

Management of green economic infrastructure and environmental sustainability in one belt and road initiative economies

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Abstract

The study aims to examine the impact of green economic infrastructure on environmental sustainability in one belt and road initiative (OBRI) and sub-regional OBRI economies for the period 1990 to 2019. The study uses two proxies to measure green economic infrastructure namely green logistics and use of the internet. For empirical investigations, the study adopts 2SLS and GMM approaches. Our 2SLS findings demonstrate that green logistics increases CO₂ in OBRI and central Asia and reduces CO₂ in Europe and MENA. However, GMM findings report that green logistics increases CO₂ in OBRI, central Asia, and MENA and reduces CO₂ in Europe. While in case of internet, 2SLS findings show that internet use reduces CO₂ in OBRI, East and Southeast Asia Europe and increases CO₂ in MENA. While GMM findings reveal that use of internet reduces CO₂ in OBRI and Europe and increases in East and Southeast Asia and MENA. Based on the findings, environment policies can be revised for OBRI economies.

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 emissions (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 but 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 et al. 2020).

Sustainable development simply means to constantly improve the economic development of the nations without damaging the environment or exerting an extra burden on it and to save it for future generations. Reducing carbon emissions to a manageable level is essential for achieving the goal of sustainable development (Lackner 2010; 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; Rahman 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 (Chisti et al. 2020), information and communication technology (Usman et al. 2021), 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 are 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 centre 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 is also very pertinent. The future of economic development and its role in contaminating the environment will depend on today's decisions with regards 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, 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 & 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, green ICT (US EPA, 2013). In this paper, our aim is to see the role of green economic infrastructure in mitigating CO₂ emissions in emerging Asian economies. To that end, we have applied 2SLS and GMM.

The composition of the study is as follows. In section two, we provide data and methodology followed by results in section three and a conclusion in section four.

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 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:

$$CO_{2,it} = \phi_0 + \phi_1 GEI_{it} + \phi_3 IND_{it} + \phi_4 EC_{it} + \phi_5 FDI_{it} + \alpha_i + \epsilon_{it} \quad (1)$$

Arrangement (1) is the carbon dioxide emissions (CO₂) function of emerging 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 two proxies to measure green economic infrastructure namely green logistics and use of the internet. 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 doesn't 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 don't need to add the dummy for each cross-section just like FEM. The selection criteria between both the fixed and random effect model is not easy but Hausman specification tests can help us in solving the issue.

$$CO_{2,it} = \phi_0 + \lambda_1 CO_{2,it-1} + \phi_1 GEI_{it} + \phi_3 IND_{it} + \phi_4 EC_{it} + \phi_5 FDI_{it} + \alpha_i + \epsilon_{it} \quad (2)$$

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). 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 case of a larger number of country (T) and small periods (T) of data spans, as in our case. The dynamics GMM model forms of economic growth and CO₂ emissions model are as follows:

Data

The study aims to examine the impact of green economic infrastructure on the sustainability of environment for OBRI economies for period 1990–2019. 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 environment. CO₂ emission is measured in kilotons, while green economic infrastructure is measured by using two proxies namely green logistics and use of internet. Along with these two 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. The detailed descriptive statistics and correlation matrix are shown in Table 1.

Table 1
Descriptive statistics and correlation matrix

	CO2	GL	Internet	IND	EC	FDI
Descriptive statistics						
Mean	11.16	2.874	46.72	30.66	79.40	4.292
Std. Dev.	1.712	0.458	25.92	10.35	17.91	7.208
Correlation matrix						
CO2	1					
GL	-0.242	1				
Internet	-0.024	0.562	1			
IND	0.183	-0.167	-0.252	1		
EC	0.107	-0.086	-0.003	0.380	1	
FDI	-0.069	0.004	-0.019	-0.041	0.062	1

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 0.562, whereas the lowest correlation appears between GL 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. For detailed results of the correlation matrix and descriptive statistics, see Table 1. Once confirmed that our variables are not perfectly correlated, we can now proceed to the next step, discussing our estimates.

