0.1329**
fin _2		[0.055]
IC	0.0594	0.0589
	[0.038]	[0.037]
lngdp	0.3090	0.2898
	[0.291]	[0.275]
lnfdi	−0.0049	−0.0019
	[0.017]	[0.016]
lnei	0.0084	0.0121
	[0.265]	[0.254]
lnind	0.0076	0.0292
	[0.138]	[0.120]
lntro	0.2184*	0.2195
	[0.129]	[0.134]
IC # fin _1	−0.0341*	−0.0396**
	[0.019]	
IC # fin _2		[0.019]
Constant	−3.4091	−3.3391
	[3.181]	[3.013]
Observations	254	254
Instruments	33.0000	33.0000
Overall	32.0000	32.0000
Arellano-Bond: AR (1)		
Arellano-Bond: AR (2)	0.9234	0.9542
Sargan test (p-Val)	0.2430	0.2652
Hansen test (p-val)	0.6008	0.6193
Joint F-test (p-val)	0.0796	0.0018

This table shows the results of System GMM, where the dependent variable is CO_2 emissions per capita. Fin_1 and Fin_2 represent the two indexes of financial development. The instruments are lagged levels for differences and lagged differences for levels. Sargan and Hansen are the over-identification tests, where the null hypothesis is that the use of instruments is not correlated with the residuals. The AR (2) test is the Arellano-Bond serial correlation test, where the null hypothesis is that a second-order serial correlation does not exist in the differenced error terms. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. F-test shows the joint significance of all core variables, i.e., GDP growth, FDI, energy intensity, industrialization, and trade openness

on scale shows higher institutional capacity), when policy and institutional capacity is higher than 3.75 and 3.5, respectively, the impact of financial development on CO_2 turns to favourable. This is because higher institutional capacity may divert the investment from traditional energy-intensive projects to technological innovative and energy-efficient projects through a developed financial system and resultantly decreases the CO_2 emissions.

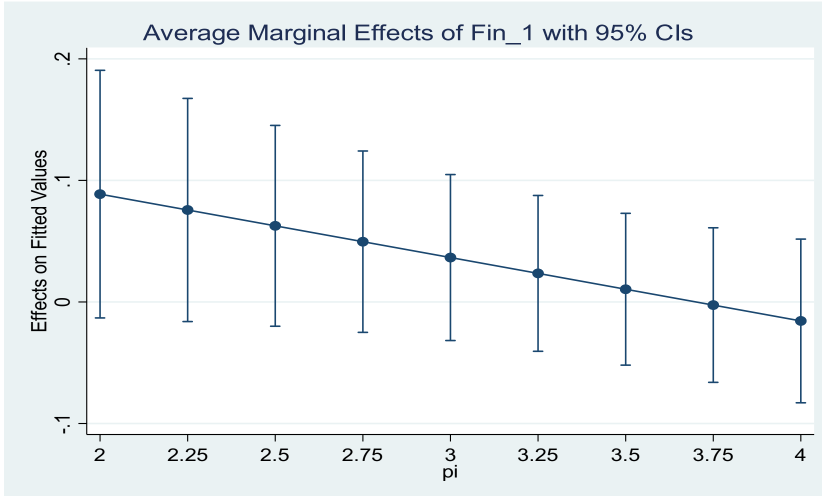
The impact of corruption, policy, and institutional capacity and their interaction on CO_2 are recorded in Table 5. The results find a positive sign for corruption, which suggests that improvement in corruption (increase in corruption index) leads to economic growth (Mauro 1995; Méon and Weill 2010) that subsequently increases the CO_2 concentration. The results show that a 1% improvement in corruption may induce a 0.24% increase in CO_2 emissions. Noticeably, the interaction of corruption and policy and institutional capacity is significantly negative, which shows that lower corruption may cause the institutional capacity to reduce the carbon emissions as it is meant to improve the environmental quality. On the other hand, policy and institutional capacity may fail to contribute positively if certain members of the economy will circumvent it by using illegitimate means—corruption—and using traditional approach for manufacturing and other economic activities rather than following energy-efficient sources that would intensify the CO_2 emissions. Hence, reduction in corruption along with higher policies and institutional capacities may divert the investment to energy-efficient projects that may curtail environmental degradation.

