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RESEARCH ARTICLE

Achieving carbon neutrality through Economic and Institutional Reforms: Evidence from the Belt and Road Initiative Countries

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Abstract
The increasing concern over carbon dioxide emissions necessitates a comprehensive understanding of the factors influencing environmental degradation, particularly in Belt and Road Initiative (BRI) countries. This study investigates the impact of economic, institutional, and environmental variables on carbon emissions using Fixed Effect and dynamic panel models covering the period from 2000 to 2020. The findings reveal that economic freedom has a negative and significant effect on carbon emissions, suggesting that higher levels of economic freedom promote investments in green energy and efficiency, which ultimately reduce emissions. Financial development, however, is consistently shown to positively and significantly increase emissions, indicating that economic expansion, without sustainable practices, exacerbates environmental degradation. Renewable energy consumption demonstrates a significant negative relationship with emissions across models, reinforcing its role in mitigating pollution. Industrial growth is positively correlated with carbon emissions, highlighting the reliance on fossil fuels for production in BRI countries. The robustness check using control of corruption and rule of law confirms the main model results, demonstrating that weak institutional quality exacerbates emissions. The study underscores the importance of strengthening institutional frameworks and promoting renewable energy to reduce carbon emissions in BRI countries. The results have significant policy implications for integrating economic, environmental, and institutional reforms to achieve sustainable development.

Keywords: Carbon Dioxide Emissions; Economic Freedom; Institutional Quality; Renewable Energy; Industrial Growth

Introduction

Countries around the world, particularly those with developing and emerging economies, are increasingly confronted with the challenge of balancing economic growth with environmental sustainability. Economic activities such as industrialization, international trade, and urban development are central to these countries' strategies for improving their economic standing and raising living standards. However, these activities often rely heavily on non-renewable energy sources, leading to significant carbon dioxide emissions and subsequent environmental degradation. Khan et al. (2022) highlight that while economic growth is essential for development, it is also crucial to manage its impact on the environment. Achieving this balance requires effective institutional frameworks that not only facilitate economic growth but also enforce measures to protect environmental quality. High institutional quality is therefore critical as it enables governments to establish and enforce policies that drive sustainable development (Khan, Han et al., 2021). Government arrangements and institutions can exert both direct and indirect influences on environmental quality. Institutions serve as predecessors and indicators for numerous developmental outcomes, making their role in influencing carbon dioxide emissions particularly significant. Some researchers argue that economic institutions can provide the necessary funds for green energy projects and advanced technologies, ultimately improving environmental quality by decreasing the reliance on non-renewable resources (Diallo & Masih, 2017; Lee, Chen, & Cho, 2015). Previous studies have examined the economic, social, and institutional factors contributing to environmental degradation, focusing on variables such as energy consumption, financial development, and economic growth as key determinants of environmental sustainability (Abbasi et al., 2022; Alola et al., 2022; Khan, Weili, & Khan, 2022c; Sunday Adebayo et al., 2022; Zhao et al., 2022). Institutions play a critical role by enforcing regulations, creating a stable legal and cultural context for socioeconomic activities, and managing the resources needed for sustainable development (Acemoglu & Robinson, 2008). The quality of institutions, therefore, reflects a government's ability to develop and implement laws and policies that foster private sector growth while maintaining environmental integrity. This includes enhancing contract enforcement, protecting property rights, upholding the rule of law, and ensuring that institutions remain impartial and free from political influence (Canh, Schinckus, & Thanh, 2019). Conversely, ineffective institutions often lead to corruption, inefficient bureaucracies, and weak environmental regulations (Asoni, 2008). In recent years, economists, scientists, and policymakers have increasingly focused on the role of institutional quality in addressing environmental challenges, emphasizing that governments have the power to shape environmental outcomes both directly and indirectly. Olson (1996) posits that competent and impartial government institutions are crucial for fostering productive collaboration among market participants, which is vital for addressing environmental concerns. The rule of law, in particular, becomes an essential tool in managing carbon emissions and environmental policies. Strong institutions are therefore necessary to enforce processes aimed at reducing emissions, ensuring that businesses comply with these regulations. In the absence of high institutional quality, businesses may easily bypass regulations, prioritizing economic gains over environmental protection, as noted by Welsch (2004). Despite the recognition of institutional quality as a critical factor in the nexus between economic activities and environmental quality, there is still a research gap concerning its multifaceted impact. Previous studies have often focused on single indicators of institutional quality, such as government effectiveness or rule of law, without considering the broader array of institutional factors. This study seeks to address this gap by investigating multiple aspects of institutional quality, including the legal and political systems, and their combined influence on carbon emissions. Specifically, the study examines the effects of political system indicators such as control of corruption, political stability, and government effectiveness, alongside legal system indicators like regulatory quality, voice and accountability, and rule of law. By comprehensively analyzing these factors, the research aims to provide a deeper understanding of the various institutional elements that impact economic activities and environmental outcomes.

This research innovatively integrates institutional quality indicators with other variables, such as non-renewable energy consumption, renewable energy usage, and financial development, to explore their collective impact on carbon emissions. It posits that improved institutional quality can lead to better policies that support financial institutions in funding renewable energy projects, thereby reducing reliance on fossil fuels. By promoting renewable energy, quality institutions can help mitigate environmental degradation. Furthermore, the study examines how institutional policies can influence the behavior of financial institutions, making them more environmentally conscious and supportive of sustainable development. This comprehensive approach to studying institutional quality and its interaction with other economic and environmental factors is relatively new and provides valuable insights into how BRI countries, which are still in various stages of economic development, can achieve growth without sacrificing environmental quality. The choice of BRI countries for this study is crucial, as these nations represent a diverse group of developing and emerging economies that are still striving to increase economic growth and improve living standards. However, this growth often comes at the cost of environmental degradation. By focusing on these countries, the study aims to develop policy recommendations that can guide them toward a balanced approach to development. These recommendations may include strengthening governance structures, enhancing institutional frameworks, improving financial sector support for sustainable projects, and promoting the use of renewable energy sources. The study's findings indicate that institutional quality factors have both negative and positive impacts on carbon emissions, depending on their strength and implementation. For instance, regulatory quality, voice and accountability, and other aspects of governance that are well-established help reduce emissions, while weaker institutional elements contribute to environmental degradation. The study also finds that renewable energy usage significantly reduces emissions and improves environmental quality, while fossil fuel-based energy consumption, industrial growth, and financial development are the primary drivers of carbon emissions in the BRI countries. This research is structured as follows: after the introduction, the next section provides a detailed literature review, examining past studies and highlighting the gaps this research aims to fill. The third section outlines the methodology, including econometric techniques and data sources used to conduct the analysis. The fourth section presents the results and discussions, offering insights into the research gap and how this study addresses it through its innovative approach. Finally, the conclusion and policy implications are provided, summarizing the study's findings and offering recommendations for policymakers and future research directions. By comprehensively examining the role of institutional quality and its interaction with economic and environmental factors, this study contributes to the literature and provides practical solutions for countries aiming to achieve sustainable development.

