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# Fiscal spending and green economic growth: fresh evidence from high polluted Asian economies

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## ABSTRACT

Green growth is deliberated as an effective way for attaining environmental sustainability, but the nexus between fiscal spending and green growth is ignored in highly polluted Asian economies. To fill this gap, this study attempts to investigate the impact of public sector education and research and development expenditures on green economic growth for selected Asian economies for the period 1991–2019. The study employed FMOLS and DOLS methods to assess the association between public expenditures on education and research and development sectors and green economic growth. The study found that education and research and development expenditures both contribute significantly to enhancing green economic growth in most of the selected Asian economies. The study proposed some important policy implications for fostering green economic growth and environmental sustainability by mitigation of pollution emissions.

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## 1. Introduction

Global environmental pollution and climatic change urge environmentalists and policymakers to produce new solutions for sustainable growth. The green economy is among the effective solutions for achieving sustainability, which concentrates on economic development, resource protection, and environmental friendliness (Bina, 2013; Ying et al., 2021). The green economy is considered as an instrument to enhance social well-being and equity, while considerably mitigating environmental scarcities and risks (Raleigh & Urdal, 2007). The increasing environmental calamities have made green growth a strategic choice in attaining sustainable development objectives (Burke & Stephens, 2018). The concept of green growth has stimulated extensive concerns around the globe and is considered an effective way for raising economic development, saving resources, and reducing environmental degradation (Hallegatte et al., 2012). Some organizations and studies have made a proper definition of green growth

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(UNEP, 2012), and some organizations have considered green growth as a strategic concept (OECD, 2011).

Although for green economic growth, it is imperative to deeply examine the elements of its development. Among the fundamental elements, the main emphasis of the study is on fiscal spending. Fiscal spending is composed of 20–40% of the total GDP of the economy (López et al., 2011). Previous studies have confirmed that the change in the structure of fiscal expenditures exerts a significant impact on the economy and environmental pollution (Ullah et al., 2021). However, the association between government fiscal expenditure and green growth has not been described systematically. The influential impact of the former on the latter can be described by the rationalization of public fiscal expenditures (Fetai, 2017; Hua et al., 2018; Ryu, 2015). Government fiscal spending on R&D is considered a substantial driver, as technological innovations are considered as a better option to fetch green economic growth.

A bulk of literature shows that the structure of government fiscal expenditure is directly influenced by environmental degradation (Yuelan et al., 2019). The association between green economic growth and government fiscal expenditure still lacks extensive evidence. Existing previous literature elucidates the role of government fiscal spending as an imperative determinant for green economic growth (Facchini & Seghezza, 2018). Green economic growth is augmented by enlarged fiscal spending, but green economic growth also declines due to increasing environmental vulnerabilities. Fiscal spending can also be used to compensate for market failure, which intensifies new solutions for technological innovations. As private-sector R&D expenditures are not adequate to produce sufficient solutions, thus, government fiscal support is obligatory (Xie et al., 2021). In contrast, evolutionary theory reveals that the basis for developing sufficient technologies by an enterprise might not be established merely on the basis of the provision of new technologies developed by fiscal expenditures. It indicates that the involvement of private sectors is obligatory in the process of technological innovation with the support of the public sector (Li et al., 2022). The fiscal spending cut on the green economy results in miserable social consequences (Afonso & Furceri, 2010; Li et al., 2021).

Composition of fiscal spending and green economic growth, and the scale of fiscal spending in green economic growth influence fiscal policy representation. Iram et al. (2020) highlighted the level and intensity of total fiscal spending on R&D and its positive impact on green growth. The growth strategy amongst the developing countries is transforming from agriculture to the manufacturing industrial sector. Developing economies from Africa and Asia are trying to attain substantial output to fulfill their growth objectives by concentrating on their industrial and manufacturing sectors (Yang et al., 2017). To achieve an improved and smooth level of output the emerging Asian economies have enlarged their dependence on energy capitals. However, to alleviate global environmental degradation, the developing economies must collaborate towards green economic growth along with economic benefits.

