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RESEARCH ARTICLE

Management of Green Economic Infrastructure and Environmental Sustainability in One Belt and Road Enitiative Economies

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Abstract
Green infrastructure has been considered as one potential solution for improving air quality as well as enhancing environmental sustainability in the modern era. Therefore, the study aims to examine the impact of green economic infrastructure on environmental sustainability in one belt and road initiative (OBRI) economies for the period 2007 to 2019. For empirical investigations, the study adopts 2SLS and GMM approaches. The study uses three proxies to measure green economic infrastructure, namely, green logistics, use of the internet, and green technology. Our 2SLS findings demonstrate that green logistics increases CO2 in OBRI, Central Asia, MENA and reduces CO2 in Europe. However, GMM findings report that green logistics increases CO2 in OBRI, central Asia, and MENA and reduces CO2 in Europe. While our 2SLS findings show that internet use reduces CO2 in OBRI and East and Southeast Asia Europe and increases CO2 in MENA. While GMM findings reveal that the use of the internet reduces CO2 in OBRI and Europe and increases in East and Southeast Asia and MENA. While green technology also enhances environmental sustainability in OBRI. Based on the findings, environmental policies can be revised for OBRI economies.

Keywords Green logistics · Internet · Green technology · Environmental sustainability

Introduction

Since the industrial revolution economic and social activities performed by humans have massively infused carbon emissions into the environment. The primary source of carbon emissions is heavy reliance on fossil fuels (e.g., coal, oil, and gas) to speed up the process of economic growth. However, massive greenhouse gas emission (GHG) in the ecosystem is the main reason behind severe weather change, droughts, floods, melting of glaciers, rising sea levels, and high temperatures (Usman et al. 2021) which have jeopardized the existence of mankind on the earth. Among GHG emissions, the leading source of polluting the environment and global warming is CO2 emissions (Ozturk, 2017). Though the process of economic development has started after the industrial revolution, this process has gathered the pace in the last half of the previous century. As a result, the speed of carbon emissions in the environment has also increased manifold, inducing academics, environmentalists, and policymakers to look into the factors that can protect the environment without hampering the process of economic growth. Consistent with this view a growing number of economists in the world are presently trying to produce economic models that rely less on the low amount of carbon for development (Roberts and Stalker 2020).

Sustainable development simply means to constantly improve the economic development of the nations without damaging the environment or exerting an extra burden

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on it and to save it for future generations. The long-term goal of the Paris Agreement is to maintain the increase in worldwide temperature below the level of 2 °C (Ullah et al. 2021). Reducing carbon emissions to a manageable level is essential for achieving the goal of sustainable development (Lackner et al. 2012; Ozturk & Acaravci, 2010). In this context, empirics have extensively focused on the environment-growth nexus by incorporating various variables into it. Most of the erstwhile studies have primarily focused on the role of energy consumption and confirmed that energy consumption based on fossil fuels is the biggest source of CO2 emissions and other GHG emissions in the environment (Usman et al. 2020; Rehman et al., 2021). Later on, several studies have included other variables in the carbon emission functions such as renewable energy (Usman et al. 2021; Jafri et al, 2021), industrialization (Ullah et al, 2020), tourism (Chishtiet al. 2020), information and communication technology (Usman et al. 2021), and technological innovation (Ullah et al. 2021) and found mixed results.

