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Identifying the Key Driving Factors of Carbon Emissions in 'Belt and Road Initiative' Countries

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Abstract: The 'Belt and Road Initiative' (B&R) countries play a key role in mitigating global carbon emissions, but their driving factors behind carbon emissions remain unclear. This paper aimed to identify the key driving factors (KDFs) of carbon emissions in the B&R countries based on the extended STIRPAT (stochastic impacts by regression on population, affluence, and technology) model. The empirical results showed that: (1) Population and GDP per capita were the KDFs that promoted carbon emission, while energy intensity improvement and renewable energy were the KDFs that inhibited carbon emissions. Urbanization, another KDF, had a dual impact across countries. (2) The KDFs varied across the B&R countries. For the high-income group (HI), population had the greatest impact. It was identified as the KDF promoting carbon emission, while for the other three income groups, GDP per capita, as the dominant factor, was identified as the KDF promoting carbon emission. (3) Moreover, two interesting trends were found, namely, the higher the income, the greater the impact of energy intensity while the lower the impact of GDP per capita. These results could provide guidance for carbon reduction in the B&R countries.

Keywords: carbon emissions; KDFs; STIRPAT model; B&R countries

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1. Introduction

China proposed the "Belt and Road Initiative" (B&R) in 2013 to improve connectivity and cooperation on a transcontinental scale. As of 2021, 143 countries signed the "Belt and Road Initiative" to develop infrastructure, economy, trade, culture, and tourism [1]. However, one of the side effects of promoting the economies of the B&R initiative member countries is that their carbon emissions increase [2,3]. To investigate the key driving factors (KDF) of carbon emissions, this paper takes 65 B&R countries located along the ancient Silk Road as the target. From 2000 to 2018, the total carbon emissions of the 65 B&R countries increased from 10.21 billion metric tons to 20.33 billion metric tons, with an average growth rate of nearly 5%, which was far higher than the global average [4]. The surging economic development and cooperation across the B&R countries translate into the increasing growth rate of CO_2 emissions. A temperature control target of 2 °C/1.5 °C was stipulated in the Paris Agreement. These 65 B&R countries are signatories to the Paris Agreement with established NDC (Nationally Determined Contribution) targets. Almost half of these countries have also proposed to achieve the carbon neutrality goal by 2050, except for China, Ukraine, Indonesia, and Kazakhstan, whose carbon neutrality goal is targeted to be achieved by 2060. As an emerging economic group, it is a daunting task to achieve carbon neutrality in 30/40 years' time. Most of these B&R countries are developing or underdeveloped. They will therefore face multiple challenges concerning the eco-environment and climate change. To balance economic development and environmental protection to achieve a green and low-carbon transformation, they need to take targeted measures to mitigate their future carbon emissions. To this end, the first step in this research is to identify the KDF of carbon emission in the B&R countries.

Due to different resource endowments and socio-economic development levels, the KDF of carbon emission varies across countries [5]. For instance, Irziar et al. [6] reported that GDP per capita was the KDF of carbon emissions in Spain, while Khan et al. believed that energy intensity was the KDF in Bangladesh, Pakistan, and India [7]. These identified KDFs are not only affected by the different socio-economic development levels of these countries but they are also affected by the choice of potential driving factors. An incomprehensive driving factor analysis may lead to inaccurate KDF identification. This will influence the formulation of effective carbon reduction policies. To identify accurate KDF in the B&R countries, it is necessary to explore a comprehensive pool of potential driving factors based on the status of the B&R countries.

Currently, many studies explored the driving factors by decomposing carbon emissions into some predefined factors to identify the KDF of carbon emissions across or within a country. Some of the related literature is summarized in Table 1. Previously used methods include decomposition analysis (i.e., structural decomposition 'SDA', index decomposition 'IDA', and Logarithmic Mean Divisia Index 'LMDI'), IPAT model, and STIRPAT model. For example, José employed the SAD model to identify the key driving factors of carbon emission in Spain [8]. Diakoulaki et al. employed the IDA analysis to investigate the KDFs of carbon emission from electricity generation in Greece [9]. Yao et al. applied the LMDI model to identify the KDF of carbon emissions in the G20 countries [10]. These decomposition analysis methods decompose carbon emissions into specifics and give real meaning to the factors. However, the factors behind carbon emissions are complex, and some are even without physical significance [11,12]. Therefore, some studies also adopted the IPAT model to examine the KDFs of carbon emissions [13,14]. However, it is difficult to track the non-linear relationship between parameters [15]. The STIRPAT model, which is extended from the IPAT model, is capable of incorporating unlimited additional factors, such as industrial structure, foreign direct investment, as well as research and development investment. Thus, the STIRPAT model can overcome these flaws. Its advantages in exploring potential driving factors of carbon emissions make it a commonly-used method in identifying the driving factors of carbon emissions [16,17].

With regards to the selection of driving factors, it is seen from Table 1 that different studies selected different potential driving factors to identify the KDFs. For example, Shuai et al. selected total population, GDP per capita, and energy intensity as the potential driving factors to investigate the key driving factors in 125 countries [18]. Brizga et al. selected total population, GDP per capita, fossil energy consumption, and industry proportion as the potential driving factors to explore the KDFs in the former Soviet Union countries [19]. Khan et al. examined the KDFs of carbon emission in three developing Asian countries based on potential factors such as energy intensity, GDP per capita, financial development, and income inequality [7]. The potential driving factors adopted by Shahbaz et al. were GDP per capita, energy intensity, trade openness, and financial development. The study concluded that energy intensity was the KDF in Indonesia [20]. The differences in selecting potential factors do not only occur in different countries but also occur in the KDFs identified in the same country. For instance, Li et al. identified the GDP per capita as the KDF in China from RG, energy intensity, and urbanization rate [21], while Xiao et al. identified the final demand effect as the KDF in China from energy structure, final demand effect, GDP per capita, and energy intensity [22]. The difference in potential driving factors led to different results of the KDF from their studies. This results in complications in the formulation of carbon reduction policies. To avoid ignoring the factors that might become the KDFs when selecting potential driving factors, it is necessary to expand the pool of potential driving factors for identifying a more reliable KDF of carbon emissions.

Table 1. Summary of relevant studies and major findings.