The existing stock of literature reveals that green economic growth is low-carbon intensive and resource-efficient. In the green economic framework, the growth of income and employment is driven by private and public investment. These green growth investments impel economic activities, protect ecosystems and biodiversity,

improve resource and energy efficiency, and development of green energy infrastructure for the reduction in CO<sub>2</sub> emissions (Liu et al., 2018; Sun et al. 2020). Consequently, green economic growth has been recognized as a new mechanism for economic development around the globe (Rodriguez-Gonzalez et al. 2018). Previous studies have precisely defined the concept of green economic development (see for instance; Ekins, 2002; Barbier, 2011; Luukkanen et al., 2019; Cheng et al., 2021). Nieto et al. (2018) studied the association between green economy, sustainable development, and dimensional characteristics of the green economy. Fiscal spending is not adequate to attain goals of green growth and SDGs set by the United Nations (Sachs et al., 2019). Hence, the government allows green economic projects to attract more private green investments (Taghizadeh-Hesary & Yoshino, 2019). An economy can preserve green resources and create low carbon emissions by adopting green economic projects (Lin and Jia 2019). Several studies denoted that employment generation and environmental safety can support green growth in confirming economic progress (Hallegatte et al. 2019).

Previous studies have discussed several other factors that affect green growth such as Wang et al. (2019) study incorporated economic and social status, population, and level of education to examine variations in green economic growth. Lin and Zhu (2019) explored how the green economic development of China is influenced by technological shocks, efficiency, and lack of efficient practices. Shu et al. (2016) investigated how resource-intensive cities have more opportunities of generating pollution emissions by considering green and natural resources to affect the green economic growth of China. Paramesh (2018) investigated the evolution of Asian economies towards green economic growth by fiscal instrument and concluded that these economies materialize the transition at a slow speed. Lin and Zhu (2019) explored the impact of public sector education spending and R&D on the green economic growth of China. Zhang et al. (2021) explored the association between fiscal spending on R&D, energy efficiency, and green economic growth. Due to dependence on the non-renewable energy sector and industrial sector, green economic growth has enhanced, but the gradual environmental pollution mitigates (Montalbano & Nenci, 2019). The development targets can be attained through living standards and energy (Usman et al., 2021). Particular indicators play contribute significantly to the failure of green economic growth, like over-dependence on the non-renewable energy sector, inadequate fiscal spending on R&D, and unsuitable environmental planning (Ullah et al., 2021).

Asia is the largest continent and also the biggest contributor to CO<sub>2</sub> emissions. Thus, these high-polluted Asian economies become an ideal choice in scrutinizing the influence of fiscal spending on green economic growth. We have tried to analyze the impact of fiscal spending on green growth in highly polluted Asian economies. For empirical analysis, the study will use data set of selected Asian economies from 1991 to 2019 by employing NARDL approach. This study contributes to the existing literature in the following ways. Firstly, the findings of the study will add to the understanding of the contribution of fiscal spending in the market mechanism by suggesting that fiscal spending on public goods is helpful to lessen the risk of market failure. Secondly, the study helps in policy formulation, as green economic growth

requires a balance association between environmental protection, energy conservation, and economic development, and these all are directly affected by government regulatory policies. This study also helps in the modification of green economies policies.

## 2. Model and methods

Following earlier empirical and theoretical literature Jacobs (2012) and Lin and Zhu (2019), we assume that the main determinants of green growth are fiscal spending, internet, financial development, and clean energy consumption. Therefore, we begin with the following econometric models:

$$\text{GEG}_{it} = \varphi_0 + \varphi_1 \text{EE}_{it} + \varphi_2 \text{RD}_{it} + \varphi_3 \text{Internet}_{it} + \varphi_4 \text{FD}_{it} + \varphi_5 \text{REC}_{it} + \alpha_i + \varepsilon_{it}$$

Where  $\text{GEG}_{it}$  represents green economic growth, but  $\text{EE}_{it}$  and  $\text{RD}_{it}$  separately represents public educational expenditure and R&D expenditure in the model. The fiscal spending produces a positive significant impact on green economic growth (Lin & Zhu, 2019; Zhang et al., 2021), we expect estimates of  $\varphi_1$  and  $\varphi_2$  to be negative. Where  $\text{Internet}_{it}$ ,  $\text{Internet}_{it}$ ,  $\text{FD}_{it}$ , and  $\text{REC}_{it}$  separately represent control variables and named as internet users, financial development, and renewable energy consumption. In model, subscripts  $i=1, \dots, N$  signifies the country,  $t=1, \dots, T$  indicates the time separately.