Overall, the P-values—higher than 5% or 10%—of Hensen and Sargan tests show that there is no over-identification problem in results, while p-value of AR (2) proves that null hypothesis—no autorotation—among variables fails to reject. F-test shows that all core variables, i.e., GDP per capita, FDI, energy intensity, industrialization, and trade openness, are jointly significant.

Graph 3 shows how institutional capacity may affect the environmental quality differently at different levels of corruption. Institutional capacity has a positive relation with CO_2 when corruption is high. But as corruption improves (index goes up), the relation turns to negative. On a scale of 100, when corruption (CPI) improves more than 40 then the impact of institutional capacity on CO_2 emissions turns to be favourable. This is because higher corruption may create loopholes in policy and institutional capacity, where some member of the economy may find ways to bypass the policies, values, rules, and regulation that weakness in the system may deteriorate the environmental degradation. This is in line with our theoretical expectation that a higher level of corruption may divert the role of institutional capacity while control in corruption may enhance the efficiency of the institutional capacity and improve the environmental quality.

Discussion of the findings

First, we find that financial development increases the CO_2 emissions, which implies that these emerging countries face impediments to energy-efficient projects, where huge



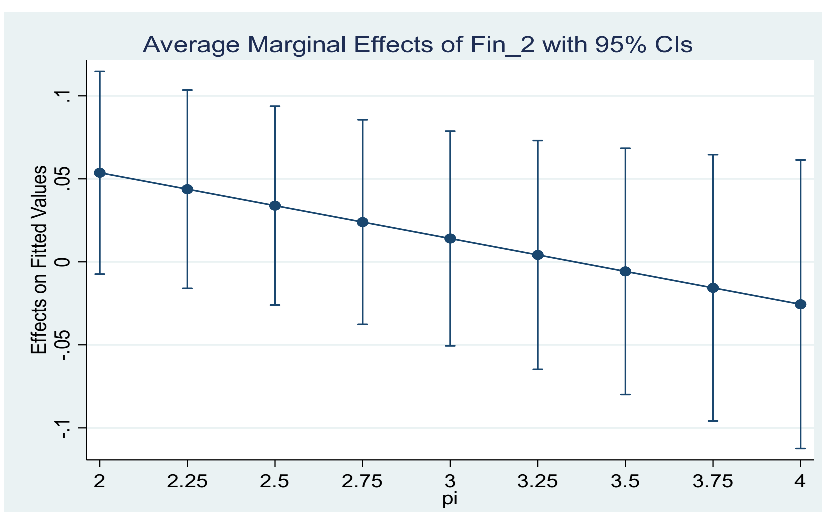
Graph 1 Marginal impact of financial development (index 1) on environmental quality at a different level of policy and institutional capacity

investment is being made in energy-intensive projects. The reason could be a higher initial fixed cost or inefficient allocation of financial resources. Furthermore, though institutional capacity may not significantly affect CO_2 separately, it may wipe out the negative impact of financial development on environmental quality. In other words, financial development and policy and institutional capacity have a complementary effect on the improvement of environmental quality. This is because higher institutional capacity-strong norms, values, networks, institutions, rules, and regulations create a conducive environment for investment in innovative and energy-efficient projects.

Additionally, lower corruption may shoot the economic growth that may intensify the CO_2 emissions. One reason could be lower corruption induces investment in good projects through proper asset allocation, which may boost economic growth (Mauro 1995), so the negative impact of growth on environmental quality can be effaced through strong environmental policies and institutional capacity. On the way around even strong institutional capacity may fail to curb the environmental degradation if corruption creates loopholes in the system. Corruption may give illegitimate ways to some people to avoid the rules and regulation and may distort the impact of institutional capacity. Hence, lower corruption along with higher institutional capacity may have a complementary effect on the reduction of environmental degradation. Overall, lower corruption and higher financial development along with strong institutional capacity may improve environmental quality.

