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Green growth and fiscal policy in Asian developing countries: The role of institutional quality

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Abstract

A green economy promotes resource efficiency through lower carbon emissions, social inclusivity, and green economic opportunities. Fiscal spending is a key indicator of a green economy, especially in research and development (R&D) and education. This paper used panel data on 18 Asian developing economies from 2010 to 2023 to examine the impact of fiscal spending through technique and composition channels on the green economy. We also introduced the importance of institutions by constructing the institutional quality index and applying principal component analysis. By using system generalized method of moments, we obtained the following results: (i) there is a positive association between total government spending and green growth; (ii) there exists a positive and significant correlation between education spending and R&D spending on green growth, confirming the presence of composition and technique effect; (iii) the magnitude of the technique effect is substantially greater than that of the composition effect in the sample; and (iv) institutional quality further strengthens the association between fiscal total spending and individual spending on green growth. R&D and education spending foster green economic growth through technological and human-capital-intensive activities, respectively. Although education spending exceeds R&D spending, education spending has a weaker impact on green growth; policymakers should emphasize technical education and allocate more funds to R&D. Moreover, fostering the institutional setting is essential for green growth in Asian developing countries.

Keywords: Green growth; Fiscal policy; Institutional quality; Asia

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1. Introduction

Green growth evaluates a country's progress toward critical sustainability objectives, including the Sustainable Development Goals. It emphasizes four key areas: the efficient and sustainable use of resources, the conservation of natural ecosystems, the promotion

of opportunities within the green economy, and inclusive access to the benefits of sustainable development. Unlike conventional sustainable development, green growth emphasizes that economic prosperity and environmental protection are not only compatible but also mutually reinforcing and essential for long-term progress.[1]

A green economy fosters resource efficiency by minimizing carbon emissions and promoting social inclusivity. In this model, employment and income are generated through public and private investments in economic activities, infrastructure, and assets that reduce carbon emissions and pollution, improve energy and resource efficiency, and help preserve biodiversity and the ecosystem.[2] Green growth centers on balancing economic advancement and environmental stewardship, with fiscal policy pivotal in this endeavor. The structure of government tax and spending policies can significantly influence both economic development and environmental outcomes. Through well-designed fiscal measures, governments can incentivize businesses and individuals to embrace sustainable practices, invest in clean technologies, and transition toward a low-carbon economy.[3,4] Nevertheless, realizing green growth demands more than adopting supportive fiscal policies alone.[5]

Asia is on course to become the world's fastest-growing economic region. However, the region's growth is oriented toward fossil fuels, which still account for almost 85% of its energy use. As economies grow and energy needs rise, people increasingly worry about the environmental impacts of greenhouse gas emissions and their link to climate change. The main challenge is maintaining economic growth while adopting cleaner, more sustainable energy options to further reduce environmental damage.[6,7]

As shown in Figure 1, fiscal spending is increasing in Asian economies. Following a sudden drop in fiscal spending starting in 2014 due to budget constraints and external shocks, there is a sudden increase in government spending, potentially in infrastructure, technology, or environmental programs, in the later years.

Paramesh *et al.*[8] argued that Asian countries are moving slowly toward a green economy using fiscal tools. Economic growth that is relatively environmentally friendly requires the government to be firmly behind research and development (R&D), which is critical to developing cleaner technologies. No alternative comes close to technological progress's potential for a green economy. Similarly, public investment in education is key to reducing pollution by enabling a transition from resource-based to knowledge-driven sectors. R&D and education are the two main pillars of sustainability.