While  $\varphi_0$  denotes the intercept,  $\varphi_1 - \varphi_5$  are coefficients to be estimated, and  $\alpha_i$  is unobservable individual effects, and  $\varepsilon_{it}$  is a random error term. Thus, Eq. (1) is a standard panel data model. Our data has two dimensions one spreads across time and the other across cross-sectional units. Such type of data is known as panel or longitudinal data, and this type of data has many advantages over time series and cross-sectional data. The first and foremost advantage of panel data is that it combines the observations across time and cross-section; therefore, the number of observations increases manifold. Along with the increase in the number of observations, we enjoy the luxury of more variability, information, efficiency in our panel data set as compared to the cross-section and time-series data set (Baltagi, 2008). As the data, we have used in the analysis is panel; hence, such type of data requires special econometric techniques such as fixed effect model (FEM), random effect model (REM), and generalized methods of movement (GMM). However, these techniques are applicable in the type of data where  $T$  is small, and  $N$  is large. Conversely, different panel estimation techniques like pooled OLS (POLS), dynamic OLS (DOLS), and fully modified OLS (FMOLS) are appropriate when  $T$  and  $N$  are both large.

In POLS, we add all the time series and cross-section observations and then estimate them with the help of a single regression without taking into consideration the time-series and cross-sectional properties of the data. POLS is an efficient estimator when we use a different sample for each time dimension in a panel data set (Wooldridge, 2010). However, a major disadvantage of POLS is that it can't consider the unobserved heterogeneity; therefore, it provides inconsistent results (Gaibulloev et al., 2014). The problems encountered while applying the POLS technique can be resolved with the help of more advanced and sophisticated techniques like FMOLS and DOLS. Both these estimators are highly efficient even in the presence of

**Table 1.** Definitions and data description.

Variables	Symbol	Definitions	Mean	Std. Dev.
Green economic growth	GEG	Environmentally Adjusted Multifactor Productivity	4.521	3.711
Education expenditure	EE	Government expenditure on education, total (% of GDP)	3.478	1.437
Research and development	RD	Research and development expenditure (% of GDP)	1.283	1.158
Internet users	Internet	Individuals using the Internet (% of population)	28.55	31.92
Financial development	FD	Domestic credit to private sector (% of GDP)	3.856	0.972
Renewable energy consumption	REC	Nuclear, renewables, and other (quad Btu)	2.050	2.862

Source: Author's Estimations.

endogeneity among regressors and serial correlation in error terms. To solve the problems mentioned above FMOLS technique applies a non-parametric approach. Conversely, the DOLS applies a parametric approach by including leads and lags values to deal with the issues of endogeneity and serial correlation (Kao & Chiang, 2001). Moreover, DOLS is a good estimator in the case of a small number of observations (Dogan & Seker, 2016). Another problem that makes the panel data results biased is the problem of cross-sectional dependence. An added advantage of the DOLS technique is that it can obtain country-specific coefficients that provide unbiased and consistent results in the case of cross-sectional dependence. Further, the issues of heterogeneity in the long-term variance, and cointegrated panel can be resolved with the help of weighted criteria of FMOLS and DOLS.

### 3. Data

This study explores the dynamic effects of fiscal spending on green growth in the case of highly polluted Asian economies named China, India, Russian, Japan, Saudi Arabia, Korea, Rep., Indonesia, and Turkey for the period 1991 to 2019. For that purpose, green growth is a dependent variable, education and research & development expenditures are independent variables, while internet, financial development, and renewable energy consumption are taken as control variables. Green growth is measured by environmentally adjusted multifactor productivity. Government expenditures on education as percent of GDP are used to measure education expenditures. Research and development expenditures are measured in terms of percentage of total GDP. Internet variable is measured by individuals using the internet as percent of population. Domestic credit of private sector in percent of GDP is used to measure financial development. Renewable energy consumption is taken as energy consumption of nuclear, renewables and others. All the data for this study have been extracted from the World Bank and OECD. A detailed description of the data is also reported in Table 1.