Brown et al. (2015) highlighted three critical and primary reasons for making the correct investment choices concerning infrastructure. The first and foremost reason is to aid the process of economic growth. The rate at which emerging economies and developing nations are growing is much higher, i.e., 5.4% in the year 2015 as compared to the developed and advanced economies which grew at the rate of 2.3% in the same year. The economic achievement of developing and emerging economies and the related environmental influence on the world will pivot on the approach in which their economies nurture, which in turn will center on the kinds of infrastructure they construct and function. The second reason behind the choice of green infrastructure is to lay a cornerstone for sustainable development (Karaman et al. 2020). Climate variation is exerting a massive burden on the sustainability of existing economic development frameworks. Traditional infrastructures such as energy and transport infuse additional carbon into the ecosystem that will eventually dent growth, and pitiable choices in rainwater and land-usage infrastructure will make it tough to handle with adaptation requirements, which are exclusively imperative in the evolving world. Last but not the least, the decisions regarding the scheduling of green investment are also very pertinent. The future of economic development and its role in contaminating the environment will depend on today's decisions with regard to the infrastructure investment, i.e., pointing out the areas which will receive a major chunk of infrastructure investment and the channels through which this investment will be financed. Moreover, today's green investment decisions will also decide about the fate of the developing nations whether they will be to achieve their growth and development targets or not and that too without contaminating the environment too much (Liu et al. 2018). The main hurdle in this way is to discover the way out that persuades the investors to invest heavily in green infrastructures that would be beneficial in the attainment of sustainable economic growth, regardless of the view that this type of infrastructure will be more pricey (An et al. 2021).

Green infrastructure is a very important factor in making the growth process much more effective and valuable. It can affect economic growth directly and indirectly. Green infrastructure can serve as an input in the production process; hence, it can directly impact the green growth process (Brown et al. 2015). On the other side, the indirect effects of green infrastructure can be noticed through increased productivity and improved efficiency of green economic activities (Aghion et al. 2013). Any economic activity can impact the environment in either way. Repeated struggles have been made to calculate green infrastructure requirements for the coming decades, predominantly in the evolving and developing nations. Some assessments of green infrastructure demand that would help to reduce carbon emissions to an acceptable level that seems less detrimental to the environment also exist (Zaman and Shamsuddin 2017). However, a lot more and determined effort is required to build a broader agenda for green infrastructure that can develop an economic model for sustainable development. Moreover, raising the finances for such an infrastructure is also an essential issue because of the high cost attached to it; hence, regarding finances, the investors should be educated in a way that convinces them to invest in such exorbitant projects. Against this backdrop, the term "green infrastructure" has been used in various disciplines though differently. In the early concepts, green infrastructure was only referred to as the products that are freely available in the ecosystem from nature. However, in recent years, "green infrastructure" also includes human-developed infrastructure that would preserve the environment from the damages caused by the development-related economic activities. This type of infrastructure includes renewable energy, green logistics, and green ICT (US EPA, 2013).

Carbon neutrality can be achieved via green infrastructure. We have used three proxies to measure green economic infrastructure, namely, green logistics, use of the internet, and green technology, but some past studies are only focused on one dimension of green infrastructure. As shown in Table 1, the existing stock of studies takes into account only one dimension of the green economic infrastructure and CO2 emissions nexus; however, the current study will also investigate the other dimensions of green economic infrastructure. There is a need to explore how does green economic infrastructure reduces CO2 emissions. Based on the existing stock of literature, the study develops two fundamental queries that need to be explored. Firstly, does green economic infrastructure significantly mitigate CO2 emissions? Secondly, to what extent do green logistics, internet, and green technology contribute to the reduction

Table 1 Previous studies on green economic infrastructure and CO2 emissions

Author(s)	Region/Country	Time span	Methods	Independent variable	Outcomes
Zaman & Shamsuddin (2017)	Europe	2007–2014	GMM	Green logistics	Negative
Liu et al. (2018)	Asia	2007–2016	GMM	Green logistics	Negative
Karaman et al. (2020)	Global	2007–2016	Poisson regression	Green logistics	Negative
Karaduman et al. (2020)	Balkan	2006–2016	FE	Green logistics	Positive
Li et al. (2021)	OBRI	2007–2019	2SLS and GMM	Green logistics	Positive
Magazzino et al. (2021)	25 topmost Logistics economies	2007–2018	GMM	Green logistics	Positive
Ye et al. (2021)	Asia	2007–2018	GMM	Green logistics	Negative
Shobande & Ogbeifun (2021)	OECD	1980–2019	GMM	ICTs	Negative
Usman et al. (2021)	Asia	1990–2019	NARDL	ICTs	Mixed
Lahouel et al. (2021)	Tunisia	1970–2018	Logistic smooth transition regression	ICTs	Negative
Chatti (2021)	Global	2002–2014	GMM	ICTs	Negative
Cheng et al. (2019)	BRICS	2000–2013	Panel quantile	Environmental technology patents	Insignificant
Alataş (2021)	EU15	1977–2015	ARDL-PMG	Environmental technology	Insignificant
Meirun et al. (2021)	Singapore	1990–2018	ARDL	Green technology	Negative
Razzaq et al. (2021)	BRICS	1990–2017	Quantile on Quantile regression	Green technology	Negative
Ullah et al. (2021)	Pakistan	1990–2018	NARDL	Green technology	Negative
Mongo et al. (2021)	Europe	1991–2014	ARDL	Environmental Innovations	Negative