Authors	Period	Method	Country	Driving Factor	Result
Fan et al. (2006) [23]	1975–2000	STIRPAT	208 countries	TP RG EI UR WP	TP→+CO_2 (KDF in UMI group) RG→+CO_2 (KDF in LMI group) WP→−CO_2 (in HI group) WP→+CO_2 (in LMI and LI group) UR→+CO_2 (KDF in LI group) EI→−CO_2
Poumanyvong and Kaneko (2010) [16]	1975–2005	STIRPAT	99 countries	TP UR RG EI IG EC	UR→+CO_2 UR→−EI (LI group) UR→+EI (MI and HI group)
Brizga et al. (2013) [19]	1990–2010	IDA	Former soviet union	TP RG FE IG EI	RG→+CO_2 (KDF in 1971–1990, 2001–2010) EI→+CO_2 (KDF in 1991–2000) TP→+CO_2 (2001–2005) FE→+CO_2 (2001–2005) TP &FE→×CO_2 (2006–2010)
Khan et al.(2018) [7]	1980–2014	STIRPAT	Three developing Asian countries	RG FD income inequality EI	EC→+CO_2 (KDF) FD→+CO_2 financial development Income inequality→+CO_2 (Bangladesh) Income inequality→−CO_2 (Pakistan and India)
Inmaculada et al. (2011) [17]	1975–2003	STIRPAT	93 developing countries	TP RG EI UR WP	TP→+CO_2 RG→+ CO_2 (KDF in the short term) EI→−CO_2 UR→+CO_2 (LI group) UR→−CO_2 (MI and HI group)
Yao et al. (2015) [10]	1971–2010	IDA	G20 countries	RG TP IG EI	RG→+CO_2 (KDF in China, India, Australia, and Korea) TP→+CO_2 (KDF in South Africa, Brazil, Mexico, Argentina, and Turkey) EI→+CO_2 (KDF in Saudi Arabia) IG→−CO_2 (Saudi Arabia, South Africa, Argentina, Australia)
Shuai et al. (2017b) [18]	1990–2011	IPAT	125 countries	RG UR EI	RG→+CO_2 (KDF for UMI, LMI, LI) EI→+CO_2 (KDF for HI) UR→+CO_2
Irziar et al. (2016) [6]	2005–2012	STIRPAT	Spain	RG RE EI TP	RG→+CO_2 (KDF) RE→−CO_2 EI→+CO_2 TP→+CO_2
Shahbaz et al.(2013) [20]	1975–2011	STIRPAT	Indonesia	RG EI TO FD	EI→+CO_2 (KDF) RG→+CO_2 FD→+CO_2 TO→+CO_2
Roula Inglesi-Lotz (2018) [24]	1990–2014	IDA	South African and BRICS countries	TP EI RG IG	RG→+CO_2 (KDFs in Brazil, China, India) TP→+CO_2 (KDFs in South Africa) IG→+CO_2 (KDFs in Russia)
Behera & Dash (2017) [25]	1980–2012	STIRPAT	SSEA(South and Southeast Asian	UR FE EC FDI	FE, EC, FDI→+CO_2 (in HI and MI group) FE, EC→+CO_2 (in LI group) ER, FDI→×CO_2 (in LI group)
Li et al. (2011) [21]	1991–2009	STIRPAT	China	TP RG EI UR	TP→+CO_2 RG→+CO_2 (KDF) UR→+CO_2 EI→+CO_2
José M.Cansino (2016) [8]	1995–2005	SDA	Spain	ES EI, FDE SE	SE→CO_2 (KDF) ES (FE↓, RE↑)→−CO_2 EI→−CO_2 Policy→FDE
Xiao et al. (2016) [22]	1997–2010	SDA	China	ES EI, FDE	EI→−CO_2 ES (FE↓, RE↑)→−CO_2 FDE→+CO_2 (KDF)

Note: × is no significant effect; + is a positive effect, − is a negative effect.

In summary, the research method and potential driving factors selected may lead to a different KDF. To ensure the identified KDFs of carbon emission are more reliable, it is necessary to expand the pool of potential driving factors and investigate which KDFs impacted carbon emissions. As discussed above, the STIRPAT model is an appropriate method because it can explore and screen the potential driving factors. Furthermore, the method can quantitatively analyze and identify key driving factors. This will support important theoretical and practical methods for countries to carry out carbon emissions reduction actions and formulate carbon emissions reduction policies.

Therefore, this paper applied the extended STIRPAT model to identify the KDFs and provide a valuable reference for carbon reduction policy. To that end, this paper firstly selected ten potential driving factors from previous studies to extend the stochastic impacts by regression on the population, affluence, and technology (STIRPAT) model. The KDFs were separately identified and compared in individual countries and countries with different income groups to make targeted policy recommendations.

The rest of this paper is organized as follows: Section 2 describes the model and data used in this study; Section 3 presents the results; Section 4 presents the discussions of the study, while Section 5 addresses conclusions and policy implications.

2. Data and Method

2.1. Data

In this study, the annual CO_2 emissions and socio-economic data from 1990 to 2018 of the B&R countries were used. The annual CO_2 emissions (in millions of tons) and the proxy of the dependent variables were obtained from the database of the World Bank [26]. The data of the ten related independent variables were also collected from the world development indicators database, which is manned by the World Bank [26]. This includes population (in a million), urbanization (%), and GDP per capita (fixed at 2010 US$). To eliminate the inflation factor, the GDP was converted into the 2010 fixed price. The rest of the related independent variables are energy intensity (in kg of oil equivalent per $1000 GDP), industry structure (%), fossil energy consumption (%), renewable energy consumption (%), research and development expenditure (%), foreign direct investment (%) and trade openness (%). Detailed descriptions of the variables are shown in Table 2. Besides, all variables were standardized to eliminate the impact of variable inconsistency.

Table 2. The detailed driving factors in the STIRPAT model.

Variable	Short Name	Description	Unit
C	Carbon emissions	Carbon emissions from energy-relate	Kt
TP	population	total population	Ten thousand person
UR	Urbanization	The ratio of urban population to total population	%
RG	GDP per capita	Real GDP per capita	%
RDE	Research and development expenditure	The ratio of the Research and development expenditure over the total GDP	% of GDP
FDI	foreign direct investment	The ratio of total foreign direct investment in GDP	% of GDP
TO	Trade openness	The total export and import goods and services in GDP	% of GDP
FE	fossil energy consumption	The ratio of fossil energy in total energy consumption	%
RE	renewable energy consumption	The ratio of renewable energy in total energy consumption	%
IG	Industry structure	The industrial value-added over the total GDP	constant 2011 US (% of GDP)
EI	Energy intensity	Energy consumption per GDP	kg of oil equivalent per constant 2010 PPP$

It is worth noting that the B&R countries in this paper refer to those that signed the "Belt and Road Initiative" with China before 2016. Given the data availability, only 62 B&R countries were studied except Palestine, Croatia, and East Timor. Besides, these countries were divided into four groups according to the World Bank list of economies from June 2010 [4]. These income groups include the low-income group (LM), lower-middle-income group (LMI), upper-middle-income group (UMI), and high-income group (HI) (as listed in Appendix A Table A1).

2.2. The STIRPAT Model

This paper extended the STIRPAT model to identify the KDF from potential driving factors. The model is created based on the IPAT model and describes the impact of population, affluence, and technology on environmental pressure [27]. The mathematical formulation of the STIRPAT model is shown in Equation (1).

$$I = \alpha P^a A^b T^c e \tag{1}$$

After taking the natural logarithm, it is written in the linear form as Equation (2).

$$\ln I = \ln \alpha + a \ln P + b \ln A + c \ln T + \ln e \tag{2}$$

where I represents the environmental pressure (carbon emission), P, A, and T denote the factor of population, affluence, and technology, respectively (independent variables); α is the intercept; a, b, and c represent the elastic coefficients of P, A, and T; e is the random error term. Equation (2) could be further extended by integrating additional driving factors as:

$$\begin{aligned} \ln I_i \quad &= \ln a_1 + a_2 \ln TP_i + a_3 \ln UR_i + a_4 \ln RG_i + a_5 \ln FE_i + a_6 \ln RE_i \\ &+ a_7 \ln IG_i + a_8 \ln RDE_i + a_9 \ln EI_i + a_{10} \ln TO_i + a_{11} \ln FDI_i + \ln e \end{aligned} \tag{3}$$

where subscript i stands for each country, a_1 is the intercept, and e is the error; TP, UR, RG, FE, RE, IG, RDE, EI, TO, and FDI denote the driving factors in Table 2 with a_2, $a_3 \ldots a_{11}$ as their elastic coefficients which are calculated by regression analysis. Considering the existence of multi-collinearity among variables in this study, the ridge regression method was used. It is worth mentioning that the factors with higher coefficient values were more important, and the one with the highest coefficient was selected as the KDF of each country in this paper.

3. Results

3.1. Estimated Coefficients

The optimal STIRPAT model of the B&R countries selected through regression analysis is listed in Table 3. The KDFs of the B&R countries were identified by estimated coefficients. As seen in Table 3, the coefficients of population, fossil energy, GDP per capita, and energy intensity were all positive in all the B&R countries. This indicated that these factors had positive effects on carbon emissions. Renewable energy had a negative influence on carbon emission due to the negative coefficient. However, the response to emissions by urbanization, trade openness, and foreign direct investment varied across countries. For example, urbanization had a positive effect on low-income countries such as India, Armenia, and Vietnam but had a negative effect on some high-income level countries like Slovenia, Kuwait, and Israel. This indicated that urbanization had a dual impact. With increasing income levels, its impact on carbon emissions has shifted from increasing to reducing carbon emissions. The same trend was also found with regards to trade openness and foreign direct investment (i.e., the coefficient of trade openness is found to be positive in Armenia, Indonesia, Iran, and Nepal, while negative in Slovenia, Lebanon, and Russia. Foreign direct investment promoted carbon emission reduction in Qatar and Azerbaijani, but it increased carbon emissions in Armenia, India, and Kyrgyzstan). Moreover, these two factors were statistically insignificant in most countries (see Table A2). This indicated that these two factors were not the KDF of carbon emissions in the B&R countries for that duration.