### 4. Results and discussion

Firstly, it is imperative to investigate the cross-sectional dependence when we are dealing with panel data in order to follow methods and strategies (Pesaran et al., 2004). As a first step, the study investigates the cross-sectional dependence of the data. Various cross-sectional dependence tests are proposed in the literature, but our

**Table 2.** Cross-sectional dependence test.

	GEG	EE	RD	Internet	FD	REC
Pesaran's test	4.767***	0.206	0.536	5.461***	3.004***	4.845***
Prob.	0.000	0.837	0.598	0.000	0.002	0.000
off-diagonal elements	0.210	0.269	0.427	0.485	0.423	0.414

Note: \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; and \* $p < 0.1$ .

Source: Author's Estimations.

**Table 3.** Panel unit root and Cointegration tests.

	LLC I(0)	I(1)	IPS I(0)	I(1)
<b>Unit root tests</b>				
GEG	-0.515	-4.362***	I(1)	-0.456
EE	-0.783	-5.728***	I(1)	1.012
RD	-0.470	-5.091***	I(1)	1.024
Internet	-0.578	-4.103***	I(1)	1.422
FD	-0.452	-3.258***	I(1)	1.022
REC	0.255	-1.484*	I(1)	-0.542
<b>Cointegration test</b>				
Kao-cointegration test	-3.994***			

Note: \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; and \* $p < 0.1$ .

Source: Author's Estimations.

study employed Pesaran's et al. (2004) cross-sectional dependence test, and the outcomes are displayed in Table 2. The findings of the cross-sectional dependence test suggest that the null hypothesis of no cross-sectional dependence is not accepted. Suggesting that if any positive or negative shock occurs in one economy; its spillover impact can be observed in the rest of all economies of the selected sample. The finding implies that cross-sectional dependence exists among the Asia region.

As a second step, stationarity processes of the series have been confirmed in order to obtain the most valid decision regarding panel regression. For that purpose, the study conducts Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) unit root tests which are capable of taking into consideration the cross-sectional dependencies across economies. The findings of both panel unit root tests are displayed in Table 3. The obtained coefficient estimates suggest that all the variables are stationary at their first difference, i.e., I(1). The first difference I(1) stationarity level calls for investigating cointegration association among variables as their linear combination could be level stationary. In this regard, Kao residual cointegration test has been employed, and the findings are displayed in the lower panel of Table 3. According to the findings of Kao cointegration test, it is suggested that cointegration exists among green economic growth, education and R&D expenditures, internet use, financial development, and renewable energy consumption. The validation of cointegration indicates the presence of a long-run relationship among the variables.

In the last step, the study employed FMOLS technique to empirically investigate the impact of fiscal green expenditures on green economic growth. In order to confirm the robustness of findings, the study also employed DOLS regression technique. The study adopted two proxies to measure the impact of fiscal expenditures, which are, education expenditures and research and development expenditures. Table 4 displayed group-wise coefficient estimates of FMOLS and DOLS approaches and

**Table 4.** FMOLS and DOLS estimate of green economic growth.

	FMOLS		DOLS			
	(1)	(2)	(3)	(4)	(5)	(6)
EE	0.090*** (3.040)		1.010*** (8.870)	1.280 (0.030)		1.002*** (8.740)
RD		2.660*** (2.870)	1.610*** (4.910)		2.710*** (8.550)	2.080 (1.540)
Internet	0.010*** (17.18)	0.020*** (14.17)	0.010*** (8.070)	0.150*** (6.730)	0.280*** (3.510)	0.410*** (7.920)
FD	1.450*** (2.980)	2.220*** (6.190)	2.330*** (9.140)	2.210*** (10.07)	1.780*** (2.450)	2.740* (1.720)
REC	2.570* (1.680)	3.640*** (4.420)	2.540 (1.390)	2.120*** (5.790)	3.090*** (1.250)	2.810*** (11.80)

Note: \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; and \* $p < 0.1$ .

Source: Author's Estimations.

**Table 5.** Economy-wise estimates of green economic growth (FMOLS).

	EE	RD	Internet	FD	REC
China	2.080*** (5.180)	3.730*** (5.210)	0.010 (0.590)	2.240*** (3.810)	0.090 (1.080)
India	0.280 (0.870)	2.140 (0.480)	0.010 (0.460)	0.790 (0.570)	0.830 (1.070)
Russian	0.100 (0.130)	1.230*** (2.720)	0.160*** (3.900)	1.920** (2.340)	2.570*** (3.970)
Japan	0.660*** (3.420)	2.470*** (4.130)	0.010*** (4.060)	2.290*** (2.680)	0.290*** (8.610)
Saudi Arabia	1.090*** (3.160)	0.620 (0.360)	0.040 (0.890)	5.460** (2.380)	2.000 (0.880)
Korea, Rep.	2.500*** (4.420)	0.680*** (2.800)	0.200*** (8.810)	2.920*** (7.760)	2.780*** (5.980)
Indonesia	2.930*** (7.010)	2.610*** (4.720)	0.170*** (2.400)	2.480*** (2.680)	2.240** (2.380)
Turkey	0.780 (0.660)	2.150*** (2.850)	0.050 (0.990)	2.120** (2.220)	3.100*** (2.720)