Literature review

Institutional Quality, Economic growth, and Carbon dioxide emissions

There have been conducted large number of studies on the effect of different factors on carbon dioxide emission such as economic growth, financial development, trade and so on however there is still conflicting view in this investigation. Institutional quality has also been considered by large number of researchers which argues that institutional quality can help imped the harmful effect of economic factors on environmental quality. For instance, (Abid, 2017) used the data of 41 European Union and 58 Middle East and African (MEA) nations for the period of 1990 - 2011. They found that institutional quality is vital in the designated countries reducing carbon dioxide emissions. Though, (Godil, Sharif, Agha, & Jermsittiparsert, 2020) claimed that as institutional quality increases, the carbon dioxide emissions also increases. This can be the reason that institutional quality in the countries are still below the standard level. (H. P. Le & Ozturk, 2020) examined the effect of institutional quality on carbon dioxide emission for 47 developing and Emerging Market for the period of 1990 - 2014. Noticeably, the increasing institutional quality promotes investment activities, attract more trade, and economic activities using economic globalization which as a result increases the scale effects economic activities on emissions of carbon dioxide. As mentioned above, economic growth increase carbon dioxide emission as increased economic activities while institutional quality might be needed to facilitate these activities as well to protect environmental quality. For instance, (Yuelan et al., 2019) studied the impacts of economic growth on environment for the period of 1980-

2016, which confirmed that economic growth deteriorated the quality of environment. Though, (Wang & Li, 2021) found that the role of economic growth per capita with per capita carbon dioxide emissions, as GDP per capita increases, it decreases per capita emissions of carbon dioxide. Good institutions are sources of growth in the country. Institutions can improve or deteriorate the environmental sustainability of a country. (Anser, Hanif, Alharthi, & Chaudhry, 2020) studied 16 lower middle and middle income economies from 1990 - 2015.Their empirical findings show that industrial development prominently increasing emissions of carbon dioxide in these economies. (Rahman & Kashem, 2017) investigated the relation of industrial progress and carbon dioxide emissions in Bangladesh from 1972 - 2011. Their result show that industrial progress have significant and positive influence on the emissions of carbon dioxide for short run as well as in long run. (Ali, Audi, Senturk, & Roussel, 2022) examined the influence of sectorial progress and emissions of carbon of Pakistan from 1970 - 2019. They found that industrial progress significantly positively linked with emissions of carbon dioxide. (U. Ali et al., 2022) studied Malaysia from 1971 - 2016. Their result show that emissions of carbon dioxide have an informal association with carbon dioxide and industry. Energy is vital driver of economic development. The growth of demand of energy at various phases of economic growth needs a practical solution for problems of environment. For instance, (Zhang et al., 2017) demonstrated the EKC theory for 10 new industrialized nations for the period of 1971 - 2013 and found that real GDP demonstrated conflicting effects. (Van & Bao, 2018) examined the effects of GDP per capita on environment in Vietnam for the period of 1985 - 2015 using ARDL and found that GDP per capita increases carbon dioxide emissions.

Renewable energy use, non-renewable energy consumption and carbon dioxide emission

Energy is needed to facilitate economic activities such as industrialization, production and other related factors however an increase in energy consumption raise carbon dioxide emissions and leads to environmental degradation. Renewable energy as a substitute of fossil fuels might be beneficial to be used in economic activities and safeguard environmental quality. However, developing, and emerging economies are not yet reached the desired level of use renewable energy sources. This is among the most argued issues of the last recent decades. For instance, (Waheed, Chang, Sarwar, & Chen, 2018) studied energy consumption and carbon emission in Pakistan from 2014 5o 2019 and found that renewable energy had significant negative relationship with carbon dioxide emission. (T.-H. Le, Chang, & Park, 2020) studied a global panel of 102 countries, found that green energy decreases carbon emission in high-income countries. because these economies' have strict environmental rules. (Chen, Wang, & Zhong, 2019) explored the instance of BRICS economies for the time period of 2000-2013, green energy decreases toxin emissions. (Nathaniel & Iheonu, 2019) explored Africa for the period of 1990-2014, and found a one directional association existing from green energy towards emissions of carbon. (Pata, 2018) examined Turkey for the period of 1974 to 2014 between consumption of renewable energy and emissions of carbon dioxide. Their results show that emissions of carbon dioxide has no relationship with renewable energy. (Vural, 2020) studied the association between emissions of carbon dioxide and non renewable energy for eight Sub Saharan African economies 1980 - 2014. Their results demonstrates that, non renewable energy have crucial part in growing emissions of carbon dioxide. (Chen, Wang, et al., 2019) found that non-renewable energy give raise to carbon emissions. (Chen, Zhao, Lai, Wang, & Xia, 2019) found that non-renewable has significant positive influence on carbon dioxide emissions. (Inglesi-Lotz & Dogan, 2018) studied carbon dioxide emissions for ten main power producers in Sub-Saharan Africa during 1980-2011. Growth in non-renewable energy usage increases pollution. Forests are vital to consider as the main source for captivating carbon dioxide emissions from the air. According to (World Bank, 2013) forests is one of the most mishandled resource in different countries of the world. For instance, (Farooq, Shahzad, Sarwar, & ZaiJun, 2019) suggested that greater afforestation activities can aid to lessen carbon dioxide emissions. (Minnemeyer, Harris, & Payne, 2017) claimed that discontinuing disforestation in the biosphere will decrease 7 billion of carbon dioxide emissions per annum, and 42 percent of the entire emission reductions might be attained via replantation in forested eco-regions. (Abbasi, Adedoyin, Radulescu, Hussain, & Salem, 2022) examined the association between forest area with emissions of carbon dioxide for 22 countries for time period of 1980-2019. They found that forest areas significant positive adverse effect on environmental damage. (Sarwar, Waheed, Farooq, & Sarwar, 2022) examined the existence of investment in forest and forest area, where forest is a carbon source or a sink. Their results show that just growing the forest area is not a productive approach to lessen carbon dioxide emissions. At the same time their empirical results stated that greater forest investment is a useful approach to decrease the carbon amount in the environment.