Table 3. The optimal STIRPAT model selected after ridge regression.

Countries	Optimal STIRPAT Model	R^2	Residual
HI level			
Slovenia	$lnC = 10.282^{a} + 0.811^{a}\ lnTP - 0.753^{a}\ LnUR + 0.69^{a}\ lnRG + 0.171^{a}\ lnFE - 0.48^{a}\ lnTO$	0.887	0.0263
Singapore	$lnC = 10.684^{b} + 0.63^{a}\ lnTP - 0.475^{a}\ lnRG - 0.121^{b}\ lnTO$	0.82	0.07197
Saudi Arabia	$lnC = 12.739^{a} + 0.068^{b}\ lnTP + 0.107^{a}\ lnRG + 0.229^{a}\ lnEI + 0.109^{a}\ lnTO$	0.967	0.09436
Qatar	$lnC = 10.828^{b} + 0.067^{a}\ lnTP + 0.098^{a}\ lnRG + 0.096^{a}\ lnEI - 0.015^{a}\ lnFDI$	0.989	0.0132
Kuwait	$lnC = 10.641^{b} + 0.374^{a}\ lnTP - 0.314^{a}\ lnUR + 0.219^{a}\ lnRG + 0.151^{a}\ lnEI$	0.994	0.0225
Israel	$lnC = 10.713^{a} + 0.475^{a}\ lnTP - 0.414^{a}\ lnUR + 0.22^{a}\ lnRG - 0.013^{a}\ lnRE + 0.119^{a}\ lnEI$	0.992	0.01939
Brunei	$lnC = 8.678^{a} + 0.234^{a}\ lnTP - 0.354^{a}\ lnUR + 0.377^{a}\ lnEI$	0.933	0.1122
Bahrain	$lnC = 9.744^{a} + 0.266^{a}\ lnTP - 0.085^{b}\ lnUR + 0.037^{b}\ lnRG + 0.055^{b}\ lnEI$	0.889	0.11917
United Arab Emirates	$lnC = 11.496^{b} - 0.010^{a}\ lnUR + 0.44^{a}\ lnRG + 0.479^{a}\ lnEI$	0.937	0.17732
Czech Republic	$lnC = 11.676^{a} - 0.038^{a}\ lnUR + 0.168^{a}\ lnRG + 0.088^{a}\ lnFE + 0.012^{a}\ lnEI - 0.012^{a}\ lnFDI$	0.973	0.01783
Hungary	$lnC = 10.399^{b} + 0.359^{a}\ lnTP + 0.097^{a}\ lnRG + 0.101^{a}\ lnFE + 0.131^{a}\ lnEI$	0.987	0.01687
Latvia	$lnC = 8.189^{a} + 0.047^{a}\ lnTP + 0.024^{b}\ lnUR + 0.412^{a}\ lnRG - 0.036^{a}\ lnRE + 0.371^{a}\ lnEI$	0.99	0.01178
Lithuania	$lnC = 8.971^{b} + 0.132^{a}\ lnTP - 0.033^{a}\ lnUR + 0.327^{a}\ lnRG + 0.107^{a}\ lnFE + 0.284^{a}\ lnEI$	0.967	0.01873
Oman	$lnC = 10.164^{a} + 0.33^{a}\ lnTP + 0.127^{a}\ lnRG + 0.256^{a}\ lnEI - 0.097^{a}\ lnTO$	0.966	0.1148
Poland	$lnC = 12.198^{a} + 0.009^{a}\ lnTP + 0.227^{a}\ lnRG + 0.019^{a}\ lnFE + 0.245^{a}\ lnEI$	0.995	0.00451
Slovakia	$lnC = 9.846^{b} + 0.199^{a}\ lnRG + 0.065^{a}\ lnFE + 0.235^{a}\ lnEI + 0.017^{a}\ lnTO$	0.973	0.01538
Estonia	$lnC = 4.914^{a} - 0.022^{a}\ lnUR + 0.005^{a}\ lnRG + 0.05^{a}\ lnEI$	0.983	0.00362
UMI level			
Lebanon	$lnC = 9.650^{a} + 0.158^{a}\ lnTP + 0.093^{a}\ lnRG + 0.06^{a}\ lnFE - 0.058^{b}\ lnTO$	0.951	0.06774
Malaysia	$lnC = 11.85^{a} + 0.293^{a}\ lnRG + 0.108^{a}\ lnFE - 0.022^{b}\ lnGI$	0.993	0.05212
Russia	$lnC = 13.892^{a} + 0.049^{a}\ lnTP - 0.019^{a}\ lnUR + 0.3\ ln^{a}\ RG + 0.216^{a}\ lnEI - 0.004^{b}\ lnTO$	0.995	0.00658
Turkey	$lnC = 12.208^{a} + 0.082^{b}\ lnUR + 0.209^{a}\ lnRG - 0.024^{a}\ lnRE + 0.051^{b}\ lnEI - 0.004^{b}\ lnIG$	0.999	0.00864
Azerbaijani	$lnC = 10.437^{a} + 0.696^{a}\ lnRG + 0.699^{a}\ lnEI - 0.018^{b}\ lnFDI$	0.947	0.0419
Belarus	$lnC = 11.023^{a} + 0.232^{a}\ lnTP + 0.499^{a}\ lnRG + 0.271^{a}\ lnEI - 0.024^{b}\ lnTO$	0.938	0.0313
Bulgaria	$lnC = 10.816^{a} + 0.227^{a}\ lnRG + 0.077^{a}\ lnFE + 0.270^{a}\ lnEI$	0.959	0.032
China	$lnC = 14.743^{a} + 0.786^{a}\ lnRG - 0.027^{b}\ lnRE + 0.320^{a}\ lnEI - 0.01^{b}\ lnTO$	0.998	0.02014
Kazakhstan,	$lnC = 12.11^{a} + 0.213^{a}\ lnTP - 0.644^{a}\ lnUR + 0.71^{a}\ lnRG - 0.051^{a}\ lnRE$	0.979	0.04586
Macedonia, FTR	$lnC = 9.239^{a} + 0.115^{a}\ lnTP + 0.37^{a}\ lnRG - 0.058^{a}\ lnRE + 0.534^{b}\ lnEI$	0.964	0.05432
Romania	$lnC = 11.52^{a} + 0.053^{a}\ lnTP + 0.272^{a}\ lnRG + 0.101^{a}\ lnFE + 0.298^{a}\ lnEI$	0.998	0.01045
Thailand	$lnC = 12.19^{a} + 0.106^{a}\ lnTP + 0.038^{b}\ lnUR + 0.234^{a}\ lnRG - 0.056^{b}\ lnRE + 0.045^{a}\ lnEI - 0.02^{b}\ lnTO$	0.997	0.0213
Maldives	$lnC = 6.413^{a} + 0.177^{a}\ lnTP + 0.13^{b}\ lnUR + 0.093^{a}\ lnRG - 0.093^{b}\ lnRE + 0.069^{b}\ lnEI$	0.999	0.01506
