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Financial Inclusion, Environmental Quality, and Economic Development in Asian Economies: A Panel Data Analysis

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ABSTRACT

The objective of this study is to explore the effect of Financial Inclusion and Environmental Quality on Economic Development of some selected Asian economies. For this purpose, panel data of some Asian economies has been taken from 2004 to 2023 from the World Development Indicators. The results are estimated by using the Fixed Effect Model and Random Effect Model, descriptive statistics, correlation, and causality analysis. The results of Fixed Effect model reveal that GDP is significantly increased by Internet Subscribers & Mobile users (Financial Inclusion variables), FDI, Government expenditure and Carbon dioxide emission while GDP is insignificantly increased by energy use in the Asian economies. The Fixed Effect model suggests policy implications for Asian economies, focusing on digital connectivity, FDI attraction, targeted public expenditure, sustainable growth practices, and energy efficiency.

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1. Introduction

The utmost desire of the Asian countries allowed them to find their path to development at certain environmental costs. These countries experienced the harmful impact of certain factors that reduced their environmental quality (EQ) that causes certain health issues, but it boosted economic activities. Financial inclusion (FI) has diverse impacts on different countries. Therefore, it becomes important to understand the impact of polluting emissions and financial inclusion in these countries while making balanced environmental and economic policies (Zhu, Duan, Guo, & Yu, 2016). Asian countries are in the midst of industrialization and boosting their economic growth (EG) rate over time. It not only increases environmental pollution (EP) but also raises

certain environmental concerns. The developed countries have successively passed the growth period and now are sustaining their environment (Fan, An, Zhang, & Wang, 2024; Feng et al., 2024; Vu et al., 2023; Wu et al., 2024).

Keeping in mind the diverse landscape of Asian countries and levels of FI and EP such as carbon dioxide (CO2) emissions uncovers an important topic for discussion. Many definitions of financial inclusion are proposed in the past, but some studies i.e. Khan, Noreen, and Farooq (2024) and Lutfi et al. (2021), described FI as to what extent digital financial services are available to all residents of a particular region or country through different digital sources like E-cards or bank cards, internet, and mobile devices etc. Financial inclusion is also meaningful in helping an economy to grow by reducing deprivation and promoting development. There are certain benefits associated with FI such as promoting financial services in a region, ultimately reducing transaction costs on the small transactions. However, the efficacy of financial inclusion depends on the extent to which it is integrated into the economy (Li, Sun, Gao, & Cheng, 2023; Nawaz, Ahmad, Hussain, & Bhatti, 2020; Tay, Tai, & Tan, 2022). CO2 emissions (CO2) are recognized as one of the polluting emissions produced by burning fossil fuels, reducing environmental quality (EQ). According to Gao, Zhu, Umar, Kchouri, and Safi (2024), CO2 emissions are positively linked with GDP growth.

Previous studies showed that these variables are linked with each other. For example, Hussain, Ahmad, Ullah, Rehman, and Shahzad (2024) found FI has both beneficial and harmful effects on the economic performance of Asian economies. According to Chowdhury and Chowdhury (2024); Tay et al. (2022), FI significantly influenced human development and EG.

This study uses FI and air quality to understand sustainable economic development in Asian economies. With increased economic activities and high rates of population growth in Asia, financial inclusion is very important because it provides access to financial services that not only reduce poverty but also a pathway to a more balanced economy. In addition, environmental quality is also very important because it promotes balanced economic growth. Low air quality not only increases expenditures on health but also introduces lower productivity. It is also a major cause of resource depletion. This research is timely and also fills the gap in the existing literature.

1.1. Research Gap

Asian countries are experiencing rapid industrialization and increased economic activities allowing these countries to boost their EG rates at certain environmental costs. A vast amount of literature is available that explored the association between different environmental and economic factors. These studies revolved around exploring the impact of, renewable (RE) and non-renewable energy (NRE) use, EG, FI, and urbanization on EP. However, little work has been done to discuss the impact of EQ and (FI) on the growth of Asian economies. For instance, some studies addressed the role of FI not only promoted EG but also human development (Matekenya, Moyo, & Jeke, 2021; Sha'ban, Girardone, & Sarkisyan, 2021). Another research by Li, Ozturk, Majeed, Hafeez, and Ullah (2022) assessed the impact of financial deepening on CO2 emissions. While Ozturk, Farooq, Majeed, and Skare (2024) analyzed the impact of energy use and FD on EQ. This study considers those variables that were not studied before. By doing so, this study adds to the existing knowledge by studying the impact of FI and EQ on the economic development of Asian economies.