of CO2 emissions? In this paper, our aim is to see the role of green economic infrastructure in mitigating CO2 emissions in OBRI economies. To that end, we have applied 2SLS and GMM.

Hence, understanding the factors of CO2 emissions delivers a pragmatic foundation to combat against greenhouse gas emissions. Unlike the prevailing stock of literature, this study does not limit the investigation on the direct impact of green economic infrastructure on environmental quality but the study also highlights various important channels through which green economic infrastructure influences environmental quality in OBRI. The study will provide such an outcome that recommends a novel framework to ease the procedure of selecting the performance indicators for green economic infrastructure. This study offers a comprehensive empirical analysis on the relationship between economic infrastructure and CO2 emissions by using a wide set of green infrastructure variables such as green logistics, use of the internet, and green technology.

The composition of the study is as follows. In "Model and methods," we provide data and methodology followed by results in "Results and discussions" and a conclusion in "Conclusion and policy implications."

Model and methods

In this study, our main goal is to see the effects of green economic infrastructure on CO2 in emerging OBRI economies. A bulk of studies has indicated the green economic infrastructure has negative effects on CO2 emissions, but it has direct and indirect transmission channels in environmental quality (Avom et al. 2020 and Li et al., 2021). Hence, the fundamental form of the model is as follows:

$$CO_{2,it} = _{\varphi_0} + _{\varphi_1} GEI_{it} + _{\varphi_\partial} IND_{it} + _{\varphi_4} EC_{it} + _{\varphi_5} FDI_{it} + a_i + \varepsilon_{it} \quad (1)$$

Equation (1) is the carbon dioxide emissions (CO2) function of OBRI economies that depend on green economic infrastructure (GEI), industrialization (IND), energy consumption (EC), foreign direct investment (FDI), and randomly distributed error term (ε_{it}). The study uses three proxies to measure green economic infrastructure, namely, green logistics (GL), use of the internet (Internet), and green technology (GT). To do so, we have used panel data models. Panel data is a combination of both time series and cross-sectional data; hence, it has some additional benefits as compared to the time series and cross-sectional data. Gujrati et al. (2012) highlighted these advantages by saying that each cross-section unit has some unique characteristics and due to these characteristics there must be some sort of heterogeneity among them which panel data techniques take into account when estimating the model. The combination of two different data settings increases the number of observations in panel data which has many benefits such as more informative data, more flexibility in the sample, more degrees of freedom, and more efficient estimates. Moreover, the analysis of the repetitive cross-sections makes the panel data techniques efficient in capturing the dynamics of change.

Various estimation techniques, e.g., fixed effect model (FEM), random effect model (REM), 2-Stage least squares (2SLS), and generalized method of moments (GMM) are available that can tackle the panel data or longitudinal data. The starting point of all these techniques is pooled OLS which can be represented as a baseline model in comparison to the more sophisticated techniques (Verbeek 2017). Pooled OLS is the simplest of all techniques used in the panel data analysis as it makes a large pool of all the time series and cross-sectional observations and estimates them with a "grand" regression without considering the time series and cross-section properties of the data (Gujrati et al. 2012). The downside of this technique is that it does not consider the heterogeneity among the cross-sectional units and the results from this technique could be biased.