Green growth is influenced by fiscal spending through two channels: the composition effect and the technique effect. Government spending on education shifts the focus from capital-intensive industries to human capital-intensive activities, resulting in a composition effect that helps reduce environmental pollution and enhance the green economy.[9] Spending on R&D encourages the adoption of more environmentally friendly technologies and improves resource efficiency in production, thereby promoting efficient resource utilization, reducing pollution, and fostering a clean and green environment.[10]

Increasing government spending on education shifts economic activity toward cleaner, knowledge-intensive sectors, reducing reliance on more polluting, capital-intensive industries—this is known as the composition effect. However, the real inspiration lies in the greater

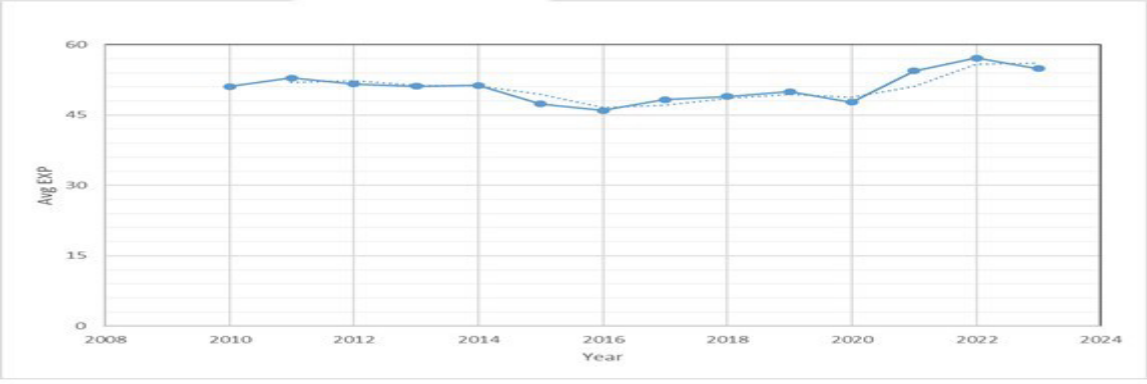

Figure 1. Mean government spending in Asian economies. Data from ADB fiscal dataset https://asianbondsonline.adb.org/fiscalasia/#spotlight. Image is created by author.

fiscal investment in R&D. This accelerates firms' adoption of cleaner technologies, ultimately lowering the pollution generated per output unit—an impact referred to as the technique effect.[11]

In Asian developing countries, Figure 2 shows that the average education spending was higher than the average R&D spending. However, the impact of education spending on green growth is lower than that of R&D. A possible reason is that in these Asian countries, education emphasizes conventional, outdated approaches rather than innovation that improves sustainability.

Fiscal policy is crucial in aligning government spending with environmental priorities and enhancing effectiveness. Wong *et al.*[12] found that increased public spending drives greater investment in green infrastructure, including renewable energy projects, public transportation networks, energy-efficient buildings, and advanced waste management systems. Such investments stimulate economic growth and encourage the development and widespread adoption of clean technologies, contributing to sustainable development and environmental protection. Their findings show that, in the long run, increased government spending contributes to greater environmental degradation. However, in the short run, higher government spending is associated with reducing environmental degradation.[13]

Countries with better institutional quality respond more positively to fiscal stimulus.[14] They use physical and human capital more efficiently to achieve higher income levels.[15] Autocratic regimes typically allocate a smaller share of their budgets to education, as improving education can empower citizens, raise overall wages, and reduce the regime's control over resources. Instead, these governments often channel more funds into the military to strengthen their grip on power and secure access to economic rent.[16]

The present study aims to achieve the following research objectives. Firstly, to assess the green growth indices of the economies under study by examining social, economic, and environmental factors. Secondly, to examine whether R&D spending supports green growth through the technique channel of fiscal policy. Thirdly, to analyze how education spending promotes green growth via the composition channel. Lastly, to evaluate the role of institutional quality in enhancing the efficiency of fiscal spending that promotes green growth.