The objectives of the study are to analyze the role of financial inclusion (Internet and Mobile users) and Environmental Quality (Carbon dioxide emission) with economic development of Asian countries. The major focus of this study is to provide evidence that financial inclusion not only provides access to resources but also promotes economic growth (Tay et al., 2022). Eventually, this study also focuses on the impact of air quality on the economic performance of Asian countries. This study is organized as the first section explains the background of the study,

objectives of the study, second section is about Literature review, 3rd section explains the data and methodology used in this study, results are discussed in 4th section while conclusion along with policies are explained in 5th section.

2. Literature Review

Redmond and Nasir (2020) utilized data from 30 countries and performed the DOLS and FMOLS econometric approaches to investigate the impact of international trade and ED of natural resources. This study found that FD, global trade, and natural resources harmed ED. The increased use of natural resources promoted EP. Raheem, Tiwari, and Balsalobre-Lorente (2020), captured an immediate favorable impact of ICTs and FD and a detrimental impact on EG and CO2 emissions over time. Egbetokun et al. (2020) confirmed the EKC hypothesis for Suspended Particulate Matter (SPM) and carbon emissions or CO_2 emissions. This study also found that environmental pollution did not affect the EG of the country. Godil, Sharif, Agha, and Jermsittiparsert (2020) performed QARDL econometric approach to the data collected between 1995Q1 and 2018Q4. This study found that ICT, institutional quality, and GDP fueled CO_2 emissions. In contrast, ICT and FD reduced CO_2 emissions. Furthermore, it also confirmed the validity of EKC hypothesis in Pakistan.

By employing the two-step difference and system GMM method on the data gathered between 1990 and 2017, Khan, Khan, and Muhammad (2021) assessed how energy use and FD were linked with CO_2 emissions. Results revealed that energy use and GDP increased while FD reduced CO_2 emissions around the globe. According to Ibrahiem (2020), technological innovations in technology and other energy sources did improve, and in contrast, EG and FD worsened EQ. According to Aluko and Obalade (2020), FD reduced EQ. This study also found technological changes driven by the advancements in FD reduced environmental quality. This study also found a two-way causal association between FD and CO_2 emissions. Murshed, Ahmed, Kumpamool, Bassim, and Elheddad (2021) analyzed how RE transition and regional trade impacted CO2 emissions. This study utilized data between the years 1990 and 2016 from the selected South Asian economies. It was concluded that promoting regional trade and increased RE consumption had an immediate and overtime favorable impact on CO2 emissions in the sample economies.

By employing different statistical techniques including FMOLS, DOLS, and Canocial Cointegration analysis (CCA) on the data gathered between 1960 and 2016 from Turkey, Rjoub, Odugbesan, Adebayo, and Wong (2021) found moderating role of FD for ED, and EG. Redmond and Nasir (2020) found an influencing effect of FD, trade openness, and energy use on CO2 emissions. However, it did not confirm the EKC hypothesis because of their influencing impact on CO2 emissions over time. Sha'ban et al. (2021) analyzed how advancements in financial systems impacted EG in 95 countries. This study gathered data from 2000 to 2015 and found further developments in FI. Another study discussed how FI affected human development. It performed a Generalized Method of Movement (GMM) approach on the data collected from the Sub-Saharan African countries. It found a beneficial impact on human development (Matekenya et al., 2021).

Baloch, Ozturk, Bekun, and Khan (2021) captured a favorable effect of FD on EQ. In addition, globalization fueled CO2 emissions (Bhatti, Raheem, & Zafar, 2020). Zeraibi, Balsalobre-Lorente, and Murshed (2021) found technological innovation and GE production capacity reduced while EG and FD increased environmental degradation. Li, Sohail, Majeed, and Ahmad (2021) discovered a favorable effect of green logistics performance on the EG and EQ of OBRI, MENA, and European countries. In contrast, green logistics performance caused environmental degradation in central Asia, MENA, and OBRI countries. Yang, Jahanger, and Ali (2021) found a favorable impact of technological innovations on EQ in the BRICS countries. Moreover, this study also found FD reduced environmental quality. It also confirmed the U-

shaped association between GDP and environmental quality in China and India. In the case of South Africa and Brazil, it confirmed the validity of the inverted U-shaped EKC hypothesis. Another study found FD promoted carbon emissions.