To overcome the problem of undetected heterogeneity fixed effect estimation technique is appropriate but it assumes that these heterogeneous effects are constant over time. Therefore, we can add the dummy variables into the fixed effect model because it removes such variables due to perfect collinearity between the binary variables and the unobserved fixed effects. Moreover, the fixed effect is suitable if the cross-section units are predetermined and if they are randomly selected we should apply the random effect model. The random effect model assumes that cross-sectional units are randomly selected and the unobserved fixed effects are not correlated with any of the regressors otherwise the results may be predisposed and unpredictable. In other words, the REM says that the intercept of a single cross-section unit is randomly sketched from a much bigger population the mean of which is constant. (Gujrati 2003). Then we can express this intercept of the individual cross-section as a deviation from the mean value. The REM has the advantage that we can add the dummy variables into it and it does not eat too much of the degree of freedom because we do not need to add the dummy for each cross-section just like FEM. The selection criteria between both the fixed and random effect models are not easy but Hausman specification tests can help us in solving the issue.

$$CO_{2,it} =_{\varphi_0} + \lambda_1 CO_{2it-1} +_{\varphi_1} GEI_{it} + \varphi_3 IND_{it} + \varphi_4 EC_{it} + \varphi_5 FDI_{it} + a_i + \varepsilon_{it} \quad (2)$$

Equation (2) has one focused variable named green logistics which is treated as an endogenous variable in previous studies (Liu et al. 2018 and Li et al. 2021). Based on the literature, our panel data consist of 45 countries and a relatively small time period of 13 years (from 2007 to 2019), so 2SLS and GMM estimator is a suitable technique (Liu et al. 2018). We estimate the econometric model with an endogenous variable by using the 2SLS, which fixed the problem of endogeneity in the panel model. Panel model has also problems of serial correlation and heterogeneity, we addressed the problems via a system of the GMM. Moreover, GMM is a superior estimation approach in the case of a larger number of the country (T) and small periods (T) of data spans, as in our case.

Data

The study aims to examine the impact of green economic infrastructure on CO2 emissions for OBRI economies for the period 2007–2019. The study also investigates this nexus for sub-regional OBRI economies as well. The sub-regional OBRI economies are classified as Central Asia, South Asia, East and Southeast Asia, Europe, and MENA economies. For empirical investigation, the study uses CO2 emissions as a dependent variable to measure the sustainability of the environment. CO2 emission is measured in kilotons, while green economic infrastructure is measured by using three proxies, namely, green logistics, use of the internet, and green technology. Along with these three independent variables, the study also incorporated the role of control variables to capture the effect of green economic infrastructure on CO2 emissions in OBRI and sub-regional OBRI economies. Industrialization, energy consumption, and FDI are taken as control variables. All the required data is extracted from the World Bank, while green technology data is obtained from OECD.

Results and discussions

To investigate the relationship between green economic infrastructure and CO2 emissions in the OBRI countries, we have relied on panel data estimation techniques, including FE, RE, 2SLS, and GMM. First of all, we have performed a preliminary check such as correlation matrix and descriptive statistics. The correlation matrix confirms that the correlation between the variables is within the range. We did not find evidence of perfect multicollinearity. The highest correlation is recorded between the internet and GL, which is 0.55, whereas the lowest correlation appears between GL

Table 2 Descriptive statistics and correlation matrix

Variable	CO2	GL	Internet	GT	IND	EC	FDI
Descriptive statistics							
Mean	11.19	2.891	47.31	11.84	30.59	79.10	4.102
Std. Dev	1.732	0.451	25.85	7.191	10.45	18.00	6.611
Correlation matrix							
CO2	1						
GL	−0.322	1					
Internet	−0.030	0.550	1				
GT	−0.013	−0.008	0.070	1			
IND	0.305	−0.162	−0.252	0.067	1		
EC	0.365	−0.061	−0.014	0.017	0.379	1	
FDI	−0.154	0.066	−0.012	0.006	−0.052	0.046	1

and FDI. As far as the descriptive statistics are concerned, we have reported two components, i.e., mean and standard deviation that confirms the normality of our data. The mean of CO2, GL, internet, GT, IND, EC, and FDI are 11.19 kt, 2.891 index, 47.31%, 11.84%, 30.59%, 79.10, and 4.102%, respectively. While our model is also free from multicollinearity problems, which indicates by the correlation matrix. For detailed results of the correlation matrix and descriptive statistics, see Table 2. Once confirmed that our variables are not perfectly correlated, we can now proceed to the next step, discussing our estimates.