This paper proceeds as follows: First, we examine the impact of government spending on green growth in Asian developing countries using the system generalized method of moments (GMM). Then, we explore the individual impacts of education and R&D spending on green growth to evaluate composition and technique effects. Lastly, we introduce the moderating role of institutional factors in the nexus between fiscal spending and green growth, as well as in the nexus between spending on education and R&D and green growth. Analysis revealed a positive association between fiscal spending and green growth, which is further strengthened by the inclusion of institutional factors. We also observed that the technique effect is stronger than the composition effect, both individually and in the presence

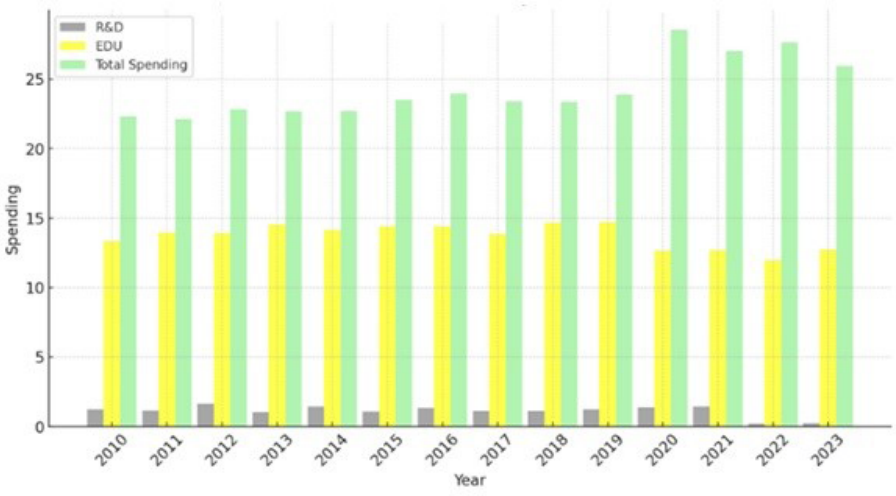

Figure 2. Average government spending on research and development (R&D) and education (EDU), and total spending over the years, in Asian developing countries. Data from https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS. Image is created by author.

of institutional factors. A possible reason is that R&D within the company is more aware of environmental issues and is introducing cleaner technologies, while education spending is more traditional.

The hypotheses are as follows:

(i) Hypothesis 1: H_0: There is a significant relationship between green growth and government spending.
(ii) Hypothesis 2: H_0: There is a significant relationship between education and R&D spending and green growth.
(iii) Hypothesis 3: H_0: Institutional quality plays a significant role in the nexus between education spending and green growth.
(iv) Hypothesis 4: H_0: Institutional quality plays a significant role in the nexus between R& D spending and green growth.

2. Methodology

The dataset comprised a sample of 18 countries from South, East, and Southeast Asia spanning 2010–2023 (Table 1). Most Asian developing countries were excluded due to data unavailability. The primary dependent variable was the green growth index, and the explanatory variables were total government spending, education spending, and R&D spending (Table 2). Institutional quality served as a moderating variable in the nexus between green growth and fiscal spending. Control variables included gross domestic product (GDP) growth, population, industry structure, trade openness, and total resource rent. To examine the association among the variables of interest, we used the system GMM to address endogeneity, unobserved heterogeneity, and reverse causality. The system GMM estimation technique is applicable to address country-specific effects, simultaneity bias, and reverse causality. The dependent variable was used as an instrument. Moreover, for empirical estimation, Stata and R software were used.

Table 3 presents the green growth index's core pillars: efficient and sustainable resource use, social inclusion, green economic opportunities, and natural capital protection, to promote sustainable, inclusive, and resilient development.

The empirical models are as follows:

$$GG_{it} = \alpha + \beta_1 GG_{it-1} + \beta_2 TS_{it} + \beta_3 RENT_{it} + \beta_4 POP_{it} + \beta_5 GDP_{it} + \beta_6 IND_{it} + \beta_7 TOP_{it} + \varepsilon_{it} \quad (1)$$

$$GG_{it} = \alpha + \beta_1 GG_{it-1} + \beta_2 R\&DS_{it} + \beta_3 EDUS_{it} + \beta_4 RENT_{it} + \beta_5 POP_{it} + \beta_6 GDP_{it} + \beta_7 IND_{it} + \beta_8 TOP_{it} + \varepsilon_{it} \quad (2)$$