Zaidi, Hussain, and Uz Zaman (2021) stated FI increased energy use which promoted CO2 emissions. In contrast, corruption reduced CO2 emissions. When there was a need to adopt clean practices for production, many Asian economies boosted their production at certain environmental expenses (Shittu, Adedoyin, Shah, & Musibau, 2021). ICTs are very crucial in spurring economic development. Bhujabal, Sethi, and Padhan (2021), FDI and ICTs had a beneficial impact on environmental pollution. In contrast, EG, FD, and global trade fueled EP and reduced EQ in Asia Pacific economies between 1990 and 2018. While increased globalization promoted energy use. The reliance of selected South Asian economies on non-renewable energy (NRE) sources (fossil fuels) encouraged EP confirming the validity of the EKC hypothesis (Sadiq et al., 2023). Tay et al. (2022) explored how FI promotes EG. This study found a beneficial impact of FI on EG.

By performing the generalized method of moments on 176 countries' data gathered between 2000 to 2019, Khan, Weili, and Khan (2022), found trade openness, FDI, and RE consumption, reduced EP. In contrast, NRE and FD promoted EP. Khan et al. (2022) captured the favorable impact of FI and reduced poverty and income inequality by providing employment. It also strengthened the economy by promoting financial stability. Murshed, Apergis, Alam, Khan, and Mahmud (2022) stated FD was crucial because it financed such activities for boosting export-led economic activities which ultimately, boosted EG in Asia. Ali et al. (2022) employed the Augmented Mean Group estimator to analyze data from BRRICS countries between 1990 and 2014. However, it also found a unidirectional causal link between CO2 emissions to urbanization and GDP in the sample countries. Usman and Balsalobre-Lorente (2022) found that total reserves, industrialization, and financial growth increased economic activities which in turn increased CO_2 emissions.

According to Zahoor, Khan, and Hou (2022) manufacturing sector value-added, urbanization, and FD increased EG and worsened environmental quality. Ramzan, Raza, Usman, Sharma, and Iqbal (2022) found FD, ICTs, and fossil fuels increased environmental pollution in Pakistan. Anwar et al. (2022) found no minimal effect of agriculture on the CO_2 emissions. While FD, EG, and urbanization were promoted while clean energy uses reduced CO_2 emissions in the selected Asian economies. According to Chishti and Sinha (2022), financial innovation had mixed effects on CO2 emissions. However, FDI and technological innovation had a beneficial impact while fossil fuel use and urbanization promoted carbon emissions. This study also confirmed validity of both pollution EKC and halo hypotheses in the BRICS countries. Li et al. (2021) found both favorable and unfavorable effects of FI on EQ. Ahmad et al. (2022) stated that technological innovation and green openness had a favorable in reducing environmental quality. Shabir (2024) by employing an Augmented Mean Group (AMG) captured the favorable impact of FI and energy use on CO2 emissions.

Tian and Li (2022) globalization, corruption, and FI fueled while RE reduced CO_2 emissions in the G20 economies between 2005 and 2018. In the case of EG, Ozturk and Ullah (2022) stated FI promoted EG at a certain environmental cost. FD and both RE as well as NRE energy fueled EG. Zafar, Zaidi, Mansoor, Sinha, and Qin (2022) discovered that ICT and FD decreased CO_2 emissions. Fareed et al. (2022) employed MMQR on the data collected between 1995 to 2018 and found innovation activities reduced the favorable impact of financial innovation on EQ. Shahbaz et al. (2022) found varying impacts of FI on CO_2 emissions.

Usman, Kousar, Makhdum, Yaseen, and Nadeem (2022) found RE and FD reduced RP while NRE, trade openness, and EG promoted environmental pollution. According to Tram, Lai, and Nguyen (2023), FD is crucial for economic development and must be considered in forming economic policies. In contrast, FI had an unfavorable effect on the environment because it

increased energy consumption and CO2 emissions in the case of developing and developed countries (Singh, Raza, Nakonieczny, & Shahzad, 2023). Furthermore, Ozturk et al. (2024) found FD improved and energy use decreased environmental quality. This study is evidence for the presence of both the pollution halo and EKC hypotheses in South Asian economies. Discussing the case of Pakistan, Bangladesh, and India, Chowdhury and Chowdhury (2024) performed the GMM method and found the favorable impact of FI on human development.