In Table 3, we have provided the results of FE and RE techniques for a complete sample of OBRI and sub-samples of Central Asian, South Asian, East and Southeast Asian, European, and MENA countries. The estimates of GL are significant and positive in OBRI, South Asia, and MENA, while negative in European countries in FE and RE models. Similarly, in Table 4, applying the 2SLS and GMM techniques found the positive impact of GL on CO2 emissions in OBRI, Central Asian, and MENA countries. While estimates of GL appeared to be negatively significant in the context of European countries. In general, our findings imply that green logistics is not helpful to mitigate CO2 emissions, particularly in a sample of OBRI countries. However, in the case of a sub-sample of European economies, green logistics help reduce CO2 emissions. In other sub-regions such as South Asia, Central Asia, and MENA, we find mixed results regarding the effects of GL.

Finding infers that the logistics structure of a country is essential to promote its economic growth and consequently the CO2 emissions. While eating enormous energy reserves, the logistics sector releases a greater quantity of carbon discharges (Rashidi and Cullinane, 2019). Consequently, proficient and green ecological management is required to give a pollution-free and clean environment for effective conveyance and logistics. Growing globalization makes logistics global (Rodrigue et al., 2001), and while easing trade, logistics actions cause an upsurge in carbon discharges. Against this backdrop, the logistics sector has been under immense pressure to make its carbon management more efficient and effective. So that the role of logistics in achieving economic development can be increased alongside the goal of a sustainable environment (Herold and Lee 2017). According to Roth and Kåberger (2002), it is essential to make the economic characteristic according to the standards of sustainability for the logistics sector in contrast to the other sectors. Likewise, Oberhofer and Dieplinger (2014) contended that environmentally friendly and green logistics are essential to mitigate CO2 emissions. Our results show that logistics have played a positive role in reducing CO2 emissions in European countries. The probable reason could be the aforementioned green aspects of the logistic industry and supply chain services.

In the FE model, the estimates of the internet are also positive and significant in OBRI and its sub-regions such as South Asia, Central Asia, East and Southeast Asia, and MENA. Likewise, the estimates are positively significant in all regions except South Asia in the RE model. Surprisingly, 2SLS and GMM provide either negative or significant estimates of the internet except for the MENA countries where the estimates attached to the internet are positively significant in 2SLS and GMM models. To sum up these findings, we can say that the effects of the internet on CO2 emissions in OBRI countries and its sub-regions are a mix. This finding is also favored by Usman et al. (2021), who noted that the ICT sector enhances the efficiency in the energy sector that tends to reduce greenhouse gas emissions and carbon emissions.

Regarding control variables, the estimates attached to IND are positive and significant in the Central Asian and European sub-regions, while negative and significant in South Asian and MENA countries and insignificant in an OBRI and sub-sample of Europe in FE and RE models. However, using 2SLS and GMM provides insignificant estimates of IND except for the European sub-region where the estimates are positive and significant. The process of

Table 3 Green economic infrastructure and CO_2 (FE and RE)