$$GG_{it} = \alpha + \beta_1 GG_{it-1} + \beta_2 TS_{it} + \beta_3 IQ_{it} + \beta_4 TS_{it} \times IQ_{it} + \beta_5 RENT_{it} + \beta_6 POP_{it} + \beta_7 GDP_{it} + \beta_8 IND_{it} + \beta_9 TOP_{it} + \varepsilon_{it} \quad (3)$$

$$GG_{it} = \alpha + \beta_1 GG_{it-1} + \beta_2 R\&DS_{it} + \beta_3 EDUS_{it} + \beta_4 IQ_{it} + \beta_5 R\,\&\,DS_{it} \times IQ_{it} + \beta_6 EDUS_{it} \times IQ_{it} + \beta_7 RENT_{it} + \beta_8 POP_{it} + \beta_9 GDP_{it} + \beta_{10} IND_{it} + \beta_{11} TOP_{it} + \varepsilon_{it} \quad (4)$$

3. Results and discussion

The mean green growth index was 52.92, ranging from 35.14 to 63.36 (Table 4), where higher values reflect stronger green growth (economic growth with environmental sustainability). The country with a maximum green growth index (63.36) is likely to have strong environmental policies, sustainable energy use, and green innovation. Meanwhile, the country with the

Table 1. List of countries

Region	Countries
South Asia	India, Nepal, Pakistan, Sri Lanka
Southeast Asia	Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
East Asia	China, Japan, the Republic of Korea, Macao Special Administrative Region (China), Mongolia

Table 2. Description of the variables

Variable	Measurement	Acronym	Source
Dependent variables			
Green growth index	Consists of 4 dimensions and 16 indicators: (i) Efficient and sustainable resource use (ii) Natural capital protection (iii) Green economic opportunities (iv) Social inclusion The green growth index scores range from 1 to 100, classifying 1–20 as very low, 20–40 as low, 40–60 as moderate, 60–80 as high, and 80–100 as very high green growth performance[17]	GG	Global Green Growth Institute
Explanatory variables			
Total government spending	Total government spending as a percentage of GDP[18]	TS	IMF database
Government spending on education	Government spending on education, total (% of GDP)[19]	EDUS	World Development Indicators (World Bank)
Government spending on research and development	Research and development spending (% of GDP)[20]	R&DS	World Development Indicators (World Bank)
Moderating variable			
Institutional quality index	Control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, and voice and accountability[21]	IQ	World Governance Indicator (World Bank; applies principal component analysis by combining six governance indicators)
Control variables			
Population	Population growth rate[22,23]	POP	World Development Indicators (World Bank)
Gross domestic product (GDP) growth	The growth rate of GDP per capita of the country[22,23]	GDP	World Development Indicators (World Bank)
Industry structure	Industry (including construction) value added (% of GDP)[24]	IND	World Development Indicators (World Bank)
Natural resource rent	Total natural resources rents (% of GDP)[25]	RENT	World Development Indicators (World Bank)
Trade openness	Sum the export of goods and services and Import of goods and services (% of GDP)[25]	TOP	World Development Indicators (World Bank)

Abbreviation: IMF: International Monetary Fund.

minimum green growth index (35.14) may rely more on polluting industries. Higher education spending is often associated with long-term green growth, innovation, and better governance. The mean R&D spending was 1.11% of GDP, ranging from 0.03% to 4.93%. Higher R&D spending supports technological innovation, cleaner technologies, and more efficient production—keys for green growth. Institutional quality ranged from −1.81 to 2.50, indicating that some countries have poorly performing institutions, while others have very high-quality institutions. A high institutional quality helps implement environmental laws, enforce property rights, and attract green investment.