Financial development, and carbon dioxide emissions

Financial development plays an important part in cultivating the quality of the environment. Expansion of the economic sector will enable financing investment at low cost in the environmental project. (Anwar et al., 2022) studied the effect of financial growth on emissions of carbon dioxide in Asian nations from 1990 - 2014. Their results proves that financial growth significantly increases emissions of carbon dioxide. (Ling, Razzaq, Guo, Fatima, & Shahzad, 2022) investigated the relation of emissions of carbon dioxide and financial growth for the period of 1980-2017. Their study found that the positive shocks of the financial growth had significant positive effects on emissions of carbon dioxide. (Bayar, Diaconu, & Maxim, 2020) studied the influence of financial growth and emissions of carbon dioxide in European countries. They found that financial growth have positive effects on emissions of carbon dioxide in the long run. (Manta et al., 2020) explored the relationship amid carbon dioxide emissions and financial growth in Eastern and Central European countries. Their empirical results show that, financial growth will increase emissions of carbon dioxide. However, (Odhiambo, 2010) explored emissions of carbon dioxide and financial growth in sub Saharan African nations. They used GMM, and their findings reveals a declining unconditional effect of financial growth on emissions of carbon dioxide.

Methodology

This research examines the impact of institutional quality, energy consumption, and economic growth on carbon dioxide emissions in the Belt and Road Initiative (BRI) countries from 2002 to 2020. Data on renewable energy consumption is sourced from the Energy Information Administration (EIA), while economic freedom data is obtained from the Heritage Foundation. Institutional quality indicators are collected from the World Governance Indicators, and the remaining variables are gathered from the World Development Indicators. The list of countries included in the study is provided in Table 7, and a detailed description of the data sources and variable symbols is presented in Table 8 in the appendix. The baseline model analyses the effects of institutional quality, energy consumption, and economic growth on carbon dioxide emissions.

$$CO2_{it} = \beta_0 + \beta_1 CO2_{it-1} + \beta_2 INST_{it} + \beta_3 EF_{it} + \beta_4 REC_{it} + \beta_5 FD_{it} + \beta_6 FOR_{it} + \beta_7 IND_{it} + \beta_8 GDP_{it} + \beta_9 NREC_{it} + \epsilon_{it} \quad (1)$$

In the above equation, CO2 represents carbon dioxide emissions; INST denotes institutional quality; EF stands for economic freedom; REC indicates renewable energy consumption; FOR represents forest cover; IND stands for industrial structure; GDP is economic growth; and NREC refers to non-renewable energy consumption, while ϵ is the error term. $CO2_{it-1}$ is the lag of previous year effect of carbon emission which shows the effect of the previous year's emissions on the current year. The inclusion of this lag follows the understanding that a country's carbon dioxide emissions are likely to be influenced by its previous emissions levels, as suggested by Dogan & Seker (2016). Therefore, the lag of carbon dioxide emissions is incorporated into the model. All variables, except for institutional quality and forest area, are transformed using the natural logarithm. CO2 is measured in metric tons per capita, as used in recent studies by Khan, Weili, & Khan (2022a). Extensive literature indicates that carbon dioxide emissions are a primary cause of environmental degradation (Khan et al., 2020), and countries with higher emissions levels tend to have poorer environmental quality.

Institutional quality is included in the model to examine its effect on environmental quality. Numerous studies suggest that high-quality institutions play a critical role in enhancing environmental quality by formulating and enforcing environmental protection policies and regulations. In Model 1, INST represents institutional quality, constructed using six indicators: regulatory quality (RQ), voice and accountability (VA), control of corruption (CC), government effectiveness (GE), political stability (PS), and rule of law (RL) (Kumar, 2022; Khan, Weili, & Khan, 2022c). The study applies principal components analysis (PCA) to construct an institutional quality index. It is believed that environmental degradation varies across countries due to differences in institutional quality. High-quality institutions can effectively manage corruption, enforce regulations, and ensure better governance, thereby improving environmental outcomes by monitoring the inflow of polluting foreign direct investment (FDI) and promoting the use of green energy resources. Strong and efficient institutions discourage polluting industries from investing and instead attract environmentally friendly FDI. An effective monitoring system ensures the efficient use of energy, thereby improving environmental quality (Claessens & Feijen, 2007).

Economic freedom is also introduced in the model as it has been extensively debated in the literature regarding its effect on environmental quality. The economic freedom index is constructed from twelve components, grouped into four base categories. This index has been used recently by Mahmood, Shahab, & Shahbaz (2022), Alola et al. (2022), Joshi & Beck (2018), and Graafland (2019) in environmental economics research. The study also incorporates renewable energy consumption, supported by literature that shows renewable energy use from environmentally friendly sources enhances environmental quality, unlike non-renewable fossil fuel-based energy (Hayat et al., 2021). The study measures renewable energy consumption as electricity net consumption in billion kWh, following the methodologies of Kirikkaleli, Güngör, & Adebayo (2022), Ling et al. (2022), Ali et al. (2022), and Apergis & Payne (2014) in examining its impact on carbon dioxide emissions.

Financial institutions also play a pivotal role in environmental quality. Previous research shows that strong financial institutions can fund renewable energy projects, promoting a cleaner environment (I. Khan et al., 2022). However, weak financial institutions and low levels of financial development may lead to environmental degradation. Financial development in this study is measured using domestic credit to the private sector by banks as a percentage of GDP, as recently applied by Sunday Adebayo et al. (2022) and Odhiambo (2020).

Several other factors are also included to explore the nexus between institutional quality and carbon dioxide emissions. These factors include forest area (measured in square kilometers) as used by Raihan & Tuspekova (2022), and industrial structure (IND), proxied by the logarithm of annual industry growth (including construction) as a percentage of GDP, following Rauf et al. (2018). Economic growth (GDP) is measured as the logarithm of GDP per capita annual growth, in line with Wang & Li (2021). Non-renewable energy consumption (NREC) is proxied by fossil fuel energy consumption as a percentage of total energy use, following the methodologies of Rasoulinezhad & Saboori (2018) and Koengkan et al. (2020). To further analyze the relationship between the response and explanatory variables, the study first uses the institutional quality index as mentioned in the empirical model. Then, the institutional quality indicators are divided into two categories: legal system indicators and political system indicators, to explore their deeper role in enhancing environmental quality. The legal system encompasses a country's laws and regulations, while the political system is the institutional framework that forms the state or government. Institutions have the potential to increase or decrease a country's sustainability. Therefore, this study examines how the legal and political frameworks influence carbon dioxide emissions. Legal system indicators include political stability and absence of violence/terrorism (PS), control of corruption (CC), and government effectiveness (GE), which together form the legal system index (LEG). Similarly, we use political system indicators (POL), including regulatory quality (RQ), voice and accountability (VA), and rule of law (RL), as previously used by Khan, Weili, & Khan (2022b). To study the combined effect of legal system indicators, a political index (LEGDX) is constructed using principal component analysis (PCA) from the three indicators: CC, GE, and PS. To examine the collective impact of political system indicators on carbon dioxide emissions, a political system index (POLDX) is created using PCA from three indicators: RL, RQ, and VA. For robustness checks, the study uses two indicators separately in different models that are commonly used to proxy institutional quality: control of corruption (from the legal system) and rule of law (from the political system). These indicators have recently been used as single proxies for institutional quality by Hunjra et al. (2020) and Khan, Weili, & Khan (2021). Countries may adopt various strategies to control carbon emissions, such as implementing advanced technologies, carbon taxation, promoting public transportation, and substituting polluting energy sources with clean alternatives. These strategies, however, are long-term in nature and may not significantly reduce carbon emissions within a short time frame.