Serbia	$lnC = 10.651^{a} + 0.121^{a}\ lnTP - 0.013^{b}\ lnIG + 0.054^{a}\ lnFE + 0.06^{a}\ lnEI$	0.996	0.0068
Bosnia and Herzegovina	$lnC = 9.082^{a} + 0.47^{a}\ lnRG + 0.197^{a}\ lnFE + 0.136^{a}\ lnEI + 0.014^{b}\ lnFDI$	0.999	0.01093
Montenegro	$lnC = 7.744^{a} + 0.071^{b}\ lnUR + 0.105^{a}\ lnRG + 0.205^{a}\ lnEI - 0.059^{b}\ lnTO$	0.984	0.02048
LMI level			
Albania	$lnC = 7.132^{a} + 0.306^{a}\ lnUR + 0.411^{a}\ lnRG + 0.51^{a}\ lnEI$	0.945	0.09761
Armenia	$lnC = 7.955^{a} + 0.374^{a}\ lnUR + 0.654^{a}\ lnRG - 0.11^{a}\ lnRE + 0.166^{a}\ lnEI + 0.15^{a}\ lnTO + 0.147^{a}\ lnFDI$	0.97	0.05471
Georgia	$lnC = 8.628^{a} - 0.249^{a}\ lnUR + 0.747^{a}\ lnRG - 0.206^{a}\ lnRE + 0.511^{a}\ lnEI$	0.955	0.0233
Indonesia	$lnC = 12.64^{a} + 0.847^{a}\ lnUR + 0.231^{b}\ lnRE - 0.097^{a}\ lnEI + 0.066^{a}\ lnTO + 0.322^{b}\ lnRG$	0.949	0.09458
Iran	$lnC = 12.872^{a} + 0.253^{a}\ lnTP + 0.046^{a}\ lnRG + 0.066^{a}\ lnEI + 0.017^{a}\ lnTO$	0.99	0.04029
Iraq	$lnC = 11.107^{a} + 0.357^{a}\ lnTP + 0.043^{b}\ lnUR + 0.099^{a}\ lnRG - 0.062^{b}\ lnRE + 0.526^{a}\ lnEI$	0.895	0.06551
Jordan	$lnC = 9.619^{a} + 0.246^{a}\ lnTP + 0.103^{a}\ lnRG - 0.032^{a}\ lnRE + 0.061^{a}\ lnEI$	0.99	0.02983
Philippines	$lnC = 10.61^{a} + 0.209^{a}\ lnTP + 0.196^{a}\ lnRG - 0.072^{a}\ lnFE + 0.266^{a}\ lnEI - 0.032^{b}\ lnTO$	0.99	0.02666
Sri Lanka	$lnC = 8.771^{b} + 0.322^{a}\ lnTP + 0.191^{a}\ lnRG - 0.101^{a}\ lnRE + 0.187^{a}\ lnEI$	0.99	0.04897
Ukraine	$lnC = 12.211^{a} + 0.11^{a}\ lnTP + 0.103^{a}\ lnUR + 0.216^{a}\ lnRG + 0.123^{a}\ lnFE + 0.226^{a}\ lnEI$	0.988	0.02896
Turkmenistan	$lnC = 10.321^{a} + 0.099^{a}\ lnUR + 0.326^{a}\ lnRG - 0.024^{b}\ lnIG + 0.184^{a}\ lnEI$	0.998	0.01199
Syria Arab Pepublic	$lnC = 10.776^{a} + 0.084^{a}\ lnTP + 0.126^{a}\ lnUR - 0.058^{b}\ lnRE$	0.868	0.08974
Egypt	$lnC = 11.833^{a} + 0.049^{a}\ lnUR + 0.148^{a}\ lnRG - 0.208^{a}\ lnRE$	0.976	0.0596
India	$lnC = 13.564^{a} + 0.136^{a}\ lnUR + 0.317^{a}\ lnRG + 0.103^{a}\ lnFE + 0.19^{a}\ lnEI + 0.016^{a}\ lnFDI$	0.998	0.01731
Moldova	$lnC = 8.554^{a} + 0.315^{a}\ lnUR + 0.344^{a}\ lnRG - 0.125^{a}\ lnRE - 0.11^{b}\ lnFDI$	0.951	0.03236
Mongolia	$lnC = 9.174^{a} + 0.253^{a}\ lnRG + 0.154^{b}\ lnFE + 0.004^{a}\ lnEI$	0.897	0.05987
Uzbekistan	$lnC = 9.043^{a} + 0.077^{a}\ lnUR + 0.29^{a}\ lnRG + 0.315^{a}\ lnFE - 0.045^{a}\ lnRE + 1.32^{a}\ lnEI$	0.934	0.02114
Vietnam	$lnC = 11.059^{a} + 0.664^{a}\ lnUR + 1.088^{a}\ lnRG - 0.283^{a}\ lnRE - 0.067^{b}\ lnFDI$	0.997	0.01433
Bhutan	$lnC = 5.917^{a} + 0.037^{b}\ lnRG - 0.42^{a}\ lnRE + 0.068^{a}\ lnTO$	0.98	0.07517
LI level			
Bangladesh	$lnC = 10.419^{a} + 0.216^{a}\ lnTP + 0.031^{b}\ lnRG - 0.289^{a}\ lnRE - 0.046^{b}\ lnFDI$	0.998	0.02146
Cambodia	$lnC = 7.344^{a} + 0.539^{a}\ lnRG + 0.231^{a}\ lnFE + 0.321^{a}\ lnEI$	0.995	0.03316
Kyrgyzstan	$lnC = 8.344^{a} + 0.133^{a}\ lnRG + 0.09^{a}\ lnFE + 0.215^{a}\ lnEI + 0.014^{b}\ lnFDI$	0.988	0.03076
Myanmar	$lnC = 8.771^{a} + 0.473^{a}\ lnTP - 0.093^{a}\ lnRE + 0.173^{b}\ lnEI$	0.938	0.05651
Nepal	$lnC = 7.952^{a} + 1.135^{b}\ lnTP + 0.237^{a}\ lnUR + 0.397^{a}\ lnRG + 0.287^{a}\ lnFE + 0.073^{a}\ lnTO$	0.986	0.01761
Pakistan	$lnC = 11.492^{a} + 0.164^{a}\ lnTP + 0.213^{a}\ lnRG + 0.084^{a}\ lnEI$	0.995	0.02122
Tajikistan	$lnC = 7.94^{a} + 0.622^{a}\ lnTP + 0.128^{b}\ lnUR + 0.499^{a}\ lnRG + 0.908^{a}\ lnEI$	0.938	0.02081
Yemen	$lnC = 11.492^{a} + 0.342^{a}\ lnRG + 0.032^{b}\ lnFE + 0.083^{a}\ lnEI$	0.979	0.04076
Afghanistan	$lnC = 8.196^{a} + 0.16^{b}\ lnRG + 0.283^{a}\ lnUR - 0.191^{a}\ lnRE$	0.998	0.05743
Laos	$lnC = 6.672^{a} + 0.73^{a}\ lnTP + 1.954^{a}\ lnRG + 0.392^{a}\ lnRE + 0.655^{a}\ lnEI$	0.984	0.01191