3. Data and Methodology

The objective of this study is to explore the effect of Financial Inclusion and Environmental Quality on Economic Development of some selected Asian economies. For this purpose, panel data of some Asian economies has been taken from 2004 to 2023 from the World Development Indicators that is organized by World Bank Organization. Econometric results are estimated by using the Fixed Effect Model and Random Effect Model. Moreover, descriptive statistics, correlation, and causality analysis are also applied to the data. In this study, Internet and Mobile users are taken as the proxy of Financial Inclusion while Carbon dioxide emission is taken as the proxy of Environmental Quality and GDP is taken as the proxy of Economic Development.

4. Results and Discussion

4.1. Descriptive Statistics

Developing nations' average GDP is $896 billion, showing a slowly expanding economic foundation but still lagging behind industrialized ones. With an average inflow of $177 billion, FDI is a key factor in supporting economic development and growth. The government of developing nations spends 143 billion dollars annually on social welfare, healthcare, education, and infrastructure. Despite the increasing number of individuals with access to the internet (46 million), there are still major holes in the digital infrastructure. It is clear that mobile technology is crucial to progress, since there are 123 million mobile users, making mobile connectivity more prevalent than internet access.

There is moderate industrialization, urbanization, and quality of life in developing nations, which account for their 3450 kilotons of energy use. There appears to be a persistent problem with industrialization and energy accessibility, since energy consumption is lower than in industrialized nations. As a result of increased carbon emissions caused by industrialization and urbanization, which in turn contribute to climate change, emerging nations are becoming more environmentally concerned, as seen by their carbon footprints of 7.93 metric tons per capita. Because of their reliance on fossil fuels, these nations have the difficult task of balancing economic development with environmental sustainability.

Table 1
Descriptive Statistics

	Mean	Median	Std. Dev.	Skewness	Kurtosis
GDP (Billion Dollars)	896	186	2410	4.57	26.50
INTERNET (Million)	46.25	45.79	32.78	0.15	1.64
MOBILE (Million)	123	23.20	304	3.71	16.62
FDI (Million Dollars)	177.00	2.83	46.20	4.21	21.86
GCEXP (Billion Dollars)	143	23.7	406	4.45	25.00
Energy Consumption	3450.57	1751.17	4158.87	2.13	7.80
Carbon Emission	7.93	3.80	9.08	1.73	5.89

4.2. Correlation Analysis

The research shows that in emerging nations, there is a robust linear link between GDP and a number of variables. According to the findings, there is a small but positive association between GDP and internet usage. There was a robust positive relationship between GDP and

mobile usage, suggesting that mobile usage grows substantially in tandem with GDP. Indicating a minor positive link, a weak positive correlation was observed between GDP and foreign direct investment (FDI). Government expenditure was found to have a substantial positive association with GDP, suggesting that developing nations benefit from higher government spending in relation to GDP. Energy consumption was found to have a weak positive association with gross domestic product, indicating a relationship but not a strong predictor of economic growth.

Table 2
Correlation Analysis

Variables	GDP	Internet	Mobile	FDI	Government Expenditure	Energy Use	Carbon Emission
GDP	1						
Internet	0.360	1					
Mobile	0.7847	0.153	1				
FDI	0.245	0.0720	0.273	1			
Government Expenditure	0.977	0.414	0.717	0.190	1		
Energy Use	0.267	0.60	-0.263	-0.043	0.367	1	
Carbon Emission	0.122	0.411	-0.364	-0.118	0.191	0.866	1

4.3. Fixed Effect Model Results

The findings shed light on the myriads of factors that have an impact on overall GDP in emerging nations. An interpretation of each variable and the relevance of each variable is as follows. A one-unit increase in Internet subscribers is connected with a 5.6% rise in GDP, which suggests that internet access plays a beneficial impact in economic growth by boosting communication, business activities, and productivity. This is because internet access allows for more people to access the internet. The coefficient for mobile users is 0.032, which indicates that they are statistically significant. There is a correlation between a one-unit increase in mobile users and a 3.2% gain in GDP, which suggests that mobile phone adoption encourages economic activities. This happens most likely because it improves connectivity and availability to services. The coefficient for foreign direct investment (FDI) is 0.002, which indicates that it is statistically significant. FDI has a positive impact on GDP, albeit a rather minor one. An increase of one unit in foreign direct investment (FDI) contributes to a 0.2% growth in gross domestic product (GDP). Although the amount is relatively low, it indicates that foreign direct investment (FDI) contributes to the enhancement of economic production by means of investments in infrastructure, technology, and human resources.