For the analysis, this study employs the Fixed Effects model, two-step system GMM (SGMM), and difference GMM (DGMM). The primary model used is the two-step SGMM. The Fixed Effects or Random Effects models may encounter issues with autocorrelation between lagged response variables, the error term, and endogeneity (Amuakwa-Mensah & Adom, 2017). The SGMM estimator, introduced by Arellano & Bover (1995), addresses these issues, providing a robust solution for autocorrelation and endogeneity. The two-step SGMM estimator further addresses potential instrument weaknesses, making it a more reliable and efficient estimator. The research ultimately relies on the SGMM model to examine the relationships between dependent and independent variables. The instruments used in the GMM approach mitigate the issue of endogeneity among explanatory variables, which is advantageous given the panel's structure where the number of countries exceeds the time periods in the sample. Additionally, the GMM model retains the cross-country variation, avoiding its elimination (Asongu et al., 2019). It also has the ability to manage overidentification restrictions and reduces heteroscedasticity of the instruments used, ensuring the model's robustness. The identification restrictions and overidentification tests are applied to evaluate the model's validity. Asongu et al. (2019) explain that GMM allows for the selection of explanatory, exogenous, and endogenous variables. The identification restriction confirms the impact on the response variable when strict exogenous variables are employed alongside endogenous variables. Asongu & Le Roux (2017) and Roodman (2009) clarify that endogenous variables are predictors, while exogenous variables remain time-invariant. The Hansen test results, which evaluate instrument exogeneity for overidentifying restrictions, indicate that if the null hypothesis is accepted, the model assumptions are valid. The AR2 test examines the second-order serial correlation, validating the model's assumptions concerning error term behavior and overall serial correlation.

Results and discussion

Preliminary Results

The results section analyses the effect of institutional quality and other variables on carbon dioxide emissions, presenting both descriptive statistics and correlations to offer insights into the data characteristics. The average carbon dioxide emissions (CO_2) is 6.192 metric tons per capita (mtpc), with a standard deviation (SD) of 6.983.

Over the observed period, financial development (FD) has a mean value of 3.542% with an SD of 0.848, and renewable energy consumption (REC) averages 3.065 billion kWh, showing an SD of 1.731. Industrial growth (IND) has an average of 1.64 and an SD of 0.955.

Table 1. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
CO2	6.192	6.983	.034	50.954
CC	-.24	.797	-1.71	2.33
GE	-.056	.789	-2.31	2.44
PS	-.293	.99	-3.18	1.62
RL	-.19	.798	-2.09	1.88
RQ	-.083	.873	-2.34	2.26
VA	-.445	.892	-2.26	1.21
EF	1.906	.137	1.206	2.177
REC	3.065	1.731	-2.395	8.825
FD	3.542	.848	-1.681	5.542
FOR	229281	1040909	3.7	8153116
IND	1.64	.955	-4.43	3.916
ED	1.314	.848	-4.581	3.902
NREC	4.295	.424	2.154	4.605

Institutional quality indicators such as Control of Corruption (CC), Government Effectiveness (GE), Political Stability (PS), Rule of Law (RL), Regulatory Quality (RQ), and Voice and Accountability (VA) reveal mean and SD values of -0.24 (0.797), -0.056 (0.789), -0.293 (0.99), -0.19 (0.798), -0.083 (0.873), and -0.445 (0.892), respectively.

Table 2. Correlation

	CO2	CC	GE	PS	RL	RQ	VA	EF	REC	FD	FOR	IND	ED	NREC
CO2	1													
CC	0.50	1												
GE	0.41	0.88	1											
PS	0.43	0.66	0.64	1										
RL	0.43	0.89	0.93	0.67	1									
RQ	0.34	0.81	0.89	0.59	0.90	1								
VA	-0.02	0.53	0.61	0.39	0.67	0.70	1							
EF	0.25	0.63	0.69	0.56	0.69	0.79	0.61	1						
REC	0.18	0.05	0.15	-0.13	0.08	0.05	-0.03	-0.17	1					
FD	0.29	0.51	0.64	0.39	0.61	0.56	0.34	0.46	0.33	1				
FOR	0.08	-0.13	-0.03	-0.09	-0.12	-0.06	-0.09	-0.13	0.38	0.06	1			
IND	-0.11	-0.19	-0.21	-0.03	-0.23	-0.19	-0.11	-0.14	-0.15	-0.21	-0.05	1		
ED	-0.16	-0.10	-0.11	0.04	-0.13	-0.10	-0.03	-0.02	-0.03	-0.09	0.02	0.50	1	
NREC	0.32	0.18	0.18	0.15	0.14	0.12	-0.05	0.09	0.40	0.15	0.05	-0.09	-0.13	1

Other variables include economic freedom (EF), with an average of 1.906 and an SD of 0.137, and non-renewable energy consumption (NREC), averaging 4.295 with an SD of 0.424. The forest area (FOR) has a mean of 229,281 and an SD of 1,040,909, while the education level (ED) averages 1.314 with an SD of 0.848.

The correlation analysis shows that carbon dioxide emissions have a positive correlation with several institutional indicators such as CC (0.50), GE (0.41), PS (0.43), RL (0.43), and RQ (0.34). Renewable energy consumption (REC) has a relatively low positive correlation with carbon emissions (0.18). Financial development (FD) is positively correlated with CO2 emissions (0.29), while forest area (FOR) and industrial growth (IND) show weaker correlations of 0.08 and -0.11, respectively. Economic freedom (EF) also has a mild positive correlation with CO2 (0.25), while non-renewable energy consumption (NREC) exhibits a moderate positive correlation of 0.32. The correlations among the institutional indicators themselves are generally strong, indicating interdependence between different aspects of institutional quality.