Note: \*\*\* $p < 0.01$ ; \*\* $p < 0.05$ ; and \* $p < 0.1$ .

Source: Author's Estimations.

Table 5 represents economy-wise coefficient estimates of both estimation techniques. To conserve space, we are only describing the coefficient estimates of column 3 and column 6 in detail in Table 4. In column 3, the findings show that education expenditures and research and development expenditures are positively linked with economic growth revealing that due to an upsurge in both types of fiscal expenditures, green economic growth increases. Coefficient estimates divulge that in response of 1% upsurge in education expenditures and research and development expenditures, green economic growth raises by 1.010% and 1.610%, respectively.

The estimation results reveal that public expenditures on education and R&D sector have a positive impact on green growth, revealing the existence of technique effect and composition effect. Similar results are reported in López et al. (2011); the study argued that the upsurge of fiscal expenditures on public goods can reduce carbon emissions significantly, such as wastewater and SO<sub>2</sub> emissions. More precisely, the coefficient estimates of research and development expenditures are larger than the education expenditures, suggesting that the technical effect is larger which is opposite to the findings of Hua et al. (2018). The findings of control variables are almost according to our expectations. The potential impact mechanism of public



expenditures on green economic growth infers that research and development can promote technological progress, while education expenditures can enhance human capital-based activities. The complex nature of economy-wise results reveal that the selected economies are heterogeneous, and this diversity can be described in the following ways. All the economies have a similar influence on education expenditures in strengthening the growth of human capital.

The fiscal budget for education expenditures is relatively higher in a few Asian economies, efficient human resources are developed, and the education standard is also good. At economy-wise analysis, research and development expenditures are also positively related to green economic growth. The evolutionary economics and neo-classical economic theories elaborated the importance of government expenditures in environment-friendly economic activities. Market failures can also be compensated by public expenditures on education and R&D that raise new technological innovations. Private-sector research and development expenditures are not enough to produce revolutionary solutions, thus, government sector financial support is mandatory for green growth (Zhang et al., 2021).

Regarding control variables, findings display that internet use and financial development have a positive impact on green economic growth while renewable energy production produces an insignificant impact. Coefficient estimates show that due to 1% increase in internet use and financial development, green economic growth increases by 0.010% and 2.330%, respectively. In case of the DOLS model, education expenditures and all control variables have a significant and positive impact on green economic growth, while research and development produce insignificant impact.

In Table 5, the economy-wise results show that education expenditures exert a positive impact on green economic growth in China, Japan, Saudi Arabia, Korea, Rep., and Indonesia. Coefficient estimates display that due to 1% increase in education expenditures, green economic growth increases by 2.080% in China, 0.660% in Japan, 1.090% in Saudi Arabia, 2.500% in Korea, Rep., and 2.930% in Indonesia. In terms of research and development expenditures findings reveal that green economic growth increases in China, Russia, Japan, Korea, Rep., Indonesia, and Turkey due to an upsurge in research and development expenditures. The findings reveal that a 1% increase in research and development leads to increasing green economic growth by 3.730% in China, 1.230% in Russia, 2.470% in Japan, 0.680% in Korea, Rep., 2.610 in Indonesia, and 2.150% in Turkey. Findings show that internet use has a significant impact on green economic growth in four economies and renewable energy consumption has a positive impact on green economic growth in five economies. However, financial development produces an insignificant impact on green economic growth.