[a] denotes the correlation is significant at the 0.01 level; [b] denotes the correlation is significant at the 0.05 level.

3.2. The KDF in Each B&R Country

Based on the optimal STIRPAT model, the KDF of each B&R country was identified as the driving factor with the highest regression coefficient, as shown in Figure 1. The KDF varied from country to country. For most of the B&R countries like Qatar, China, and

Russia, the GDP per capita was the KDF, and it had a positive effect on carbon emission. For Slovenia, Azerbaijan, and Iran, population was the KDF that promoted carbon emission. For Saudi Arabia, the United Arab Emirates, and Ukraine, energy intensity was the KDF of carbon emissions. Energy intensity played a positive role in promoting carbon emissions in these countries. Meanwhile, urbanization was the KDF that promoted carbon emissions in Georgia, Syria, and Afghanistan. Renewable energy was the KDF that inhibited carbon emissions in Moldova, Bhutan, and Bangladesh.

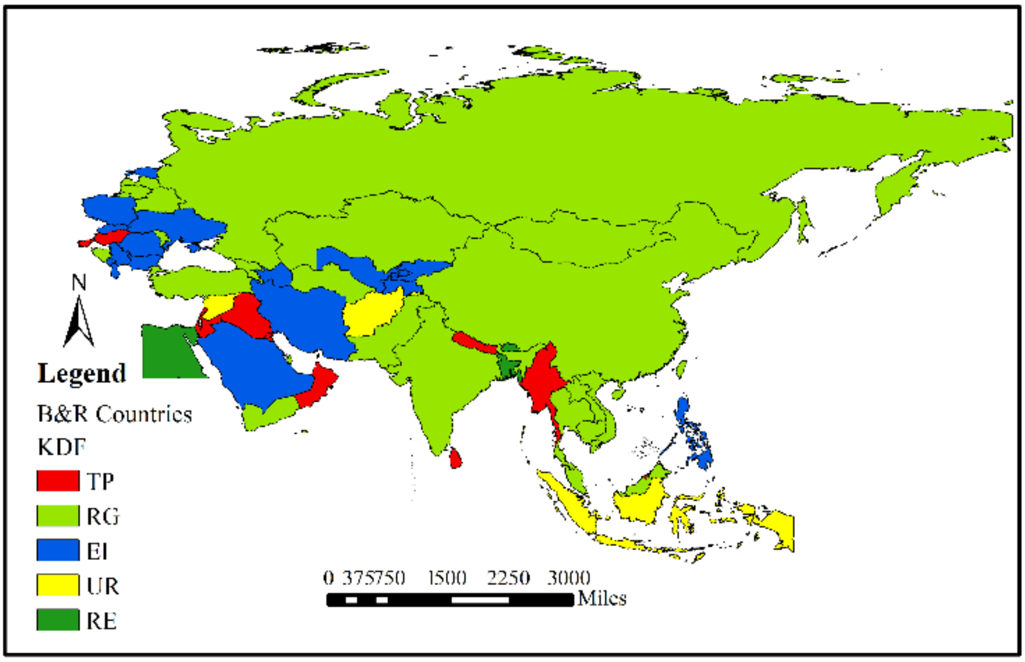

Figure 1. The KDFs in each B&R country.

3.3. The KDFs in Different Income Groups

The coefficients of KDFs by country in each group were summarized. The KDFs by income groups were identified according to the median coefficient. The results are shown in Table 4.

From Table 4, the KDFs of countries belonging to the four income groups differed. For the HI group, there were 7 (41%) countries that had populations as KDFs. The median coefficient of the population was 0.374 higher than GDP per capita and energy intensity. This indicated that population was the KDF of carbon emissions in the HI group. Similarly, the GDP per capita was the KDF in the UMI, LMI, and LI groups. This is because there were 50%, 37%, and 40% of countries that had GDP per capita as the KDF as well as had the highest median coefficient in UMI (0.346), LMI (0.353), and LI (0.369) groups, respectively. In addition, two interesting trends were found when comparing the coefficients of different driving factors in the four income groups: the coefficient of energy intensity increased as income levels increased from 0.235 for the LI to 0.351 for the HI group. In contrast, the coefficient of GDP per capita decreased as income levels decreased from 0.369 for the LI to 0.262 for the HI group. Especially for the HI group, there were only four (24%) countries that had GDP per capita as the KDF. The impact degree factor showed that the impact of energy intensity on carbon emission gradually increased with income level, while the impact of GDP per capita gradually decreased with income level.

Table 4. The coefficient of KDF in different income groups.

B&R Countries	TP	RG	EI	UR	RE
HI					
Number of countries with KDF (percentage)	7 (41%)	4 (24%)	6 (35%)		
Coefficient (median)	0.374	0.262	0.351		
UMI					
Number of countries with KDF (percentage)	3 (19%)	8 (50%)	5 (31%)		
Coefficient (median)	0.158	0.346	0.27		
LMI					
Number of countries with KDF (percentage)	3 (16%)	7 (37%)	5 (26%)	2 (11%)	2 (11%)
Coefficient (median)	0.322	0.353	0.266	0.236	−0.372
LI					
Number of countries with KDF (percentage)	2 (20%)	4 (40%)	2 (20%)	1 (10%)	1 (10%)
Coefficient (median)	0.352	0.369	0.235	0.183	−0.289

4. Discussion

To further explain the observed results, the identified KDF in the B&R countries, including total population, GDP per capita, energy intensity, urbanization, and renewable energy utilization, and their impact on carbon emissions in different countries across different income groups, are discussed in detail.

4.1. Population

There are two main views on the impact of population on carbon emissions. One is population promotes carbon emission [28,29]. The other view is that population may have a positive impact on carbon emissions reduction if the public has a higher awareness of environmental protection [23]. The influence of population in the B&R countries agreed with the first view in this study. For the HI group of countries with population as the KDF in particular, their population scale had increased 1.2 times from 1990 to 2018 (see Figure 2). Meanwhile, their energy consumption per capita had increased from 6.57 to 8.01 tons of oil equivalents, and carbon emissions per capita had also increased from 13 to 17.17 tons. All of these illustrated that increased population in the HI group led to greater energy consumption and carbon emissions. Therefore, for some of the HI countries with population as their KDF, it is essential to improve people's awareness of environmental protection based on proper population control aiming to reverse the positive impact of population on carbon emission.

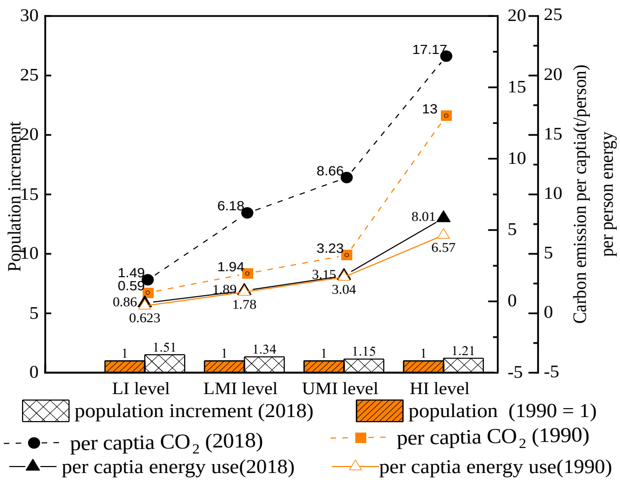

Figure 2. The level of population increment, energy use per capita, and carbon emissions per capita by income groups in 1990 and 2018 (data from the World Bank 2022).

4.2. GDP per Capita

Currently, there are two mainstream opinions about the effect of GDP per capita on carbon emission. One is that GDP per capita increases carbon emission [30,31]. They hold the view that an extensive economic pattern is the main reason that brings a substantial increase in energy use and carbon emissions [32–34]. The other opinion presents an inverted U-shaped Environmental Kuznets Curve (EKC) [35]. Namely, a turning point exists in the relationship between carbon emission and GDP per capita. This paper's results agreed with these two opinions. The positive coefficients of GDP per capita in some B&R countries corroborate the first view. In addition, analyzing the changes in GDP per capita, energy use, and CO_2 emission in the B&R countries can also explain the reason behind this observation. As shown in Figure 3, from 1990 to 2018, the GDP per capita increased 1.87, 2.03, and 2.86 times in the LI, LMI, and UMI groups, respectively. This triggered an increase in the use of fossil energy in the LI, LMI, and UMI groups of the B&R countries to 2.36, 1.88, and 2.33 times, respectively. Correspondingly, CO_2 emissions increased by 2.45, 2.08, and 2.35 in the LI and LMI groups, respectively. All of these explained their extensive economic development pattern leading to increased carbon emissions. Besides, the impact of GDP per capita weakened as income levels increased. The GDP per capita was not the KDF in HI groups. Particularly, it did not feature in the driving factors of Qatar, the United Arab Emirates, and Singapore. This indicated that the carbon emissions of these countries had decoupled from their economies. This result further proves the EKC theory. Thus, for the countries with GDP per capita as KDF and in the LI, LMI, and UMI groups, it is necessary to change the economic development models and decouple carbon emission from the economy at the earliest.