The variance inflation factor (VIF) analysis for the legal system, political system, and institutional quality variables is presented in Table 3. VIF is a diagnostic tool used to detect multicollinearity, which arises when two or more explanatory variables in a model are highly correlated. Multicollinearity can distort the estimation of coefficients, making it difficult to assess the true impact of each variable. VIF is calculated by regressing each explanatory variable against all others and using the resulting coefficient of determination to measure the degree of multicollinearity.

$$VIF_i = 1 / R_i^2$$

According to the guidelines by Curto & Pinto (2011) and Alin (2010), a VIF value equal to or greater than 10 indicates the presence of multicollinearity. However, the results in Table 3 show that none of the variables have VIF values reaching this threshold, suggesting that multicollinearity is not an issue in this model. Therefore, the explanatory variables in the analysis are not significantly correlated, allowing for accurate interpretation of the regression results.

Table 3. Multicollinearity

VIF results					
Legal (Variables)	VIF	Political (Variables)	VIF	Institutional (Variables)	VIF
GE	6.58	RQ	8.084	INST	2.477
CC	5.942	RL	7.379	LREC	1.954
PS	2.144	VA	2.325	LEF	2.176
LREC	2.149	LREC	1.941	LFD	1.779
LEF	2.196	LEF	3.178	LED	1.606
LFD	1.788	LFD	1.84	LIND	1.613
LED	1.63	LED	1.642	LNREC	1.394
LIND	1.615	LIND	1.628	FOR	1.388
LNREC	1.505	LNREC	1.408		
FOR	1.424	FOR	1.503		
Mean VIF	2.697	Mean VIF	3.093	Mean VIF	1.798

The data stationarity is checked before going to the formal analysis where the results are given in table 4. There has been improvement of unit root tests of panel data some of which are (Breitung, 2001; Breitung & Das, 2005; Choi, 2001; Hadri, 2000; Im, Pesaran, & Shin, 2003; Levin, Lin, & Chu, 2002). These researches show that unit root tests of panel will be less likely to have type II error. As the unbalanced nature and individual time series gaps of the data this study will use Fisher type unit root tests based on Augment Dickey Fuller tests. Given by (Choi, 2001) for which balanced data is not required and individual series gaps are allowed. Fisher-type Augment Dickey Fuller tests used by (Fayissa & Nsiah, 2013; Mehrara, Fazaeli, Fazaeli, & Fazaeli, 2012). For panel data unit root, Fisher-type Augment Dickey Fuller test conduct individual test for each panel for unit root and the gather all p-values for generating the results.

Table 4. Panel unit root tests

Fisher-type unit-root test based on augmented Dickey–Fuller tests				
Variables	I (0)		I (1)	
	Statistic	p-value	Statistic	p-value
CO2	103.943	0.955	993.112	0.000
CC	240.582	0.000	1187.825	0.000
GE	179.948	0.002	1159.976	0.000
PS	180.817	0.002	1023.000	0.000
RL	160.507	0.035	1119.338	0.000
RQ	193.816	0.000	1069.064	0.000
VA	148.060	0.132	965.073	0.000
LEF	312.299	0.000	578.893	0.000
LREC	124.392	0.622	1069.065	0.000
LFD	261.912	0.000	578.893	0.000
FOR	944.070	0.000	306.006	0.000
LIND	452.250	0.000	1319.262	0.000
LED	552.994	0.000	1412.518	0.000
LNREC	148.088	0.023	889.615	0.000

All of the variable are stationary at level excluding carbon dioxide emissions, VA and REC. No variable is stationary at two differences. All the variables are stationary at I(1).

Model results

Table 5 presents the empirical results of the Fixed Effect (FE) model, two-step difference Generalized Method of Moments (DGMM), and two-step system Generalized Method of Moments (SGMM) models for Belt and Road Initiative (BRI) countries over the period 2000-2020. The table is structured with the first column listing the variables, followed by columns two and three, which display the results of the FE and two-step DGMM models based on the institutional quality index. Column four shows the two-step SGMM model results for legal system indicators, while column five provides the results for the two-step SGMM model using the legal system index. Column six reports the two-step SGMM model for political system indicators, column seven presents the SGMM results for the political system index, and column eight shows the two-step SGMM model based on the institutional quality index.

In the FE model, economic freedom exhibits a negative but non-significant relationship with carbon dioxide emissions. However, in the two-step DGMM and SGMM models, economic freedom shows a negative and highly significant relationship with carbon dioxide emissions. These findings suggest that increased economic freedom is associated with reduced emissions, supporting the argument that greater economic freedom leads to improved political stability, which in turn encourages investments in clean, renewable energy sources and energy-efficient businesses (Shabani & Shahnazi, 2019). This outcome aligns with previous studies, including those by Bjørnskov (2020), Carlsson & Lundström (2001), Majeed et al. (2021), and Wu et al. (2022), which also found a negative relationship between economic freedom and emissions. In contrast, studies by Adesina & Mwamba (2019) and Bae, Li, & Rishi (2017) report conflicting results, indicating that the impact of economic freedom may vary depending on regional or structural factors not fully captured in this analysis.

Table 5. Results of FE, two-step dynamic GMM and system GMM

(1)	(FE-INSTDX)	(DGMM-INSTDX)	(SGMM-LEG)	(SGMM-LEGDX)	(SGMM-POL)	(SGMM-POLDX)	(SGMM-INSTDX)
$CO2_{it-1}$		0.202***	0.867***	0.882***	0.880***	0.879***	0.882***
		(0.017)	(0.020)	(0.011)	(0.015)	(0.014)	(0.011)
CC			0.152*				
			(0.087)				
GE			-0.032				
			(0.050)				
PS			0.109***				
			(0.028)				
EF	-0.344	-4.381***	-1.137**	-1.629***	-1.382***	-1.428***	-1.629***
	(0.730)	(0.377)	(0.459)	(0.384)	(0.184)	(0.386)	(0.384)
REC	0.598***	1.161***	-0.128***	-0.146***	-0.138***	-0.161***	-0.146***
	(0.185)	(0.098)	(0.037)	(0.028)	(0.036)	(0.029)	(0.028)
FD	0.068	0.255***	0.259***	0.271***	0.252***	0.309***	0.271***
	(0.085)	(0.038)	(0.043)	(0.022)	(0.035)	(0.031)	(0.022)
FOR	0.000***	0.000***	0.000	-0.000**	-0.000***	-0.000*	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND	0.003	0.0171*	0.113***	0.102***	0.091***	0.114***	0.102***
	(0.056)	(0.009)	(0.008)	(0.012)	(0.015)	(0.012)	(0.012)
ED	-0.023	0.0743***	0.005	0.001	-0.018	-0.027*	0.001
	(0.072)	(0.019)	(0.015)	(0.019)	(0.024)	(0.015)	(0.019)
NREC	1.242***	1.317***	0.260**	0.297***	0.224***	0.308***	0.297***
	(0.441)	(0.219)	(0.097)	(0.092)	(0.082)	(0.106)	(0.092)
INSTDX	-0.410**	0.153***					0.169***
	(0.191)	(0.038)					(0.036)
LEGDX				0.169***			
				(0.036)			
RL					0.625***		
					(0.100)		

Table 5 continue . . . .