Conclusion

This study investigates the moderating role of policy and institutional capacity on the relationship between financial development and environmental quality for 33 emerging countries covering yearly data from 2004 to 2017. Additionally, the moderating role of corruption through institutional



Graph 2 Marginal impact of financial development (index 2) on environmental quality at a different level of policy and institutional capacity

Table 5 Impact of corruption and institutional capacity on environmental quality

	(1) lnco2
lnCO2	0.9173***
	[0.070]
Corp	0.0245**
	[0.011]
IC	0.2541
	[0.160]
lngdp	0.1340
	[0.149]
lnfdi	−0.0410
	[0.048]
lnei	0.0598
	[0.131]
lnind	0.1369
	[0.128]
lntro	0.0722
	[0.134]
IC # Corp	−0.0068*
	[0.004]
Constant	−2.6683
	[1.819]
Observations	299
Instruments	26.0000
Overall	32.0000
Arellano-Bond: AR (1)	
Arellano-Bond: AR (2)	0.6987
Sargan test (p-val)	0.7187
Hansen test (p-val)	0.4713
Joint F-test (p-val)	0.0662

This table shows the results of System GMM, where the dependent variable is CO_2 emissions per capita. The instruments are lagged levels for differences and lagged differences for levels. Sargan and Hansen are the over-identification tests, where the null hypothesis is that the use of instruments is not correlated with the residuals. The AR (2) test is the Arellano-Bond serial correlation test, where the null hypothesis is that a second-order serial correlation does not exist in the differenced error terms. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. F-test shows the joint significance of all core variables, i.e., GDP growth, FDI, energy intensity, industrialization, and trade openness

capacity on environmental degradation is also examined. We develop two composite indexes from four financial development variables—financial depth, access, efficiency, and stability through principal component analysis (PCA). We use a dynamic technique system GMM to assess the heterogeneous data of different emerging countries and we use a margins plot to the moderating impact of corruption and institutional capacity on environmental quality.

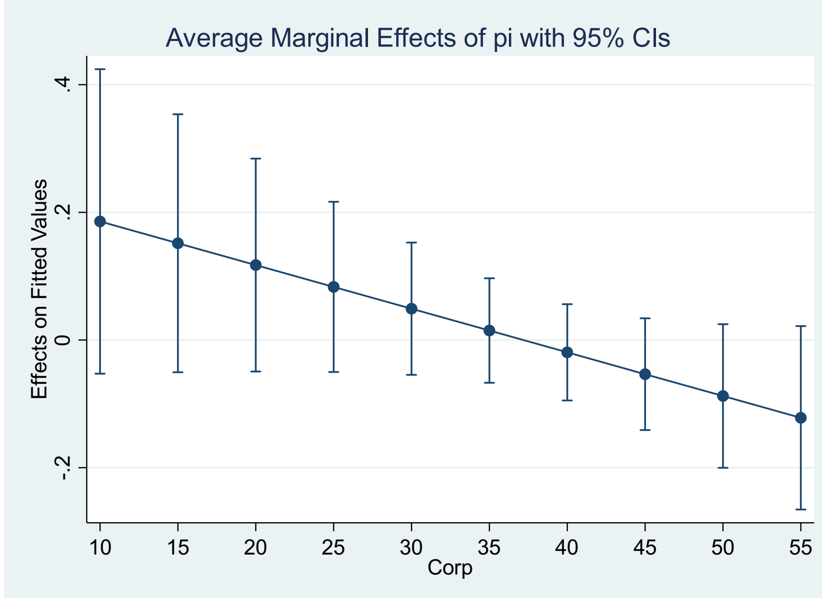
The results indicate that financial development has a significantly positive relationship with environmental degradation. It means higher the financial development, the more environmental degradation. Interestingly, the environmental institutional capacity turns this positive relation into negative when environmental institutional capacity has interacted with financial development. This shows that environmental institutional capacity moderates the impact of financial development on environmental degradation. Moreover, the results of the margins plot also suggest that relation between financial development and CO_2 changes from positive to negative when institutional quality is 3.5 or higher on a scale of 6. It means that the negative impact of financial development can be wiped out through strong environmental institutional capacity. Hence, higher institutional capacity and strong financial development may jointly improve environmental quality.