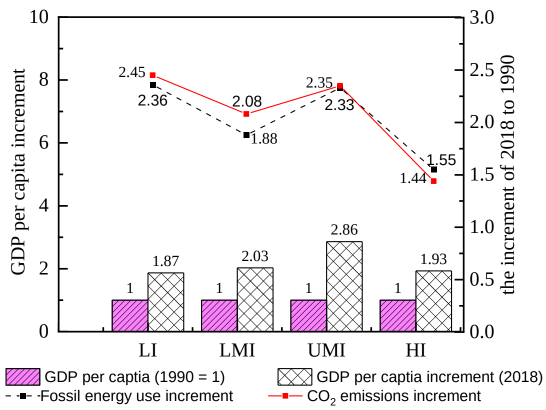

Figure 3. Increment of GDP per capita, total fossil energy consumption, and CO_2 emissions by the four income groups in 2018 (data from the World Bank 2022).

4.3. Energy Intensity

Energy intensity is also an important factor that impacts carbon emission. Many studies agree that energy intensity improvement promotes carbon reduction because it represents a country's level of energy efficiency and technological development [36–38]. Lower energy intensity brings higher energy efficiency and technology levels, leading to carbon emission reduction [39]. However, in this study, the energy intensity improvement did not reduce carbon emissions in the B&R countries. This is largely because the decrease in energy intensity in the B&R countries was insufficient to offset the increase in carbon emissions caused by other factors (i.e., population and GDP per capita). This emphasized that energy intensity was not the KDF in the four income groups. Meanwhile, the impact of energy intensity increased as income levels increased. Some indicators that represented energy intensity in the four groups were analyzed and shown in Figure 4. We found that alternative energy usage, electricity production from renewable energy, and value-added service increased as the income level increased, while electric power transmission losses decreased. All of these prove that richer countries had more advantages in energy intensity, leading to a more positive effect on carbon emission reduction. To enhance the positive effect of energy intensity improvement on carbon reduction in the B&R countries, some strategies for decreasing energy intensity should be developed (i.e., regulate the industrial structure, introduce advanced technology, and increase the input on research & development).

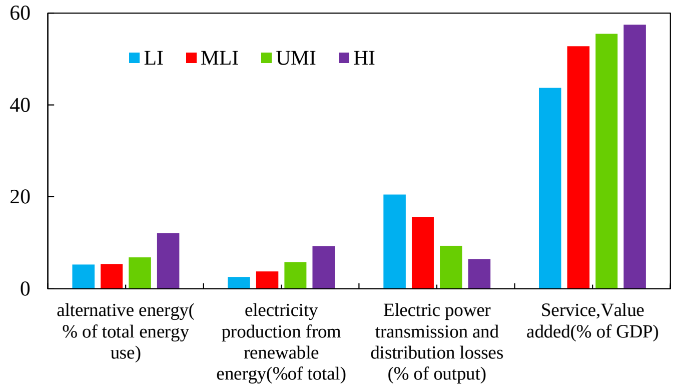

Figure 4. The energy efficiency and technology development level of the four income groups in B&R countries (data from the World Bank 2022).

4.4. Urbanization

Recently, urbanization has become an indispensable driving factor in studying carbon emissions. However, there has been no consensus on its impact on carbon emission. Some views hold that urbanization intensifies carbon emission due to increment in energy consumption [40]. Others believe it promotes emission reduction by improving the efficiency of basic public facilities (i.e., widespread mass transport and fewer private vehicles) [41,42]. The findings in this paper combined the above two opinions. For instance, the coefficient of urbanization was negative in the HI level group while it was positive in the LI and LMI level countries. This is largely because low-income countries spent more effort on an extensive expansion of urbanization without planning well. This leads to a sharp increase in energy consumption and carbon dioxide emissions. Moreover, three low-income countries, Indonesia, Syria, and Afghanistan, had urbanization as their KDF of carbon emission. This will intensify their carbon emissions if their governments do not plan their urbanization with a low carbon development concept. Therefore, urbanization should be sustainable and consistent with their economic development level. In particular, countries with urbanization as their KDF should plan well and take a path of lower carbon and sustainable development urbanization.

There is a broad consensus that renewable energy plays a positive role in carbon emissions reduction. Replacing fossil energy with renewable energy (i.e., solar, wind, hydroelectric power, etc.) is a direct way to reduce energy-related carbon emissions [43–45]. However, out of all the B&R countries, only Bangladesh, Moldova, and Bhutan had renewable energy as their KDF of carbon emission, which had a positive impact on carbon emission reduction. Although the results agreed that renewable energy promotes carbon emission reduction, the ratio of renewable energy in these countries gradually declined. Moreover, the ratio of renewable energy declined from 22.8% in 1994 to 15.4% in 2018 for the entire B&R countries (see Figure 5). This declining trend increased carbon emissions from 9.11 to 20.33 Gt. Thus, for the B&R countries with renewable energy as the KDF, it is imperative to adjust the energy consumption structure by gradually increasing the utilization of renewable energy.

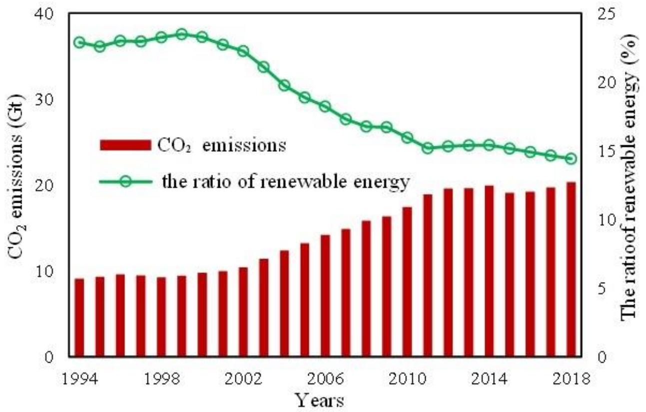

Figure 5. Carbon emission trends and the ratio of renewable energy in the B&R countries (data from the World Bank 2022).

5. Conclusions and Policy Implications

This study extended the STIRPAT model to quantitatively analyze the driving factors of carbon emissions of 62 B&R countries at four income level groups over the period of 1990–2018. Based on the analysis and comparison of the results from the model of individual countries and four income level groups, the conclusions and the corresponding policy implications are given as follows.

In general, population, GDP per capita, energy intensity, urbanization, and renewable energy are the KDFs in most of the B&R countries, while the effect of trade openness and foreign direct investment is less important. On the other hand, population and GDP per capita had positive impacts on carbon emissions; energy intensity and renewable energy had a negative effect on carbon emissions, while urbanization had a dual effect on carbon emissions. Results of KDFs in the four income groups revealed that except for the HI group that had population as the KDF, the remaining three income groups had GDP per capita as the KDF. Besides, by comparing the coefficients, two interesting trends were found. Firstly, the impact of energy intensity on carbon emissions increased as income levels increased. Secondly, the impact of GDP per capita decreased as income levels increased.

The results provide some important policy implications. Policies for each B&R country should be formulated by the following suggestions based on different KDFs to effectively mitigate carbon emissions in the future.

For countries that have GDP per capita as the KDF, it is necessary to optimize their economic development models and transform them from energy-intensive to technology-intensive (i.e., low-carbon technologies refer to alternative energy usage, electricity production from renewable energy, value-added service, etc.), and decouple carbon emission from their economy at the earliest. Firstly, governments should control the rapid expansion of industry with higher energy consumption and carbon emissions. Unified emissions control targets and standards should be formulated. Also, these higher emissions sectors should be urged to transform into technology-intensive low emissions industries. Secondly, governments should encourage the development of tertiary industries, e.g., tourism as well as financial sectors, and further promote a low carbon development of the economy.

For countries that have population as the KDF, it is crucial to improve public awareness of environmental protection to alleviate the positive impact population has on carbon emissions. On the one hand, governments are advised to increase low carbon propaganda to improve the public awareness of a low carbon lifestyle, i.e., advocating low-carbon education in school, promoting low carbon travel, etc. On the other hand, the government should strengthen public participation and supervision in low-carbon developments. They are encouraged to regularly disclose information to establish an open and transparent public supervision system.