RQ					-0.248***		
					(0.028)		
VA					-0.244***		
					(0.048)		
POLDX						0.135***	
						(0.043)	
Constant	-6.695***		1.135	1.891**	1.868***	1.415	1.891**
	(2.201)		(0.926)	(0.773)	(0.470)	(0.963)	(0.773)
Obs	439	310	415	415	415	415	415
R-squared	0.223						
No. of CID	54	48	54	54	54	54	54
AR2		-0.56	-0.63	-0.66	-0.62	-0.64	-0.66
		(0.577)	(0.529)	(0.508)	(0.537)	(0.524)	(0.508)
Sargan test		130.49	136.93	134.46	133.08	135.18	134.46
		(0.002)	(0.008)	(0.017)	(0.015)	(0.016)	(0.017)

Note: Standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Regarding renewable energy consumption (REC), the FE and two-step DGMM models indicate a significantly positive relationship with carbon dioxide emissions. However, the most reliable estimators come from the SGMM models, which show that renewable energy usage is highly significantly negative. This implies that increased renewable energy usage effectively reduces carbon dioxide emissions. The results suggest that a 1% increase in renewable energy usage leads to a reduction in emissions of approximately 14.6% (LEGDX), 16.1% (POLDX), and 14.6% (INST-IND). This finding underscores the importance of transitioning from non-renewable to green energy sources in BRI countries to mitigate emissions effectively. The results align with the conclusions of previous studies, such as those by Apergis, Ben Jebli, & Ben Youssef (2018), Jebli, Farhani, & Guesmi (2020), and Sinha & Shahbaz (2018), which also demonstrate the emissions-reducing impact of renewable energy consumption. However, contrasting evidence comes from Apergis, Payne, Menyah, & Wolde-Rufael (2010), who found a positive relationship between renewable energy consumption and carbon dioxide emissions when examining 19 developing and developed economies from 1984 to 2004. The divergence in findings could be attributed to different time periods, regions, or the stages of economic development and energy transition in the countries studied.

The findings indicate that financial development has a highly significant and positive effect on carbon emissions. This suggests that as financial development progresses, carbon emissions increase, a pattern observed in other studies such as those by Guo, Hu, & Yu (2019), Ling et al. (2022), and Nasir, Huynh, & Tram (2019). The reasoning behind this relationship is that financial development often stimulates economic growth, leading to increased industrial activities and energy consumption, which in turn raises emissions. The positive relationship is consistently observed across most models, though it is non-significant in the FE model. These results contradict the findings of studies like Boutabba (2014), Diallo & Masih (2017), Jian et al. (2019), Jiang & Ma (2019), Omri et al. (2015), Raza & Shah (2018), and Zhang & Cheng (2009), which reported differing impacts of financial development on carbon emissions, potentially due to differences in the stages of economic development or variations in the implementation of environmental regulations across countries.

The empirical evidence further confirms that forest area has a significant negative impact on carbon emissions, aligning with the findings of Stern (2006) and Waheed et al. (2018). This is explained by the fact that forests play a critical role in absorbing carbon dioxide through photosynthesis, thus acting as a natural carbon sink. These findings highlight the importance of forest conservation and expansion in mitigating carbon emissions. Preventing deforestation and promoting reforestation and afforestation are effective strategies for reducing emissions, as forests are essential in balancing the carbon cycle. The significant negative effect observed in the results underscores the urgent need to integrate forest preservation into national and regional environmental policies, a factor often overlooked in previous research.

The analysis also shows that industrial growth has a significantly positive impact on carbon emissions. This is consistent with studies by Afawubo & Ntouko (2016), Martínez-Zarzoso & Maruotti (2011), Rauf et al. (2018), and Shahbaz et al. (2014). The positive relationship suggests that as industrial activities expand, they rely heavily on energy primarily derived from fossil fuels thus increasing emissions. In developing economies, environmental policies may not be stringent enough, and globalization often promotes the growth of pollution-intensive industries. As industrialization and globalization advance, the demand for energy intensifies, typically supplied by non-renewable sources such as coal and oil. This further explains why industrial growth is positively correlated with emissions, as noted by Sabir & Gorus (2019). However, some studies, including those by Aslam et al. (2021), Dodman (2009), Dong et al. (2020), and Fan et al. (2006), found that industry, when supported by appropriate environmental regulations and energy-efficient practices, can also reduce emissions, highlighting the potential for policy interventions to mitigate the negative environmental impacts of industrialization.

Economic development shows a mixed relationship with carbon emissions. In the FE and two-step SGMM (political system) models, it is non-significant and negative, while it is non-significant and positive in the two-step SGMM (legal system) and two-step SGMM (legal system index) models. In the political system index, it is significantly negative. These variations are consistent with Wang & Li (2021), who argue that the influence of economic development on emissions may depend on the strength of governance and institutional quality. Studies such as those by Abdallh & Abugamos (2017), Balibey (2015), Muhammad (2019), Saidi & Hammami (2015), Saidi & Mbarek (2017), Sharif Hossain (2011), and Zaman & Abd-el Moemen (2017) found a positive relationship between GDP per capita and emissions, indicating that as economies grow, emissions tend to rise. This is expected in developing economies where growth often relies on energy-intensive sectors. Conversely, Kasman & Duman (2015) found that GDP could have a discouraging influence on emissions, particularly when countries adopt cleaner technologies and environmental policies. Additionally, studies by Salahuddin & Gow (2014), Acheampong (2018), Gorus & Aydin (2019), and Soytas et al. (2007) present evidence that GDP may have no significant effect on carbon emissions, suggesting that the impact of economic growth on emissions is complex and varies depending on the context.

Non-renewable energy consumption consistently shows a strongly significant and positive relationship with carbon emissions across all models. This indicates that reliance on fossil fuels, a major energy source in BRI countries, is detrimental to the environment. Most countries in the sample are classified as low-income or lower-middle-income economies (World Bank, 2021), where economic growth is heavily dependent on energy from non-renewable sources. This reliance leads to environmental degradation, as fossil fuel consumption contributes significantly to carbon emissions. These findings emphasize the need for a transition to green energy sources to reduce emissions effectively. The results are consistent with studies by Chen et al. (2019), Dogan & Seker (2016), Liu et al. (2017), and Vural (2020), which highlight the importance of renewable energy in reducing emissions.