## 5. Conclusion and implications

Green economic growth has great significance to attain sustainable development. Previous literature has explored the association between pollution emissions and fiscal spending but ignores the influence of public expenditures on green economic growth. In this study, the fundamental influencing determinants of green economic growth

have been investigated for highly polluted Asian economies for the period 1991 to 2019. The study explored the effects of public spending on green economic growth. The study employed two proxy measures of fiscal spending, such as education expenditures and R&D expenditures. For empirical investigation, FMOLS and DOLS techniques have been adopted. The group-wise findings reveal that education expenditures and research and development expenditures both contribute significantly to enhancing green economic growth. However, the respective coefficient estimates of both measures display that research and development expenditures effect is larger than that of education expenditures effect on green economic growth. However, the economy-wise analysis produces heterogeneous influence in different regions with different degrees. In short, the findings of the study illustrate that education expenditures and research and development expenditures enhance the green economic growth through technological activities, but reveal different roles in different economies.

On the basis of these findings, this study put forward the following policy recommendations. The study reports the positive role of research and development in enhancing green economic growth, which suggests that initiatives are required to encourage green technological innovations by reforming financial development markets. Renewable energy consumption promotes green economic growth, which reemphasizes the significance of renewable energy consumption into the total energy consumption for achieving sustainable economic growth. As it is found that renewable energy consumption is the driving factor of green energy consumption, so governments should subsidize renewable energy sources and encourage the production of renewable energy in the private sector. It is also suggested that highly polluted Asian economies should improve their economic policies according to the environment and firmly implement environmental laws. Policymakers and governments should increase investment for environment-enhancing technologies such as increased spending for renewable energy sources, technological innovation, and research and development in the energy sector for sustainable economic development. Investing in research and development and environment-friendly technologies will reduce production-based pollution emissions as well. Therefore, stimulating collaboration on the growth of environment-friendly technology will be beneficial in addressing regional pollution and global climate change issues. Technological innovation and green growth can transform industrial structures from non-renewable energy to renewable energy sources and contribute significantly to the mitigation of pollution emissions. Furthermore, for the successful implementation of these policies, human capital development is needed. Enhancing the skills of human capital through education can generate awareness among people regarding environment-friendly technologies.

Our study contains several limitations. This study is ignoring other polluted economies and other green growth variables in empirical analysis. Other green growth variables such as green investment, green innovation, financial inclusion, and trade can also be explored. The objectives of our research can be replicated for other regions and countries also. Future studies can also investigate the impact of fiscal spending on other determinants of green growth such as green innovation and green investment. The monetary sector's role can also be explored on green growth.

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## References

- Afonso, A., & Furceri, D. (2010). Government size, composition, volatility and economic growth. *European Journal of Political Economy*, 26(4), 517–532.
- Baltagi, B. H. (2008). *Econometric analysis of panel data* (Vol. 4). Wiley.
- Barbier, E. (2011). The policy challenges for green economy and sustainable economic development. *Natural Resources Forum*, 35(3), 233–245. <https://doi.org/10.1111/j.1477-8947.2011.01397.x>
- Bina, O. (2013). The green economy and sustainable development: An uneasy balance? *Environment and Planning C: Government and Policy*, 31(6), 1023–1047. <https://doi.org/10.1068/c1310j>
- Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy Research & Social Science*, 35, 78–93. <https://doi.org/10.1016/j.erss.2017.10.018>
- Cheng, Z., Li, X., & Wang, M. (2021). Resource curse and green economic growth. *Resources Policy*, 74, 102325. <https://doi.org/10.1016/j.resourpol.2021.102325>
- Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews*, 60, 1074–1085. <https://doi.org/10.1016/j.rser.2016.02.006>
- Ekins, P. (2002). *Economic growth and environmental sustainability: The prospects for green growth*. Routledge.
- Facchini, F., & Seghezza, E. (2018). Public spending structure, minimal state and economic growth in France (1870–2010). *Economic Modelling*, 72, 151–164. <https://doi.org/10.1016/j.econmod.2018.01.014>
- Fetai, B. (2017). The effects of fiscal policy during the financial crises in transition and emerging countries: Does fiscal policy matter? *Economic research-Ekonomska Istraživanja*, 30(1), 1522–1535. <https://doi.org/10.1080/1331677X.2017.1340181>
- Gaibulloev, K., Sandler, T., & Sul, D. (2014). Dynamic panel analysis under cross-sectional dependence. *Political Analysis*, 22(2), 258–273. <https://doi.org/10.1093/pan/mpt029>
- Hallegatte, S., Heal, G., Fay, M., & Treguer, D. (2012). *From growth to green growth-a framework* (No. w17841). National Bureau of Economic Research.
- Hallegatte, S., Rozenberg, J., Maruyama Rentschler, J. E., Nicolas, C. M., & Fox, C. J. E. (2019). Strengthening new infrastructure assets: a cost-benefit analysis. World Bank Policy Research Working Paper, (8896).
- Hua, Y., Xie, R., & Su, Y. (2018). Fiscal spending and air pollution in Chinese cities: Identifying composition and technique effects. *China Economic Review*, 47, 156–169. <https://doi.org/10.1016/j.chieco.2017.09.007>
- Iram, R., Zhang, J., Erdogan, S., Abbas, Q., & Mohsin, M. (2020). Economics of energy and environmental efficiency: Evidence from OECD countries. *Environmental Science and Pollution Research International*, 27(4), 3858–3870. <https://doi.org/10.1007/s11356-019-07020-x>
- Jacobs, M. (2012). *Green growth: Economic theory and political discourse* (Vol. 108). London: Grantham Research Institute on Climate Change and the Environment.
- Kao, C., & Chiang, M. H. (2001). On the estimation and inference of a cointegrated regression in panel data. In B. H. Baltagi, T. B. Fomby & R. Carter Hill (Eds.), *Nonstationary panels, panel cointegration, and dynamic panels* (pp. 179–222). Emerald Group Publishing Limited.