Tables 2 & 3 reports the estimates of all the main variables included in our analysis. In Table 2, 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 FE and RE models, in the countries of OBRI, South Asia, and MENA, while negative in European countries. Similarly, applying the 2SLS and GMM techniques found the positive impact of GL on CO2 emissions in OBRI and Central Asian countries. Once again, the estimates of GL appeared to be negatively significant in the context of European countries with the 2SLS and GMM techniques. However, for MENA countries, the estimate of GL is positively significant with GMM and negatively significant with the 2SLS approach. In general, our findings imply that green logistic is not helpful to mitigate the CO2 emissions, particularly in the complete 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.

Table 2
Green economic infrastructure and CO2 (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** (0.021)	0.043** (0.022)	-0.084 (0.134)	-0.079 (0.430)	0.219** (0.106)	4.776*** (0.461)	0.217 (0.175)	0.238 (0.175)	-0.117*** (0.039)	-0.108*** (0.040)	0.138** (0.056)	0.000 (0.000)
Internet	0.004*** (0.001)	0.004*** (0.001)	0.003** (0.001)	0.004 (0.004)	0.006** (0.002)	-0.024* (0.013)	0.009*** (0.001)	0.009*** (0.001)	0.001*** (0.001)	0.001*** (0.001)	0.003*** (0.001)	0.000 (0.000)
IND	0.0003 (0.002)	0.0009 (0.0025)	0.013** (0.006)	0.091*** (0.015)	-0.018** (0.008)	-0.084*** (0.025)	-0.008 (0.007)	-0.006 (0.007)	0.008*** (0.003)	0.009*** (0.003)	-0.007** (0.003)	-0.000 (0.000)
EC	0.017*** (0.002)	0.017*** (0.002)	0.048*** (0.010)	0.057*** (0.003)	0.0409*** (0.006)	0.045*** (0.010)	-0.020** (0.008)	-0.019** (0.008)	0.011*** (0.001)	0.011*** (0.001)	0.021* (0.011)	0.000 (0.000)
FDI	0.001 (0.001)	0.001 (0.001)	-0.007 (0.006)	-0.055*** (0.019)	-0.046** (0.020)	0.304** (0.151)	0.001 (0.002)	0.001 (0.002)	0.001 (0.0008)	0.001 (0.0008)	-0.009 (0.007)	-0.000 (0.000)
Constant	9.498*** (0.224)	9.386*** (0.294)	6.308*** (0.922)	3.730*** (0.929)	9.400*** (0.441)	-2.134* (1.111)	13.19*** (0.879)	13.07*** (0.985)	9.473*** (0.194)	9.424*** (0.289)	9.145*** (1.138)	8.000 (0.000)
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	

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

On the other side, with the FE model, the estimates of 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, with the RE model, the estimates are positively significant in all regions except South Asia. Surprisingly, 2SLS and GMM provide either negative or significant estimates of internet except for the MENA countries where the estimates attached to Internet are positively significant in and GMM models. To sum up these findings, we can say that the effects of internet on CO2 emissions in OBRI countries and its sub-regions are mix.

Logistics are an essential part of a wide variety of firms, organizations, and businesses such as manufacturing or service and public or private. The importance of logistics has been increased manifold due to the effects of globalization. Several things fall in the category of logistics e.g., customs procedures, information and communication technologies, transport infrastructure, port and shipping facilities, tracking and tracing etc. 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). As a result, it is essential to make the economic characteristic according to the standards of sustainability for the logistics sector in contrast to the other sectors (Roth and Käberger, 2002). Cosimato and Troisi (2015) established that novelties in the logistics sector can tackle negative environmental influences and boost efficiency and competition among firms. 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 list of control variables, the first one is industrialization. If we use the FE and RE models, 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 a complete sample of OBRI and sub-sample of Europe. 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 industrialization requires a lot of energy, thus add 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 2, we gather that the estimates of EC are significantly positive in all regions and with 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 only with GMM technique.