The legal system index, political system index, and institutional quality index all show a positive and significant relationship with carbon emissions. Weak institutional quality can lead to environmental damage and economic risks, as suggested by Le et al. (2016) and Shah et al. (2019). The study shows that financial development depends on institutional quality (La Porta et al., 1997), and when institutional quality is low, it can degrade the environment (Ling et al., 2022). The analysis identifies specific variables within the political and legal systems such as regulatory quality, voice and accountability, and government effectiveness that have significant negative impacts on carbon emissions (Karim et al., 2022; Khan et al., 2022; Piabuo et al., 2021). Conversely, other variables like political stability, control of corruption, and rule of law show positive and significant influences on emissions, consistent with findings from Abid (2016), Cansino et al. (2019), and Damania et al. (2003). Olson (1996) highlighted that the quality of political institutions can foster productive competition. A well-structured political system is crucial in enforcing emission control measures. If clear and robust regulations exist, firms are likely to comply, reducing emissions. In contrast, weak regulatory frameworks may allow firms to evade compliance, exacerbating environmental harm. Poor institutional quality can hinder economic development without addressing environmental impacts (Lopez & Mitra, 2000; Welsch, 2004).

In models 3, 5, 7, and 8, the construction of legal system index, political system index, and institutional quality index using principal component analysis shows that these indices are strongly significant. The positive sign indicates that weaknesses in indicators such as rule of law, voice and accountability, government effectiveness, control of corruption, political stability, and regulatory quality contribute significantly to increased carbon emissions. This highlights that deficiencies in these institutional aspects have adverse consequences for environmental quality, underscoring the importance of strengthening institutions to manage and mitigate carbon emissions effectively.

Robustness Check

The robustness check results for the legal and political system indexes, using the control of corruption (CC) from the legal system and rule of law (RL) from the political system, are presented in Table 6. These variables have been utilized recently by studies such as Hunjra et al. (2020) and Khan et al. (2022b). The findings are consistent with the main model results, confirming the robustness of the selected variables. In the two-step system GMM results, the lagged carbon dioxide emissions (LCO2) variable shows a highly significant positive relationship with coefficients of 0.876 and 0.879 in the CC-LEG and RL-POL models, respectively, indicating that past emissions positively influence current levels. The rule of law (RL) also shows a positive and significant coefficient of 0.169 in the RL-POL model, supporting the impact of political system strength on emissions. Economic freedom (LEF) displays a significant negative relationship with carbon emissions, with coefficients of -1.284 and -1.428 in the CC-LEG and RL-POL models, respectively. This aligns with the expectation that higher economic freedom reduces emissions through investments in cleaner technologies. Renewable energy consumption (LREC) is significantly negative in both models, with coefficients of -0.140 and -0.161, suggesting that increased renewable energy use leads to lower emissions.

Conversely, financial development (LFD) exhibits a significant positive relationship with emissions, with coefficients of 0.272 and 0.309 in the CC-LEG and RL-POL models, respectively. This reinforces the earlier findings that financial development, while essential for economic growth, may increase emissions if not accompanied by sustainable practices. Forest area (FOR) shows a non-significant result in the CC-LEG model but is weakly significant ($p<0.1$) with a negative coefficient in the RL-POL model, indicating the importance of forest preservation in emission reduction efforts. Industrial growth (LIND) is positively associated with carbon emissions, with coefficients of 0.105 and 0.114, reflecting the emissions-intensive nature of industrial activities. Education level (LED) shows a weak negative association in the RL-POL model, but it remains non-significant in the CC-LEG model. Non-renewable energy consumption (NREC) has a strong and significant positive impact on emissions, with coefficients of 0.207 and 0.308, highlighting the role of fossil fuel consumption in increasing carbon emissions. The control of corruption (CC) variable also shows a significant positive coefficient of 0.202 in the CC-LEG model, indicating that despite the intention of improving governance, its current influence still correlates with higher emissions.

Table 6. Robustness check (Two step system GMM results)

Variables	CC-LEG	RL-POL
LCO2	0.876***	0.879***
	(0.013)	(0.014)
RL		0.169***
		(0.054)
LEF	-1.284**	-1.428***
	(0.490)	(0.386)
LREC	-0.140***	-0.161***
	(0.032)	(0.0292)
LFD	0.272***	0.309***
	(0.038)	(0.0312)
FOR	-0.000	-0.000*
	(0.000)	(0.000)
LIND	0.105***	0.114***
	(0.013)	(0.0127)
LED	-0.000	-0.027*
	(0.017)	(0.015)
NREC	0.207***	0.308***
	(0.051)	(0.106)
CC	0.202***	
	(0.055)	
Constant	1.644*	1.447
	(0.942)	(0.970)
Obs.	415	415
No. of CID	54	54
AR2	-0.64	-0.64
	(0.520)	(0.524)
Sargan test	136.55	135.18
	(0.013)	(0.016)

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The constant term is weakly significant in the CC-LEG model (p<0.1) but non-significant in the RL-POL model. The robustness check models include 415 observations with 54 cross-sectional IDs, and the results for the AR2 test indicate no autocorrelation issues, as the p-values (0.520 and 0.524) are not significant. The Sargan test results (136.55 and 135.18 with p-values of 0.013 and 0.016, respectively) suggest that the instruments used are valid and the models are appropriately specified.