	OBRI		**Central Asia**		**South Asia**		**East and Southeast Asia**		**Europe**		**MENA**	
	FE	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**
GL	0.041**	0.043**	−0.084	−0.079	0.219**	4.776***	0.217	0.238	−0.117***	−0.108***	0.138**	0.134**
	(0.021)	(0.022)	(0.134)	(0.430)	(0.106)	(0.461)	(0.175)	(0.175)	(0.039)	(0.040)	(0.056)	(0.059)
Internet	0.004***	0.004***	0.003**	0.004	0.006**	−0.024*	0.009***	0.009***	0.001***	0.001***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.004)	(0.002)	(0.013)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IND	0.0003	0.0009	0.013**	0.091***	−0.018**	−0.084***	−0.008	−0.006	0.008***	0.009***	−0.007**	−0.006**
	(0.002)	(0.002)	(0.006)	(0.015)	(0.008)	(0.025)	(0.007)	(0.007)	(0.003)	(0.003)	(0.003)	(0.003)
EC	0.017***	0.017***	0.048***	0.057***	0.0409***	0.045***	−0.020**	−0.019**	0.011***	0.011***	0.021*	0.025**
	(0.002)	(0.002)	(0.010)	(0.003)	(0.006)	(0.010)	(0.008)	(0.008)	(0.001)	(0.001)	(0.011)	(0.012)
FDI	0.001	0.001	−0.007	−0.055***	−0.046**	0.304**	0.001	0.001	0.001	0.001	−0.009	−0.010
	(0.001)	(0.001)	(0.006)	(0.019)	(0.020)	(0.151)	(0.002)	(0.002)	(0.0008)	(0.0008)	(0.007)	(0.007)
Constant	9.498***	9.386***	6.308***	3.730***	9.400***	−2.134*	13.19***	13.07***	9.473***	9.424***	9.145***	8.772***
	(0.224)	(0.294)	(0.922)	(0.929)	(0.441)	(1.111)	(0.879)	(0.985)	(0.194)	(0.289)	(1.138)	(1.214)
Observations	585	585	52	52	52	52	143	143	221	221	117	117
R-squared	0.236		0.463		0.840		0.357		0.347		0.432	
Number of code	45	45	4	4	4	4	11	11	17	17	9	9
Hausman test	3.672		2.765		5.658		6.568		3.662		2.664	

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

Table 4 Green economic infrastructure and CO_2 (2SLS and GMM)

	OBRI		Central Asia		South Asia		East and Southeast Asia		Europe		MENA	
	2SLS	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**
L.CO2		0.499***		0.653***		0.770***		0.662***		0.379***		0.395***
		(0.042)		(0.093)		(0.093)		(0.055)		(0.059)		(0.084)
GL	1.590**	0.025**	0.220**	0.102**	0.468	0.054	0.394	−0.030	−0.543**	−0.014**	0.063**	0.041*
	(0.870)	(0.012)	(0.10)	(0.105)	(0.394)	(0.063)	(0.492)	(0.124)	(0.237)	(0.008)	(0.030)	(0.024)
Internet	−0.043**	−0.002**	−0.042	0.007	−0.006	−0.001	−0.014**	−0.002**	−0.002***	−0.001***	0.005***	0.003***
	(0.018)	(0.001)	(0.178)	(0.007)	(0.022)	(0.002)	(0.008)	(0.001)	(0.0001)	(0.0003)	(0.001)	(0.001)
IND	−0.071	0.001	0.010	0.0005	0.026	−0.008	−0.002	0.007	0.009**	0.009***	−0.003	−0.002
	(0.121)	(0.001)	(0.097)	(0.005)	(0.074)	(0.005)	(0.027)	(0.004)	(0.003)	(0.002)	(0.005)	(0.002)
EC	0.069**	0.010***	0.174***	0.034***	−0.012	0.012**	−0.078	−0.001	0.007***	0.008***	0.014***	0.016**
	(0.030)	(0.002)	(0.011)	(0.007)	(0.074)	(0.005)	(0.055)	(0.006)	(0.002)	(0.001)	(0.004)	(0.007)
FDI	0.027*	0.002***	0.139	−0.001	0.075	−0.008	0.029	0.003***	0.0007	0.0009	−0.003	−0.004
	(0.015)	(0.000)	(0.576)	(0.004)	(0.194)	(0.014)	(0.023)	(0.001)	(0.001)	(0.0006)	(0.009)	(0.006)
Constant	−23.59	4.658***	−32.90	0.628	−0.414	2.084**	−3.408	4.063***	10.90***	5.478***	10.15***	5.281***
	(54.06)	(0.493)	(153.3)	(1.015)	(11.95)	(0.978)	(13.03)	(0.984)	(0.814)	(0.607)	(1.506)	(1.439)
Observations	585	495	52	44	52	44	143	121	221	187	117	99
Number of code	45	45	4	4	4	4	11	11	17	17	9	9
Sargan test		0.545		0.254		0.354		0.655		0.482		0.548