The GMM coefficient for R&D fiscal spending was 2.17 (Table 5), indicating a statistically significant positive result at the 1% level. This result is consistent with a previous study[26] that reported that R&D promotes technology optimization, helping reduce environmental pollution and making green growth more prominent. In contrast, the GMM coefficient for education spending

Table 3. Green growth index

Pillars of the green growth index	Focus	Key elements
Efficient and sustainable resource use	Optimizing the use of energy, water, land, and materials.	Energy and water efficiency; Sustainable land use; Resource productivity
Social inclusion	Ensuring all social groups benefit from green growth.	Access to basic services; Gender balance; Social equity and protection
Green economic opportunities	Ensuring a sustainable economy through investment and macroeconomic variables.	Green advancement; Eco-development
Natural capital protection	Safeguarding biodiversity and ecosystem services.	Environmental quality; Ecosystem resilience; Cultural/Social value of nature

Table 4. Descriptive statistics

Variable	Observation	Mean	SD	Minimum	Maximum
GG	252	52.92	6.63	35.14	63.36
TS (%)	251	24.26	7.77	9.66	65.56
R&DS (%)	189	1.11	1.28	0.03	4.93
EDUS (%)	193	13.73	4.17	2.82	22.02
GDP (%)	252	4.31	7.61	−54.33	75.06
POP (%)	252	1.00	0.90	−4.17	4.91
TOP (%)	233	98.79	74.29	24.70	379.09
IND (%)	251	31.78	12.41	3.71	73.67
RENT (%)	226	4.420	6.960	0.001	42.210
IQ	252	0.0002	1.0003	−1.8100	2.5000

Note: Refer to Table 2 for the details of variables.

was 0.01, significant at the 5% level. The technique effect surpassed the composition effect. A possible explanation is that R&D spending promotes environmental awareness and the adoption of cleaner technologies, whereas the impact of education spending—shifting labor toward cleaner, knowledge-intensive sectors and away from more polluting, capital-intensive industries—is less pronounced. This result is consistent with a previous study,[27] which examined the impact of fiscal spending on green growth in highly polluted Asian economies. In Asian developing economies, the impact of education spending on green growth appears less pronounced than that of R&D spending, partly due to the perceived long-term benefits of R&D for economic growth and the prioritization of specific sectors for development. This result is similar to that from a previous study,[28] which highlights that public spending is important for green growth alongside private investment in technological innovations. In many Asian developing countries, government spending on education is significantly higher than on R&D. However, its effect on green economic growth remains comparatively limited. One possible reason is that education systems often emphasize traditional learning and theoretical knowledge rather than fostering innovation and practical applications. As a result, while education supports general development, it does not fully contribute to sustainability and technological advancements. Therefore, a stronger focus on research-driven, hands-on learning and innovation is essential to enhance its role in green growth.

The negative and significant effect of industry structure on green growth indicates that increased pollution from the secondary industry, driven by excessive energy consumption, hinders sustainable development. Similarly, natural resource rents were negatively and significantly associated with green growth, suggesting that Asian developing countries have not effectively used these rents to fund clean technologies or renewable energy projects, thereby contributing to environmental degradation.[29]

Table 6 presents the regression results incorporating institutional quality as a moderating factor. The significance of the lagged green growth variable indicates that green growth tends to persist over time. The interaction between government total spending and institutional quality was significant, suggesting that the effectiveness of public spending in promoting green growth is higher in countries with a higher institutional quality. Additionally, R&D spending and education spending exhibited positive and

Table 5. Green growth, technique effect, and composition effect

Variables	Model 1		Model 2	
	Coefficient	*T*-value	Coefficient	*T*-value
Constant	17.01***	14.83	14.30***	19.21
GG(−1)	0.85***	17.70	0.72***	12.11
TS	0.17*	1.99	-	-
R&DS	-	-	2.17**	2.49
EDUS	-	-	0.012*	1.97
RENT	−0.04*	−1.89	−0.10*	2.10
POP	−0.67**	−2.19	−0.47**	−2.42
GDP	0.008*	1.98	0.017*	1.99
IND	−0.15*	−1.99	−0.03**	2.91
TOP	−0.03*	−1.98	0.008	0.65
Sargan test	0.731	-	0.645	-
AR(1)	0.036	-	0.015	-
AR(2)	0.203	-	0.234	-

Notes: Refer to Table 2 for the details of variables; GG(−1) is the lag of green growth; AR(1) and AR(2) are the first-order and second-order autocorrelation, respectively; *,**,*** are the 10%,5%, and 1% level of significance, respectively.