For countries that have energy intensity as the KDF, it is essential to improve their energy intensity by either regulating the industrial structure or promoting advanced low-carbon technologies. On the one hand, governments should improve their support for technology innovation, including implementing preferential tax and financial subsidies for low carbon technology innovation. On the other hand, the government should increase input for research and development to promote the commercialization of low-carbon technologies.

For countries that have urbanization as the KDF, it is essential to plan their urbanization with a low carbon development concept and design a sustainable road that is consistent with their economic development level. For countries that have renewable energy as KDF, it is imperative to adjust the energy consumption structure to increase renewable energy usage.

The above policies are proposed specifically for the KDF in the B&R countries. Furthermore, under the guidance of the "Belt and Road Initiative", low-carbon and environmentally friendly investments or trade cooperations must be implemented among the B&R countries. With the help of multiple policies or strategies, the B&R countries should work together to positively contribute to global carbon emission reduction. With the support of national climate policies, future studies are suggested to predict the emission trajectories of the B&R countries for exploring the feasibility of achieving the carbon neutrality target.

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Nomenclature

B&R	Belt and Road Initiative
KDFs	key driving factors
STIRPAT	Stochastic Impacts by Regression on Population, Affluence, and Technology
TP	Total population
UR	Urbanization rate
RG	GDP per capita FE, RE, IG, RDE, EI, TO, and FDI
RDE	Research and development expenditure
FDI	Foreign direct investment
TO	Trade openness
FE	Fossil energy consumption
RE	Renewable energy consumption
IG	Industry structure
EI	Energy intensity
HI	High-income level
UMI	Upper-middle-income
LMI	Low-middle-income
LI	Low-income

Appendix A

Table A1. List of 62 B&R countries.

1 High-income level countries (17 countries with per capita > US$ 12,276 in 2010)
Slovenia, Singapore, Saudi Arabia, Qatar, Kuwait, Israel, Brunei, Bahrain, United Arab Emirates, Czech Republic, Hungary, Latvia, Lithuania, Oman, Poland, Slovakia, Estonia
2 Upper-middle-income level groups (16 countries with per capita GNP between US$ 3976 and US$ 12,275 in 2010)
Lebanon, Malaysia, Russia, Turkey, Azerbaijani, Belarus, Bulgaria, China, Kazakhstan, Macedonia FTR, Romania, Thailand, Maldives, Serbia, Bosnia and Herzegovina, Montenegro
3 Low-middle-income level groups (19 countries with per capita between US$ 1006 and US$ 3975 in 2010)
Albania, Armenia, Georgia, Indonesia, Iran, Iraq, Jordan, Philippines, Sri Lanka, Ukraine, Turkmenistan, Syria Arab Republic, Egypt, India, Moldova, Mongolia, Uzbekistan, Vietnam, Bhutan
4 Low-income level groups (10 countries with per capita GNP < US$ 1005 in 2010)
Bangladesh, Cambodia, Kyrgyzstan, Myanmar, Nepal, Pakistan, Tajikistan, Yemen, Afghanistan, Laos

Table A2. The Pearson's correlation coefficients between dependent and independent factors.

Countries	lnC	lnTP	lnUR	lnRG	lnIG	lnFE	lnRE	lnRDE	lnEI	lnTO	LnFDI
HI group											
Slovenia	1	0.629 [a]	−0.795 [a]	0.637 [a]	0.026	0.755 [a]	−0.271 [c]	−0.471	0.276 [b]	−0.672 [a]	0.002
Singapore	1	0.817 [a]	-	0.792 [a]	−0.039	−0.166	−0.128	−0.581 [b]	0.156 [b]	−0.680 [a]	−0.288
Saudi Arabia	1	0.904 [a]	−0.476 [b]	0.610 [a]	0.402 [b]	0.235	−0.139	-	0.832 [a]	0.749 [a]	−0.139
Qatar	1	0.907 [a]	0.422 [c]	0.936 [a]	0.292 [c]	0.277 [b]	−0.038 [c]	0.890 [a]	0.899 [a]	0.540 [b]	−0.671 [a]
Kuwait	1	0.867 [a]	−0.792 [a]	0.816 [a]	0.530 [b]	0.458 [c]	−0.017	0.261 [c]	0.648 [a]	−0.448 [b]	0.476 [c]
Israel	1	0.927 [a]	−0.873 [a]	0.936 [a]	0.430 [b]	−0.277	−0.775 [a]	0.390 [c]	0.857 [a]	0.316	0.412
Brunei	1	0.605 [a]	−0.536 [a]	0.473 [b]	0.400	0.273	−0.640 [a]	0.106	0.829 [a]	−0.287	−0.103
Bahrain	1	0.931 [a]	−0.837 [b]	0.771 [a]	-	−0.454 [b]	−0.329	0.204	0.644 [b]	−0.139	−0.109
United Arab Emirates	1	0.621 [a]	−0.839 [a]	0.934 [a]	0.502 [b]	0.518 [b]	−0.271	−0.214	0.643 [a]	0.743 [a]	0.430 [b]
Czech Republic	1	−0.712 [a]	0.770 [a]	0.741 [a]	−0.358	0.889 [a]	−0.899 [a]	−0.893 [a]	0.764 [a]	−0.204	−0.792 [a]
Hungary	1	0.700 [a]	−0.849 [b]	0.420 [a]	−0.488 [b]	0.937 [a]	−0.933 [a]	−0.203	0.660 [a]	−0.581 [a]	0.087
Latvia	1	0.885 [a]	0.635 [a]	0.842 [a]	0.487 [b]	0.603 [a]	−0.699 [a]	0.261	0.691 [a]	−0.201	0.371
Lithuania	1	0.589 [a]	0.717 [a]	0.821 [a]	−0.745 [a]	−0.896 [a]	0.140	0.242	0.691 [a]	−0.501 [b]	−0.017
Oman	1	0.940 [a]	0.683 [b]	0.878 [a]	0.832 [a]	0.194	0.152	−0.139	0.914 [a]	−0.888 [a]	0.472 [b]
Poland	1	0.518 [a]	0.244	0.797 [a]	−0.669 [a]	0.569 [a]	−0.775 [a]	0.500 [b]	0.772 [a]	−0.738 [a]	−0.431 [b]
Slovakia	1	0.621 [b]	0.673 [b]	0.910 [a]	−0.459 [b]	0.930 [a]	−0.490 [b]	0.246	0.857 [a]	−0.738 [a]	−0.103
Estonia	1	0.350	−0.856 [a]	0.730 [a]	0.568 [b]	−0.251	−0.490 [b]	0.012	0.548 [a]	−0.329	−0.551 [a]
UMI group											
Lebanon	1	0.842 [a]	0.928 [b]	0.885 [a]	0.294	0.749 [a]	−0.662 [b]	0.797 [a]	0.246	−0.699 [a]	-
Malaysia	1	0.771 [a]	0.673 [b]	0.990 [a]	0.633 [a]	0.951 [a]	−0.490 [b]	0.106	0.229	−0.078	−0.368 [c]
Russia	1	0.717 [a]	−0.573 [b]	0.813 [a]	0.633 [b]	0.724 [a]	0.145	0.352 [c]	0.899 [a]	−0.873 [a]	−0.275
Turkey	1	0.684 [a]	0.986 [a]	0.982 [a]	−0.639 [a]	0.642 [b]	−0.965 [a]	−0.551 [a]	0.717 [a]	0.540 [b]	0.525 [b]
Azerbaijani	1	0.737 [a]	0.458 [b]	0.778 [a]	−0.214	0.547 [a]	−0.390 [c]	0.118	0.800 [a]	0.418 [b]	−0.672 [a]
Belarus	1	0.764 [a]	0.140	0.639 [a]	−0.169	0.071	0.145	0.012	0.718 [a]	−0.491 [b]	0.103
Bulgaria	1	0.717 [a]	−0.723 [a]	0.537 [a]	0.672 [b]	0.905 [a]	−0.845 [a]	0.576 [b]	0.718 [a]	−0.344	−0.711 [b]
China	1	0.830 [a]	0.974 [a]	0.979 [a]	0.275	0.972 [a]	−0.994 [a]	0.852 [a]	0.861 [a]	−0.738 [a]	0.103
Kazakhstan,	1	0.851 [a]	−0.692 [a]	0.715 [a]	0.503 [b]	0.605 [b]	−0.724 [a]	−0.018	0.228	−0.048	−0.348
Macedonia, FTR	1	0.548 [a]	0.624 [a]	0.840 [a]	0.284	0.475 [c]	−0.857 [a]	0.145	0.859 [a]	−0.669 [b]	0.012
Romania	1	0.834 [a]	0.005	0.707 [a]	0.672 [a]	0.932 [a]	−0.918 [a]	0.810 [a]	0.892 [a]	−0.765 [b]	−0.652 [b]
Thailand	1	0.976 [a]	0.883 [a]	0.967 [a]	0.282	0.879 [b]	−0.694 [a]	−0.431 [b]	0.878 [a]	0.923 [a]	0.177
Maldives	1	0.975 [a]	0.966 [a]	0.622 [a]	0.373	0.044	−0.998 [a]	−0.039	0.866 [a]	0.486 [b]	0.465 [b]