Table 3
Green economic infrastructure and CO2 (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*** (0.042)		0.653*** (0.093)		0.770*** (0.093)		0.662*** (0.055)		0.379*** (0.059)		0.395*** (0.084)
GL	1.590** (0.870)	0.025** (0.012)	0.220** (0.10)	0.102** (0.105)	0.468 (0.394)	0.054 (0.063)	0.394 (0.492)	-0.030 (0.124)	-0.543** (0.237)	-0.014** (0.008)	-0.063** (0.030)	0.041** (0.024)
Internet	-0.043** (0.018)	-0.002** (0.001)	-0.042 (0.178)	0.007 (0.007)	-0.006 (0.022)	-0.001 (0.002)	-0.014** (0.008)	-0.002** (0.001)	-0.002*** (0.0001)	-0.001*** (0.0003)	0.005*** (0.001)	0.003** (0.001)
IND	-0.071 (0.121)	0.001 (0.001)	0.010 (0.097)	0.0005 (0.005)	0.026 (0.074)	-0.008 (0.005)	-0.002 (0.027)	0.007 (0.004)	0.009** (0.003)	0.009*** (0.002)	-0.003 (0.005)	-0.002 (0.002)
EC	0.069** (0.030)	0.010*** (0.002)	0.174*** (0.011)	0.034*** (0.007)	-0.012 (0.074)	0.012** (0.005)	-0.078 (0.055)	-0.001 (0.006)	0.007*** (0.002)	0.008*** (0.001)	0.014*** (0.004)	0.016** (0.007)
FDI	0.027* (0.015)	0.002*** (0.000)	0.139 (0.576)	-0.001 (0.004)	0.075 (0.194)	-0.008 (0.014)	0.029 (0.023)	0.003*** (0.001)	0.0007 (0.001)	0.0009 (0.0006)	-0.003 (0.009)	-0.004 (0.006)
Constant	-23.59 (54.06)	4.658*** (0.493)	-32.90 (153.3)	0.628 (1.015)	-0.414 (11.95)	2.084** (0.978)	-3.408 (13.03)	4.063*** (0.984)	10.90*** (0.814)	5.478*** (0.607)	10.15*** (1.506)	5.281** (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

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

Conclusion And Policy Implications

The study aims to investigate the role of green economic infrastructure in environmental sustainability in OBRI economies and sub-regions of OBRI economies for time period 1990–2019. 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 applied RE, FE, 2SLS, and GMM techniques for regression analysis. Two proxies such as green logistics and internet are adopted to capture the role of green economic infrastructure in OBRI economies and sub-regions of OBRI economies. The empirical findings of FE model reveal that green logistics performance exerts a significant positive impact on CO2 emissions in OBRI economies, and in case of sub-regions of OBRI economies, green logistic performance upsurges CO2 emissions in MENA and reduces CO2 emissions in Europe. In case of RE, findings demonstrate that green logistics enhances CO2 emissions in OBRI economies, south Asia and MENA and decreases CO2 in Europe. The empirical findings of FE and RE models endorse that CO2 emissions increase with increase in use of internet, revealing the hypothesized impact of ICT on environmental sustainability in OBRI and sub-regional OBRI economies except for South Asia in case of RE model.

The results of 2SLS infer that green logistics is harmful for environmental quality in OBRI economies and Central Asia as green logistics results in increasing CO2 emissions while it reduces CO2 emissions in Europe and MENA. The empirical findings of GMM conclude that green logistics have significant positive impact on CO2 emissions in OBRI economies, and in case of sub-regional OBRI it has positive increasing impact on CO2 emissions in Central Asia and MENA and significant decreasing impact in Europe. In case of internet, the findings of 2SLS infer that carbon emissions declines due to increase in use of internet in OBRI, and in 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 state that CO2 emissions declines due to an increase in the use of internet in OBRI economies, and in sub-regions of OBRI economies the use of internet leads to reduction in CO2 emissions in Europe while it increases CO2 emissions in East and Southeast Asia and MENA.

From a policy perspective, OBRI policymakers should raise the green infrastructure in order to achieve low carbon economy. Authorizes should improve the green investment in telecommunication, logistics, and energy sectors on a priority basis. The green logistics performance can be developed through green energy technology. Green infrastructure is so important in modern era for sustainable economic development. Therefore, OBRI policymakers should implement green transportation, green packaging, and smart cities to promote their green economic growth. For maximizing green economic growth, a serious mind-set is required from China and OBRI authorities. This study has one of the limitations. The analysis is conduct at the regional level and do not take into account the specificities of each economy. Consequently, it is more important to extend this study at an economy level to get further insights. Future studies should also

extend this work by identifying direct and indirect transmission channels, particularly green economic infrastructure affect other environmental outcomes than CO₂.

Declarations

Ethical 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 to Publish: Not applicable

Authors' Contributions: 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.

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

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