Moreover, the positive coefficient of corruption represents improved corruption which may increase the CO_2 emissions, while environmental institutional capacity has an insignificant impact on CO_2. However, when environmental institutional capacity is interacted with corruption, the sign of coefficient changes from positive to negative, which means corruption may modify the impact of institutional capacity on CO_2. The marginal plot in Fig. 3 also advises that institutional capacity may only control environmental degradation when corruption improves to 40 or more. This suggests that even higher policy and intuitional capacity may not control environmental degradation if higher corruption is pervasive in emerging economies.

Accordingly, the findings of this study recommend improving the environmental institutional capacity and strengthen its links with the financial sector that may channelize the investment from innovative and energy-efficient projects. Institutional capacity can be built by arranging environmental-related awareness campaigns, provide subsidies for innovative and energy-efficient investments, create rules and regulation to discourage traditional energy-intensive investments, and develop strong financial and other supply chain networks to support renewable energy investments. Moreover, we also advocate the betterment of corruption in emerging countries as it may not distort the role of institutional capacity in improving environmental quality. Overall, a sound financial system and strong environmental institutional capacity along with lower corruption may reduce the environmental degradation of emerging countries.

We recommend that governments of developing countries should focus on environmental-based capacity building, i.e., arrange awareness campaigns about the harmful

Graph 3 Marginal impact of institutional capacity on CO_2 emission at different levels of corruption



impact of emissions, provide subsidies and tax exemptions, build strong networking, and extend institutional support to both private and public organizations to make an investment in innovative clean technology projects which in turn may control the carbonization. Moreover, prodigal financing facilities should be developed through financial institutions for innovative and clean energy projects at a very lower cost. Both a strong financial system and institutional capacity together may reduce the intensity of carbon emissions.

Availability of data and materials Upon a legitimate request, the sets of data utilized or evaluated in the present study may be given.

Author contribution Formal analysis and writing: Ameet Kumar; conceptualization and methodology, partial writing: Muhammad Ramzan Kalhoro; writing and data curation: Rakesh Kumar; supervision and validation: Nia Ahmed Bhutto; review and editing: Ruqia Shaikh. We all authors have read and agreed to the publishable version of the article.

Declarations

Ethical approval We consciously assure that this manuscript is the authors' original work and has not been published nor is being considered for publication elsewhere. Moreover, this study does not contain any human or animal involvement.

Consent to participate This study is based on secondary data that were extracted from open sources like World Bank and Transparency International; therefore, this study did not need to get consent from any participants.

Consent to publish The authors hereby give consent for the publication of the manuscript to be published in the journal (Environmental Science and Pollution Research) and give everyone an opportunity to read this article to be published in the above journal.

Competing interests The authors declare no competing interests.

References

Abbasi F, Riaz K (2016) CO2 emissions and financial development in an emerging economy: an augmented VAR approach. Energy Policy 90:102–114. https://doi.org/10.1016/j.enpol.2015.12.017

Adenle AA, Manning DT, Arbiol J (2017) Mitigating climate change in Africa: barriers to financing low-carbon development. World Dev 100:123–132. https://doi.org/10.1016/j.worlddev.2017.07.033

Aklin M, Urpelainen J (2014) The Global Spread of Environmental Ministries: domestic–international interactions. Int Stud Q 58(4): 764–780. https://doi.org/10.1111/isqu.12119

Ang JB (2008) Economic development, pollutant emissions and energy consumption in Malaysia. J Policy Model 30(2):271–278. https://doi.org/10.1016/j.jpolmod.2007.04.010

Anton SG, Afloarei Nucu AE (2020) The effect of financial development on renewable energy consumption. A panel data approach. Renew Energy 147:330–338. https://doi.org/10.1016/j.renene.2019.09.005

Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev Econ Stud 58(2):277–297

Attari MIJ, Hussain M, Javid AY (2016) Carbon emissions and industrial growth: an ARDL analysis for Pakistan. Int J Energy Sect Manag 10:642–658. https://doi.org/10.1108/IJESM-04-2014-0002

Baksi S, Bose P (2010) Environmental regulation in the presence of an informal sector. In: University of Winnipeg Department of Economics Working Paper, vol 3

Bardhan P (1997) Corruption and development: a review of issues. J Econ Lit 35(3):1320–1346 JSTOR

Bello AK, Abimbola OM (2010) Does the level of economic growth influence environmental quality in nigeria: a test of environmental Kuznets curve (EKC) hypothesis? Pak J Soc Sci 7(4):325–329. https://doi.org/10.3923/pjssci.2010.325.329

Bölük G, Mert M (2015) The renewable energy, growth and environmental Kuznets curve in Turkey: an ARDL approach. Renew Sust Energ Rev 52:587–595

Boutabba MA (2014) The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. Econ Model 40:33–41. https://doi.org/10.1016/j.econmod.2014.03.005

Change IC (2014) Mitigation of climate change. In: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, vol 1454

Čihák M, Demirgüč-Kunt A, Feyen E, Levine R (2013) Financial Development in 205 Economies, 1960 to 2010, Working Paper No. 18946; Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w18946

Corsatea TD, Giaccaria S, Arántegui RL (2014) The role of sources of finance on the development of wind technology. Renew Energy 66: 140–149. https://doi.org/10.1016/j.renene.2013.11.063

Dasgupta S, Laplante B, Mamingi N (2001) Pollution and capital markets in developing countries. J Environ Econ Manag 42(3):310–335. https://doi.org/10.1006/jeem.2000.1161

Dickey DA, Fuller WA (1981) Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica: J Econometr Soc 49:1057–1072

Frankel JA, Romer DH (1999) Does trade cause growth? Am Econ Rev 89(3):379–399. https://doi.org/10.1257/aer.89.3.379

Fredriksson PG, Vollebergh HR, Dijkgraaf E (2004) Corruption and energy efficiency in OECD countries: theory and evidence. J Environ Econ Manag 47(2):207–231

Ganda F (2019) The environmental impacts of financial development in OECD countries: a panel GMM approach. Environ Sci Pollut Res 26(7):6758–6772. https://doi.org/10.1007/s11356-019-04143-z

Granoff I, Hogarth JR, Miller A (2016) Nested barriers to low-carbon infrastructure investment. Nat Clim Chang 6(12):1065–1071. https://doi.org/10.1038/nclimate3142

Hansen LP, Singleton KJ (1982) Generalized Instrumental variables estimation of nonlinear rational expectations models. Econometrica 50(5):1269–1286. JSTOR. https://doi.org/10.2307/1911873

Hughes L (2012) Climate converts: institutional redeployment, industrial policy, and public investment in energy in Japan. J East Asian Stud 12(1):89–117

Hughes L, Urpelainen J (2015) Interests, institutions, and climate policy: explaining the choice of policy instruments for the energy sector. Environ Sci Pol 54:52–63

Im KS, Pesaran MH, Shin Y (2003) Testing for unit roots in heterogeneous panels. J Econ 115(1):53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Jensen JR (1996) Introductory digital image processing: a remote sensing perspective. In: Introductory Digital Image Processing: A Remote Sensing Perspective., Ed.2 https://www.cabdirect.org/cabdirect/abstract/20001911540

Kassi DF, Sun G, Ding N (2020) Does governance quality moderate the finance-renewable energy-growth nexus? Evidence from five major regions in the world. Environ Sci Pollut Res 27(11):12152–12180. https://doi.org/10.1007/s11356-020-07716-5

Lahiani A (2020) Is financial development good for the environment? An asymmetric analysis with CO 2 emissions in China. Environ Sci Pollut Res 27(8):7901–7909. https://doi.org/10.1007/s11356-019-07467-y