Conclusion

The Belt and Road Initiative (BRI) countries, primarily composed of developing and emerging economies, face significant environmental challenges due to their reliance on fossil fuels, rapid industrial growth, and evolving economic structures. These countries contribute substantially to global carbon emissions, affecting climate change and environmental sustainability. As international efforts focus on reducing emissions, understanding the economic, institutional, and environmental factors driving emissions in these countries is crucial. This research evaluates the impact of various factors such as institutional quality, economic freedom, non-renewable and renewable energy consumption, industrial growth, financial development, economic development, and forest cover on carbon emissions in 65 BRI countries between 2000 and 2020. The study employs econometric models, including Fixed Effects (FE) and dynamic panel models like the two-step difference Generalized Method of Moments (DGMM) and the two-step system Generalized Method of Moments (SGMM), to provide a robust analysis of these relationships. The findings reveal that economic freedom has a significantly negative impact on carbon emissions, demonstrating that when countries promote economic freedom with strong regulatory frameworks, they can reduce emissions. Without adequate governance, however, economic freedom can lead to environmental harm. These results emphasize that BRI countries must combine economic freedom with institutional reforms to maximize its environmental benefits. Renewable energy consumption also shows a strong negative relationship with emissions, indicating that increasing the use of renewable energy sources can significantly reduce emissions by up to 16.1% across the sample countries. Given that many of these nations are lower-income economies heavily reliant on non-renewable energy, the findings highlight the need for substantial investment and policy support to transition towards green energy. Policymakers should prioritize green energy initiatives, offering incentives to adopt cleaner technologies and reduce dependence on fossil fuels. On the other hand, non-renewable energy consumption has a strong positive association with carbon emissions, consistent across all models. The results underline the urgent need for BRI countries to reduce reliance on fossil fuels and increase the use of renewable energy to mitigate environmental impact and create new economic opportunities through the development of green technologies. Financial development is also found to have a positive effect on carbon emissions. Although financial development is essential for economic growth, it can lead to environmental degradation if not aligned with sustainability goals. In BRI countries, the financial sector often prioritizes short-term gains and traditional energy sectors, underscoring the need for policymakers to reorient financial institutions towards sustainable investments. Forest cover is shown to have a negative relationship with emissions, underscoring its importance in carbon sequestration. However, deforestation, driven by land clearance for urbanization and agriculture, remains prevalent in many of these countries, exacerbating environmental degradation. Policymakers must implement strict regulations to control deforestation while promoting reforestation and afforestation to expand forest areas, which is an effective strategy for reducing emissions. The study finds economic development to be non-significant in relation to carbon emissions, suggesting that growth in BRI countries does not inherently increase emissions. However, given that many economies in the region depend heavily on fossil fuel industries, this implies that without a shift toward greener industries, economic growth alone cannot lead to sustainable development. To achieve sustainable growth, policymakers must diversify economies and promote clean technology sectors. Industrial growth is associated with increased emissions, particularly in lower-income countries that focus on expanding energy-intensive manufacturing industries. In the early stages of industrialization, these economies often rely on pollution-heavy industries, accelerating environmental degradation. As countries become wealthier, they have the opportunity to invest in cleaner technologies. Therefore, governments should prioritize policies that promote advanced, environmentally friendly technologies as their economies develop. Institutional quality shows mixed results. Strong institutions, indicated by regulatory quality, government effectiveness, and voice and accountability, negatively affect emissions, highlighting their importance in protecting the environment. Conversely, weak institutional elements, such as inadequate rule of law, poor control of corruption, and political instability, contribute to increased emissions. These findings suggest that when institutional quality is low, regulatory gaps may be exploited, leading to greater pollution. The study finds that legal, political, and overall institutional quality indexes are associated with higher emissions, indicating the need for improvement to reduce emissions and support sustainable development. Robustness checks using control of corruption (CC) and rule of law (RL) confirm the consistency and reliability of these results, emphasizing the importance of strong governance frameworks. Despite its comprehensive nature, the study has limitations. The focus on BRI countries may limit the generalizability of the findings, as these countries have unique development trajectories that may not apply to other regions. The panel data models provide a broad view but may overlook specific local factors influencing emissions, such as governance practices and technological capabilities. Additionally, the study's macro-level approach might not capture firm-level practices or technological innovations that could influence emissions outcomes.

Future research should expand to a global sample, categorizing countries by income levels to understand the impact of economic disparities on emissions. This approach could reveal whether higher-income countries exhibit different emissions patterns compared to lower-income nations. Further exploration of the moderating role of economic freedom on environmental outcomes could provide deeper insights into how institutional and economic environments affect emissions. Future studies should also integrate micro-level data to better understand how innovation, firm-level practices, and local governance influence emissions control. Such research would provide a more detailed understanding of emissions reduction strategies, helping identify effective policies for promoting sustainability.

Appendices

Appendix 1

Table 7. One Belt One Road countries list with income level

Country	Income	Country	Income	Country	Income	Country	Income	Country	Income
Afghanistan	L	China	UM	Israel	H	Montenegro	UM	Slovak Republic	H
Albania	UM	Croatia	H	Jordan	UM	Myanmar	LM	Slovenia	H
Algeria	LM	Cyprus	H	Kazakhstan	UM	Nepal	LM	Sri Lanka	LM
Armenia	UM	Czech Republic	H	Kuwait	H	Oman	H	Syrian Arab Republic	L
Azerbaijan	UM	Egypt, Arab Rep.	LM	Kyrgyz Republic	LM	Pakistan	LM	Tajikistan	LM
Bahrain	H	Estonia	H	Lao PDR	LM	Philippines	LM	Thailand	UM
Bangladesh	LM	Georgia	UM	Latvia	H	Poland	H	Turkey	UM
Belarus	UM	Greece	H	Lebanon	LM	Qatar	H	Turkmenistan	UM
Bhutan	LM	Hungary	H	Lithuania	H	Romania	H	Ukraine	LM
Brunei Darussalam	H	India	LM	Malaysia	UM	Russian Federation	UM	United Arab Emirates	H

Table 7 continue. . . .

Bulgaria	UM	Indonesia	LM	Maldives	UM	Saudi Arabia	H	Uzbekistan	LM
Burkina Faso	L	Iran,	LM	Moldova	UM	Serbia	UM	Vietnam	LM
Cambodia	LM	Iraq	UM	Mongolia	LM	Singapore	H	Yemen, Rep.	L

Appendix 2

Table 8. Description of symbols and data sources

Symbol	Unit/Proxied by	Data Source
CO2	CO2 emissions (metric tons per capita)	
CC		
GE		
PS	WGI Indicators	World Bank
RL		(www.govindicators.org)
RQ		
VA		
LEF	Log of economic freedom. This index was normalized on a scale of 0-10 with 10 the highest score	Heritage Foundation
LREC	Log of electricity net consumption (billion kWh)	EIA
LFD	Log of domestic credit to private sector by banks (% of GDP)	World Bank
FOR	Forest area (sq. km)	EIA
LIND	Log of industry (including construction), value added (annual % growth)	World Bank
LED	Log of GDP per capita growth (annual %)	World Bank
NREC	Log of fossil fuel energy consumption (% of total)	World Bank
LEG-IND	Constructed from CC, GE, PS	
POL-IND	Constructed from RL, RQ, VA	World Bank
INST-IND	Constructed from RL, RQ, VA, CC, GE, PS	
FE	Fixed Effects	
DGMM	Difference generalised method of moments	
SGMM	System generalised method of moments	
GDP	Gross domestic product	
OBOR	One Belt One Road	
GHG	Greenhouse gas	
L	Low income	
LM	Lower middle income	World Bank Classification
UM	Upper middle income	
H	High income	
ADF	Augment Dickey Fuller	

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