Table A2. *Cont.*

Countries	lnC	lnTP	lnUR	lnRG	lnIG	lnFE	lnRE	lnRDE	lnEI	lnTO	LnFDI
Serbia	1	0.872 [a]	−0.857 [a]	0.642	−0.919 [a]	0.962 [a]	−0.499	−0.189	0.750 [a]	−0.763 [b]	−0.085
Bosnia and Herzegovina	1	−0.358	0.190	0.761 [a]	−0.092	0.882 [a]	−0.018	-	0.619 [a]	−0.066	0.782 [a]
Montenegro	1	0.107 [a]	0.901 [a]	0.400 [a]	−0.028	0.012	0.024	-	0.225 [a]	−0.378	-
LMI group											
Albania	1	−0.611 [a]	0.960 [a]	0.928 [a]	0.546 [b]	0.637 [a]	−0.501 [b]	0.104	0.838 [a]	0.352	0.414 [b]
Armenia	1	0.624 [a]	0.876 [a]	0.944 [a]	0.152	0.354	−0.727 [a]	0.313 [c]	0.691 [a]	0.764 [a]	0.818 [a]
Georgia	1	0.880 [a]	−0.886 [a]	0.894 [a]	−0.350 [b]	0.916 [a]	−0.856 [a]	0.203	0.724 [a]	0.022	−0.293 [c]
Indonesia	1	0.959 [a]	0.941 [a]	0.950 [a]	0.475 [b]	0.878 [a]	−0.931 [a]	0.033	0.683 [a]	0.378	0.256
Iran	1	0.993 [a]	0.992 [b]	0.923 [a]	0.666 [a]	0.357	−0.271	0.173	0.930 [a]	0.758 [a]	0.409 [b]
Iraq	1	0.901 [a]	−0.649 [a]	0.681 [a]	−0.149	−0.672 [a]	0.337	-	0.501 [b]	0.418 [b]	0.425 [b]
Jordan	1	0.960 [a]	0.899 [a]	0.935 [a]	0.730 [a]	0.200 [c]	−0.569 [a]	0.145	0.851 [a]	−0.105	0.676 [b]
Philippines	1	0.936 [a]	0.783 [a]	0.853 [a]	−0.444 [b]	0.936 [a]	−0.955 [a]	0.044	0.743 [a]	−0.545 [b]	−0.039
Sri Lanka	1	0.972 [a]	0.968 [a]	0.946 [a]	0.769 [a]	0.953 [a]	−0.952 [a]	-	0.811 [a]	−0.545 [a]	0.353
Ukraine	1	0.848 [a]	0.758 [a]	0.872 [a]	0.624 [b]	0.921 [a]	−0.820 [a]	0.566 [b]	0.750 [a]	−0.649 [b]	−0.348 [c]
Turkmenistan	1	0.947 [a]	0.973 [a]	0.895 [a]	−0.597 [a]	0.145	0.336 [c]	−0.028	0.541 [a]	−0.415 [b]	0.450 [b]
Syria Arab Republic	1	0.765 [a]	0.875 [a]	0.734 [a]	−0.063	−0.079	−0.616 [a]	−0.075	0.372 [b]	0.505 [a]	0.462 [b]
Egypt	1	−0.981 [a]	0.828 [a]	0.963 [a]	−0.188	0.877 [a]	−0.947 [a]	−0.366 [c]	0.136	−0.102	0.394 [c]
India	1	0.984 [a]	0.994 [a]	0.995 [a]	0.431 [b]	0.985 [a]	−0.985 [a]	0.003	0.979 [a]	0.961 [a]	0.827 [a]
Moldova	1	0.479 [b]	0.628 [a]	0.734 [a]	−0.197	0.443 [c]	−0.616 [a]	0.254	0.529 [b]	−0.014	−0.734 [a]
Mongolia	1	0.758 [a]	0.791 [a]	0.861 [a]	0.360	0.651 [a]	−0.297	−0.366 [b]	0.714 [a]	0.050	0.500 [b]
Uzbekistan	1	−0.096	0.814 [a]	0.654 [a]	−0.547 [a]	0.582 [b]	−0.484 [b]	−0.164	0.764 [a]	0.397	−0.082
Vietnam	1	0.986 [a]	0.984 [a]	0.992 [a]	0.729 [a]	0.991 [a]	−0.984 [a]	0.352	0.751 [a]	0.355	−0.819 [a]
Bhutan	1	0.811 [a]	0.885 [a]	0.893 [a]	0.836 [a]	0.292	−0.979 [a]	0.246	0.857 [a]	−0.764 [a]	0.539 [b]
LI group											
Bangladesh	1	0.985 [a]	0.994 [a]	0.987 [a]	0.876 [a]	0.980 [a]	−0.996 [a]	0.107	0.915 [a]	0.525 [b]	−0.849 [a]
Cambodia	1	0.967 [a]	0.970 [a]	0.976 [a]	0.609 [b]	0.871 [a]	−0.944 [a]	0.034	0.769 [a]	0.609 [a]	0.651 [b]
Kyrgyzstan	1	0.372	0.354 [b]	0.712 [a]	0.377 [c]	0.891 [a]	0.208	−0.085	0.819 [a]	0.241	0.485 [b]
Myanmar	1	0.940 [a]	0.922 [a]	0.886 [a]	0.844 [a]	0.880 [a]	−0.842 [a]	−0.136	0.860 [a]	0.448 [b]	0.758 [a]
Nepal	1	0.918 [a]	0.914 [a]	0.921 [a]	−0.463 [c]	0.956 [a]	−0.942 [a]	−0.102	0.378	0.861 [a]	−0.030
Pakistan	1	0.986 [a]	0.987 [a]	0.973 [a]	−0.430 [b]	0.939 [a]	−0.574 [b]	−0.214	0.758 [a]	−0.515 [a]	0.329
Tajikistan	1	0.915 [a]	0.754 [a]	0.766 [a]	0.260	0.767 [a]	−0.527 [b]	−0.169	0.839 [a]	0.216	−0.185
Yemen	1	0.886 [a]	0.907 [a]	0.973 [a]	−0.430 [b]	0.939 [a]	−0.474 [c]	−0.018	0.776 [a]	-	-
Afghanistan	1	0.930 [a]	0.953 [a]	0.975 [a]	−0.704 [b]	0.402	−0.981 [a]	-	0.515 [c]	0.529 [b]	−0.030
Laos	1	0.946 [a]	0.950 [a]	0.893 [a]	0.764 [b]	0.230	0.747 [a]	0.012	0.868 [a]	0.845 [a]	0.255

[a] Denotes the correlation is significant at the 0.01 level. [b] Denotes the correlation is significant at the 0.05 level. [c] Denotes the correlation is significant at the 0.1 level.- Denotes no data.

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