Table 6. Green growth, technique effect, composition effect, and institutional quality

Variables	Model 3		Model 4	
	Coefficient	*T*-value	Coefficient	*T*-value
Constant	12.06***	4.00	13.00**	2.49
GG(−1)	0.14**	2.70	0.123**	2.31
TS	0.09*	2.01	-	-
IQ	0.01*	1.98	0.001*	1.98
TS×IQ	0.15*	2.01	-	-
R&DS	-	-	2.01*	1.99
R&DS×IQ	-	-	2.09*	1.98
EDUS	-	-	0.005*	2.00
EDUS×IQ	-	-	0.007*	1.98
RENT	−0.006	−1.69	−0.005	-1.00
POP	−0.076*	−1.99	−0.099	−1.32
GDP	0.025	1.00	0.017*	1.98
IND	−0.006*	−1.94	−0.036*	-2.01
TOP	−0.01	−0.21	−0.001	−1.21
Sargan Test	0.51	-	0.30	-
AR(1)	0.04	-	0.01	-
AR(2)	0.30	-	0.13	-

Notes: Refer to Table 2 for the details of variables; GG(−1) is the lag of green growth; TS×IQ is the interaction between TS and IQ; R&D×IQ is the interaction between R&D and IQ; EDUS × IQ is the interaction between EDUS and IQ; AR(1) and AR(2) are the first-order and second-order autocorrelation, respectively; *,**,*** is 10%, 5%, and 1% level of significance.

significant effects on green growth. Their interactions with institutional quality further highlight that better governance enhances the impact of these investments. Overall, institutional quality emerges as a key enabler, strengthening the role of fiscal policies, innovation, and education in driving sustainable development. The technique effect is larger than the composition effect in Asian developing countries.

4. Conclusion

This study examines the impact of fiscal spending collectively and individually in the form of R&D spending and education spending on green growth in Asian developing economies. Regression analysis revealed a positive association between total government spending and green growth. Both education and R&D spending showed positive and significant effects on green growth, confirming the presence of the composition and technique effects. Institutional quality further strengthened the association between fiscal spending (both total and individual components) and green growth. Moreover, the magnitude of the technique effect was substantially greater than that of the composition effect. Although education spending was higher than R&D spending, its impact on green growth was smaller. The possible reason is that, in these Asian developing countries, education emphasizes conventional and outdated approaches without practical implementation and gives little emphasis to environmental concerns. These countries prefer innovation that helps improve sustainability. The positive associations suggest that R&D and education spending foster green growth through technological and human capital-intensive activities, respectively, but R&D has a stronger effect despite lower overall spending.

This study highlights that smart fiscal spending, especially on education and R&D, can significantly promote green growth in Asian developing economies. The results indicate that investments in human capital and innovation lead to cleaner, more sustainable development. Moreover, high institutional qualities amplify this effect by ensuring that resources are used efficiently. Interestingly, improvements in technology and production methods (the technique effect) exert a greater influence than structural shifts in the economy. Based on these insights, policymakers should focus on increasing targeted investments in education and R&D, improving institutional quality, and

supporting technologies that drive sustainable growth. Asian governments should increase R&D spending for sustainability, which requires efficient use of funds and curbing rent-seeking behavior. To enhance the impact of education spending on green growth, governments should organize environmental sustainability workshops and awareness campaigns. Furthermore, strict regulations on industrial tax structures can encourage the adoption of environmentally friendly and advanced technology, mitigating pollution. These measures not only reduce environmental degradation but also lessen the pressure on ecosystems.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Shomaila Habib, Alvaro Rocha
Formal analysis: Shomaila Habib, Alvaro Rocha
Investigation: Shomaila Habib, Alvaro Rocha , Anum Rashid
Methodology: Shomaila Habib, Sadia Batool
Writing–original draft: All authors
Writing–review & editing: All authors

Availability of data

The data are available from the corresponding author upon reasonable request.

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