Laird FN, Stefes C (2009) The diverging paths of German and United States policies for renewable energy: sources of difference. Energy Policy 37(7):2619–2629. https://doi.org/10.1016/j.enpol.2009.02.027

Levin A, Lin C-F, James Chu C-S (2002) Unit root tests in panel data: asymptotic and finite-sample properties. J Econ 108(1):1–24. https://doi.org/10.1016/S0304-4076(01)00098-7

Lipp J (2007) Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. Energy Policy 35(11):5481–5495. https://doi.org/10.1016/j.enpol.2007.05.015

López R, Mitra S (2000) Corruption, pollution, and the Kuznets environment curve. J Environ Econ Manag 40(2):137–150. https://doi.org/10.1006/jeem.1999.1107

Ma K, Mz K, Zaman K, Irfan D, Khatab H (2015) Questing the three key growth determinants: energy consumption, foreign direct investment and financial development in South Asia (Retraction of vol 68, pg 203, 2014). Renew Energy 76:806–806

Maddala GS, Wu S (1999) A comparative study of unit root tests with panel data and a new simple test. Oxf Bull Econ Stat 61(S1):631–652. https://doi.org/10.1111/1468-0084.0610s1631

Mauro P (1995) Corruption and growth. Q J Econ 110(3):681–712

Méon P-G, Weill L (2010) Is corruption an efficient grease? World Dev 38(3):244–259

Ozturk I, Acaravci A (2010) CO2 emissions, energy consumption and economic growth in Turkey. Renew Sust Energ Rev 14(9):3220–3225. https://doi.org/10.1016/j.rser.2010.07.005

Phillips PCB, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75(2):335–346. https://doi.org/10.1093/biomet/75.2.335

Roodman D (2009) How to do Xtabond2: an introduction to difference and system GMM in stata: the Stata Journal. https://doi.org/10.1177/1536867X0900900106

Sadorsky P (2010) The impact of financial development on energy consumption in emerging economies. Energy Policy 38(5):2528–2535. https://doi.org/10.1016/j.enpol.2009.12.048

Sargan JD (1958) The estimation of economic relationships using instrumental variables. Econometrica: J Econometr Soc 26:393–415

Segnestam L (2003) Country-level environmental analysis: a review of international experience

Semmlow JL, Griffel B (2014) Biosignal and medical image processing. CRC Press

Shahbaz M, Hye QMA, Tiwari AK, Leitão NC (2013a) Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Renew Sust Energ Rev 25:109–121

Shahbaz M, Kumar Tiwari A, Nasir M (2013b) The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. Energy Policy 61:1452–1459. https://doi.org/10.1016/j.enpol.2013.07.006

Shahbaz M, Mallick H, Mahalik MK, Loganathan N (2015) Does globalization impede environmental quality in India? Ecol Indic 52:379–393

Shahbaz M, Solarin SA, Mahmood H, Arouri M (2013c) Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. Econ Model 35:145–152. https://doi.org/10.1016/j.econmod.2013.06.037

Sheng J, Han X, Zhou H, Miao Z (2016) Effects of corruption on performance: evidence from the UN-REDD Programme. Land Use Policy 59:344–350

Simpson D (2012) Knowledge resources as a mediator of the relationship between recycling pressures and environmental performance. J Clean Prod 22(1):32–41

Talukdar D, Meisner CM (2001) Does the private sector help or hurt the environment? Evidence from carbon dioxide pollution in developing countries. World Dev 29(5):827–840. https://doi.org/10.1016/S0305-750X(01)00008-0

Tamazian A, Chousa JP, Vadlamannati KC (2009) Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy Policy 37(1):246–253. https://doi.org/10.1016/j.enpol.2008.08.025

Walter I, Ugelow JL (1979) Environmental policies in developing countries. Ambio 8(2/3):102–109 JSTOR

Willems S, Baumert K (2003) Institutional capacity and climate actions. OECD, Paris

Winbourne S (2002) Corruption and the environment. In: Management Systems International and USAID, Washington

Yuxiang K, Chen Z (2011) Financial development and environmental performance: evidence from China. Environ Dev Econ 16(1):93–111 JSTOR