- Li, X., Ozturk, I., Majeed, M. T., Hafeez, M., & Ullah, S. (2022). Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: Policy options for the green economy. *Journal of Cleaner Production*, 331, 129909. <https://doi.org/10.1016/j.jclepro.2021.129909>
- Li, X., Younas, M. Z., Andlib, Z., Ullah, S., Sohail, S., & Hafeez, M. (2021). Examining the asymmetric effects of Pakistan's fiscal decentralization on economic growth and environmental quality. *Environmental Science and Pollution Research International*, 28(5), 5666–5681.
- Lin, B., & Jia, Z. (2019). What will China's carbon emission trading market affect with only electricity sector involvement? *A CGE based study. Energy Economics*, 78, 301–311.
- Lin, B., & Zhu, J. (2019). Fiscal spending and green economic growth: Evidence from China. *Energy Economics*, 83, 264–271. <https://doi.org/10.1016/j.eneco.2019.07.010>
- Liu, J., Yuan, C., Hafeez, M., & Yuan, Q. (2018). The relationship between environment and logistics performance: Evidence from Asian countries. *Journal of Cleaner Production*, 204, 282–291. <https://doi.org/10.1016/j.jclepro.2018.08.310>
- López, R., Galinato, G. I., & Islam, A. (2011). Fiscal spending and the environment: Theory and empirics. *Journal of Environmental Economics and Management*, 62(2), 180–198. <https://doi.org/10.1016/j.jeem.2011.03.001>
- Luukkanen, J., Kaivo-Oja, J., Vähäkari, N., O'Mahony, T., Korkeakoski, M., Panula-Ontto, J., Phonhalath, K., Nanthavong, K., Reincke, K., Vehmas, J., & Hogarth, N. (2019). Green economic development in Lao PDR: A sustainability window analysis of Green Growth Productivity and the Efficiency Gap. *Journal of Cleaner Production*, 211, 818–829. <https://doi.org/10.1016/j.jclepro.2018.11.149>
- Montalbano, P., & Nenci, S. (2019). Energy efficiency, productivity and exporting: Firm-level evidence in Latin America. *Energy Economics*, 79, 97–110. <https://doi.org/10.1016/j.eneco.2018.03.033>
- Nieto, J., Carpintero, Ó., & Miguel, L. J. (2018). Less than 2 C? An economic-environmental evaluation of the Paris Agreement. *Ecological Economics*, 146, 69–84. <https://doi.org/10.1016/j.ecolecon.2017.10.007>
- OECD. (2011). *Towards green growth: Monitoring progress*. OECD Publishing.
- Paramesh, H. (2018). Air pollution and allergic airway diseases: Social determinants and sustainability in the control and prevention. *Indian Journal of Pediatrics*, 85(4), 284–294. <https://doi.org/10.1007/s12098-017-2538-3>
- Pesaran, M. H., Schuermann, T., & Weiner, S. M. (2004). Modeling regional interdependencies using a global error-correcting macroeconomic model. *Journal of Business & Economic Statistics*, 22(2), 129–162.
- Raleigh, C., & Urdal, H. (2007). Climate change, environmental degradation and armed conflict. *Political Geography*, 26(6), 674–694. <https://doi.org/10.1016/j.polgeo.2007.06.005>
- Rodriguez-Gonzalez, P. T., Rico-Martinez, R., & Rico-Ramirez, V. (2018). An integrated stochastic economic-ecological-social model with stratified-population. *Ecological Modelling*, 368, 15–26.
- Ryu, D. (2015). Fiscal spending and economic growth. *Journal of Economic Development*, 40(4), 91.
- Sachs, J. D., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2019). Importance of green finance for achieving sustainable development goals and energy security. *Handbook of Green Finance: Energy Security and Sustainable Development*, 10, 1–10.
- Shu, C., Zhou, K. Z., Xiao, Y., & Gao, S. (2016). How green management influences product innovation in China: The role of institutional benefits. *Journal of Business Ethics*, 133(3), 471–485. <https://doi.org/10.1007/s10551-014-2401-7>
- Sun, L., Cao, X., Alharthi, M., Zhang, J., Taghizadeh-Hesary, F., & Mohsin, M. (2020). Carbon emission transfer strategies in supply chain with lag time of emission reduction technologies and low-carbon preference of consumers. *Journal of Cleaner Production*, 264, 121664.