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

Table 5 Green economic infrastructure and CO2 (2SLS and GMM) (Robustness)

	OBRI		Central Asia		South Asia		East and Southeast Asia		Europe		MENA	
	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM
L.CO2		0.548***		0.452***		0.482***		0.540***		0.603***		0.483***
		(0.029)		(0.102)		(0.110)		(0.061)		(0.047)		(0.077)
GL	1.488***	0.022*	0.412	1.468*	0.632	0.071	0.408	0.112	−0.627***	−0.018**	0.558**	0.065*
	(0.247)	(0.012)	(0.452)	(0.807)	(0.796)	(0.054)	(0.973)	(0.101)	(0.132)	(0.007	(0.286)	(0.034)
GT	−0.004*	−0.003*	−0.002	−0.001	−0.016	−0.006*	−0.014**	−0.012*	−0.001	−0.006***	−0.013	0.002
	(0.002)	(0.001)	(0.005)	(0.006)	(0.013)	(0.001)	(0.007)	(0.007)	(0.001)	(0.001)	(0.017)	(0.002)
IND	−0.005	0.001	0.014	0.015	0.013	−0.005	−0.006	0.005	0.005	0.006***	−0.018**	−0.002
	(0.004)	(0.001)	(0.145)	(0.014)	(0.043)	(0.004)	(0.016)	(0.004)	(0.003)	(0.002)	(0.009)	(0.003)
EC	0.026***	0.010***	0.054***	0.063***	0.010	0.009**	0.041*	0.008*	0.012***	0.006***	0.058	0.013
	(0.004)	(0.001)	(0.024)	(0.022)	(0.049)	(0.004)	(0.021)	(0.005)	(0.002)	(0.001)	(0.042)	(0.010)
FDI	0.004**	0.001**	0.017	0.016	0.010	0.001	0.013**	0.002**	0.001	0.001	−0.032	−0.002
	(0.002)	(0.001)	(0.024)	(0.021)	(0.099)	(0.013)	(0.007)	(0.001)	(0.001)	(0.001)	(0.022)	(0.006)
Constant	4.929***	−13.35***	0.685	1.361	3.588	−24.24**	5.265**	−19.68***	8.947***	−4.967	2.583	−10.75
	(0.920)	(2.411)	(1.035)	(3.003)	(4.350)	(9.944)	(2.597)	(7.1430	(0.531)	(3.115)	(6.473)	(7.481)
Observations	585	495	52	44	52	44	143	121	221	187	117	99
Number of code	45	45	4	4	4	4	11	11	17	17	9	9
Sargan test		0.587		0.325		0.598		0.785		0.754		0.741

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

industrialization requires a lot of energy, thus adding CO2 emissions into the environment. However, our results are a mix, i.e., positive, negative, and insignificant. Another factor that emits a massive quantity of carbon into the environment is the consumption of energy obtained by fossil fuels. From Table 5, we gather that the estimates of EC are significantly positive in all regions in FE and RE models. Similarly, with the 2SLS and GMM methods, the estimates of EC appeared to be positively significant in all areas except for the East and Southeast Asian region. These results are confirming that energy consumption is the primary driver of CO2 emissions. Finally, the estimates of FDI seemed to be insignificant in most regions with the FE model apart from the countries of South Asia, where it is negatively significant. With the RE method, the estimate of FDI appeared to be insignificant in most of the regions except for Central Asian and South Asian regions. Likewise, with the 2SLS and GMM techniques, the estimates of FDI are insignificant in most of the regions, excluding the OBRI region, where both the methods provide positive and significant estimates of FDI. However, for the East and Southeast Asian region, the estimate of FDI is positive and significant in only GMM technique.