A one-unit rise in government spending is related with a 74.5% increase in GDP, making it the most significant factor in the relationship between the two variables. The coefficient for government spending is 0.745, and it is statistically significant. The fact that this relationship is so strong and favorable suggests that investments made by the public sector in areas such as education, health, welfare, and infrastructure have a significant influence on the success of the economy. Energy use has a positive coefficient of 0.06, but it is not statistically significant, meaning that energy use alone does not have a substantial or clear effect on GDP in this context. The implication is that the utilization of energy might not be optimum, or that the influence of energy consumption on GDP is contingent on other factors such as efficiency and sources of energy.

The coefficient for carbon emission is 0.006, which indicates that it is statistically significant. It has been demonstrated that industrial activities that contribute to carbon emissions also have a modestly beneficial impact on economic growth. This is demonstrated by the fact that a one-unit increase in carbon emissions corresponds to a 0.6% gain in GDP. On the other hand, this link suggests that there may be a potential trade-off between the expansion of the

economy and the degradation of the environment. An overall interpretation is that the majority of variables, with the exception of energy consumption, are statistically significant in explaining the increase of GDP in emerging nations. Given that there is a positive correlation between GDP and the number of people who subscribe to the internet, mobile users, foreign direct investment, government expenditures, and carbon emissions, it can be inferred that technological access, investment, public spending, and industrial activity all participate in economic performance. On the other hand, the environmental cost of expansion, which is reflected by carbon emissions, may make it necessary to implement laws that promote sustainable development.

Table 3
Fixed Effect Model

Variables	Coefficient	Standard Errors	t-Statistic	Probability
Internet Subscribers	0.056	0.014	3.847	0.000
Mobile Users	0.032	0.016	1.937	0.053
FDI	0.002	0.001	1.707	0.088
Government Expenditure	0.745	0.023	31.161	0.000
Energy Use	0.060	0.053	1.142	0.253
Carbon Emission	0.006	0.003	1.768	0.077
Constant	6.853	0.645	10.625	0.000
R-squared	0.994	F-statistic		2612.21
Adjusted R-squared	0.993	Prob. (F-statistic)		0.000

Consistency across specifications is indicated by the fact that the results for most variables are similar in the random effects model and the fixed effects model. This suggests that broad correlations persist irrespective of impacts specific to individuals, which further supports the findings' robustness. On the other hand, according to the RE model, there is a negative correlation between energy consumption and GDP, meaning that more energy consumption means less GDP. Since more economic activity is commonly believed to be associated with more energy consumption, this link appears paradoxical. Energy use's effect on GDP may be attributable more to chance than to any meaningful relationship, since the negative correlation is not statistically significant. Overall, most variables' results are consistent across the two models. However, the random effects model shows a slight negative correlation between energy use and GDP, which suggests it might not be a major role in GDP.

Table 4
Random Effect Model

Variables	Coefficient	Standard Errors	t-Statistic	Probability
Internet Subscribers	0.038	0.012	3.015	0.002
Mobile Users	0.053	0.016	3.349	0.000
FDI	0.002	0.001	1.680	0.093
Government Expenditure	0.776	0.020	37.972	0.000
Energy Use	-0.023	0.041	-0.578	0.563
Carbon Emission	0.006	0.003	1.769	0.077
Constant	6.437	0.473	13.590	0.000
R-squared	0.925	F-statistic		935.665
Adjusted R-squared	0.924	Prob. (F-statistic)		0.000

4.4. Panel Causality Tests

Based on these findings, we can infer the nature of the links that link different technical and economic factors. The results are presented below:

One important finding is the existence of a bidirectional correlation between GDP and Internet Subscribers. This means that when GDP grows, so do internet subscriptions, and vice versa. To put it simply, these two factors affect one another. There is Unidirectional causality from GDP to Mobile users. This means that more people are using mobile devices while the

economy is doing well, but the inverse is not necessarily true. Higher mobile user penetration is not substantially adding to GDP growth, but economic development is fueling mobile use. GDP directly affects government spending. As the economy grows, more money is spent by the government. The expansion of the economy allows the government to allocate more funds towards development initiatives, public services, and goods. But it seems like government spending isn't driving GDP here.