- Taghizadeh-Hesary, F., & Yoshino, N. (2019). The way to induce private participation in green finance and investment. *Finance Research Letters*, 31, 98–103. <https://doi.org/10.1016/j.frl.2019.04.016>
- Ullah, S., Ozturk, I., & Sohail, S. (2021). The asymmetric effects of fiscal and monetary policy instruments on Pakistan's environmental pollution. *Environmental Science and Pollution Research International*, 28(6), 7450–7461.
- Ullah, S., Ozturk, I., Majeed, M. T., & Ahmad, W. (2021). Do technological innovations have symmetric or asymmetric effects on environmental quality? Evidence from Pakistan. *Journal of Cleaner Production*, 316, 128239. <https://doi.org/10.1016/j.jclepro.2021.128239>
- United Nations Environment Programme. (2012). Measuring progress towards a green economy, draft working paper. Retrieved December 15, 2012, from [http://www.unep.org/green-economy/Portals/88/documents/research\\_products/MeasuringProgress.pdf](http://www.unep.org/green-economy/Portals/88/documents/research_products/MeasuringProgress.pdf)
- Usman, A., Ozturk, I., Hassan, A., Zafar, S. M., & Ullah, S. (2021). The effect of ICT on energy consumption and economic growth in South Asian economies: An empirical analysis. *Telematics and Informatics*, 58, 101537. <https://doi.org/10.1016/j.tele.2020.101537>
- Wang, Q., Wu, J., Zhao, N., & Zhu, Q. (2019). Inventory control and supply chain management: A green growth perspective. *Resources, Conservation and Recycling*, 145, 78–85. <https://doi.org/10.1016/j.resconrec.2019.02.024>
- Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.
- Xie, Y., Wu, D., & Zhu, S. (2021). Can new energy vehicles subsidy curb the urban air pollution? Empirical evidence from pilot cities in China. *Science of the Total Environment*, 754, 142232. <https://doi.org/10.1016/j.scitotenv.2020.142232>
- Yang, Z., Fan, M., Shao, S., & Yang, L. (2017). Does carbon intensity constraint policy improve industrial green production performance in China? A quasi-DID analysis. *Energy Economics*, 68, 271–282.
- Ying, L., Li, M., & Yang, J. (2021). Agglomeration and driving factors of regional innovation space based on intelligent manufacturing and green economy. *Environmental Technology & Innovation*, 22, 101398. <https://doi.org/10.1016/j.eti.2021.101398>
- Yuelan, P., Akbar, M. W., Hafeez, M., Ahmad, M., Zia, Z., & Ullah, S. (2019). The nexus of fiscal policy instruments and environmental degradation in China. *Environmental Science and Pollution Research International*, 26(28), 28919–28932.
- Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., & Taghizadeh-Hesary, F. (2021). Public spending and green economic growth in BRI region: Mediating role of green finance. *Energy Policy*, 153, 112256. <https://doi.org/10.1016/j.enpol.2021.112256>