To test the robustness of findings, the study adopted a variable-based method. Green technology variable has been added in the previous model. The findings show that green technology exerts a significant and negative impact on CO2 emissions in OBRI, South Asia, East Asia, and Europe. This finding is also consistent with Du and Li (2019), which reveals that green technology mitigates CO2 emissions that specifically embrace technological innovations related to renewable energy. Green technology can significantly reduce the mitigation cost of CO2 emissions with developing green growth. A balance between economic activities and carbon emissions is easily obtained via green technology. Most specifically, green technological innovations contribute significantly to enhancing the total-factor productivity of carbon emissions in the following three ways (Razzaq et al. 2021). Firstly, green technological innovations can enhance the efficiency of energy consumption and endorse the substitution of consumption fossil fuels in production with clean energy, thus reducing CO2 emissions. Secondly, green technological innovations can improve industrial setup by shifting production towards high value-added industries that in turn improve green economic growth. Lastly, green technological innovations can enhance human capital that is considered a vital determinant of green economic growth. In last, the remaining findings are also consistent with the previous models.

Conclusion and policy implications

The study aims to investigate the impact of green economic infrastructure on CO2 emissions in OBRI and sub-regions of OBRI economies for time period 2007–2019, by using 2SLS and GMM techniques. The sub-regions of OBRI economies are disaggregated into five groups, namely, Central Asia, South Asia, East and Southeast Asia, Europe, and MENA economies. The study contributes to the literature by using three proxies of green economic infrastructure such as green logistics, internet, and green technology. The results of 2SLS infer that green logistics has a harmful impact on environmental quality in OBRI economies, Central Asia, MENA, while it reduces CO2 emissions in only Europe. The empirical findings of GMM conclude that green logistics have a significant positive impact on CO2 emissions in OBRI economies, while it has a positive increasing impact on CO2 emissions in Central Asia and MENA and a significant decreasing impact in Europe.

The findings of 2SLS infer that carbon emissions decline due to an increase in use of the internet in OBRI, and in the case of sub-regional economies of OBRI, it results in reducing CO2 emissions in East and Southeast Asia and Europe and result in increasing CO2 in MENA. The findings of GMM show that CO2 emissions decline due to an increase in the use of the internet in OBRI economies, and in subregions of OBRI economies, the use of the internet leads to a reduction in CO2 emissions in Europe while it increases CO2 emissions in East and Southeast Asia and MENA. In robust estimates of 2SLS, findings demonstrate that green technology reduces CO2 emissions in OBRI and East and Southeast Asia. The empirical findings of the robust GMM model endorse that green technology exerts a significant negative impact on CO2 emissions in OBRI, South Asia, East and Southeast Asia, and Europe.

From a policy perspective, OBRI policymakers should raise the green infrastructure in order to achieve a low carbon economy. Authorizes should improve the green investment in telecommunication, logistics, and technology sectors on a priority basis. The OBRI policymakers should implement green transportation, green packaging, and smart cities to promote their green economy. For maximizing green economic growth, a serious mindset is required from OBRI authorities. The green technological innovations that mitigate energy consumption are highly required in OBRI regions. Policy-makers can encourage green economic solutions through the mitigations of problems on the financial costs of eco-friendly projects and technologies. OBRI nations could also advance their structure of industries and raise economic effectiveness through ICT. The OBRI authorities should increase R&D expenditures on green infrastructure projects, which would help in environmental sustainability.

This study has a few limitations. The analysis is conducted at the regional level and does not take into account the specificities of each economy. Consequently, it is more important to extend this study at each economic level to get further insights. The upcoming empirical studies should mainly focus on the heterogeneous impacts of green economic infrastructure on CO2 emissions across economies with different income levels. Authors should employ other proxies of green economic infrastructure. Future studies should also extend this work by identifying direct and indirect transmission channels, particularly green economic infrastructure, that also affect other environmental outcomes than CO2.

Author contribution This idea was given by Jian Chen. Jian Chen, Nuttawut Rojniruttikul, Li Yu Kun, and Sana Ullah analyzed the data and wrote the complete paper. While Sana Ullah read and approved the final version.

Availability of data and materials The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval Not applicable.

Consent to participate I am free to contact any of the people involved in the research to seek further clarification and information.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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