There is a one-way causation between Energy usage to GDP. This finding suggests that more energy is used to power economic growth, but it does not prove the inverse, that is, that GDP growth causes energy consumption to rise. That energy is a major factor propelling economic growth is the implication. A one-way causal relationship exists between GDP and CO_2 emissions. As the economy grows, CO_2 emissions rise. According to this correlation, more carbon emissions are produced as a result of increased industrial activity and energy consumption, which is frequently driven by fossil fuels, as the economy grows. Foreign Direct Investment (FDI) and GDP do not have a statistically significant causal relationship, meaning that the two variables are not related. Foreign direct investment (FDI) may not be the primary cause of economic growth in this scenario, and vice versa.

Table 5
Dumitrescu Hurlin Panel Causality Tests

Hypothesis	W-Stat	Zbar-Stat	Probability
LINTERNET →LGDP	4.180	3.067	0.002
LGDP → LINTERNET	6.093	6.296	0.000
LMOBILE → LGDP	2.786	0.713	0.475
LGDP → LMOBILE	4.110	2.949	0.003
LFDI → LGDP	1.438	-1.561	0.118
LGDP → LFDI	2.522	0.267	0.788
LGCEXP → LGDP	2.401	0.060	0.951
LGDP → LGCEXP	3.839	2.485	0.012
LENERUSE → LGDP	3.664	2.196	0.028
LGDP → LENERUSE	3.145	1.319	0.186
CO2EMMETRIC → LGDP	2.487	0.208	0.835
LGDP → CO2EMMETRIC	3.587	2.066	0.038

5. Conclusion and Policy Recommendations

The objective of this study is to explore the effect of Financial Inclusion and Environmental Quality on Economic Development of some selected Asian economies. For this purpose, panel data of some Asian economies has been taken from 2004 to 2023 from the World Development Indicators. Econometric results are estimated by using the Fixed Effect Model and Random Effect Model. Moreover, descriptive statistics, correlation, and causality analysis are also applied to the data. In this study, Internet and Mobile users are taken as the proxy of Financial Inclusion while Carbon dioxide emission is taken as the proxy of Environmental Quality and GDP is taken as the proxy of Economic Development.

The results identify those GDP of Asian economies is 896 billion dollars on the average, 46.25 million are internet users, 123 million are mobile users, FDI is of 177 million dollars, Government expenditure is of 143 billion dollars, energy consumption is 3450 and carbon dioxide emission is 7.93 kilotons. According to correlation results, there is exists strong correlation between GDP & Mobile users, GDP & Government Expenditure while weak correlation between GDP & Internet users, GDP & FDI, GDP & Energy use and GDP & Carbon Emission.

According to Dumitrescu Hurlin Panel Causality Tests, there is bidirectional causality between Internet users & GDP, while univariate causality between GDP & Mobile, GDP & Government expenditure, Energy user & GDP and GDP & Carbon dioxide emission. No causality is found between GDP and FDI in the Asian economies. The results of Fixed Effect model reveal

that GDP is significantly increased by Internet Subscribers, Mobile users, FDI, Government expenditure and Carbon dioxide emission while GDP is insignificantly increased by energy use in the Asian economies.

The Fixed Effect model suggests policy implications for Asian economies, focusing on digital connectivity, FDI attraction, targeted public expenditure, sustainable growth practices, and energy efficiency. Expanding digital connectivity and access to mobile networks is crucial for GDP growth, as it boosts economic activity, productivity, and innovation. Governments should invest in digital infrastructure, provide subsidies for low-income households, and foster private sector investments in telecommunications. Encouraging foreign direct investment (FDI) can increase capital inflows, stimulate industrial growth, and enhance technology transfer, promoting economic development.

Increasing government expenditure in productive sectors, such as education, healthcare, infrastructure, and technology, can further stimulate economic growth. A strategic increase in public spending in areas that enhance human capital, infrastructure, and innovation can have a multiplier effect on the economy, accelerating growth. Addressing carbon dioxide emissions and promoting sustainable growth is also important, as economic growth is currently linked to higher emissions. Policymakers should adopt green growth strategies by transitioning to cleaner energy sources, promoting energy efficiency, and incentivizing green technologies.

Reassessing energy use policies is necessary, as current energy consumption patterns are not contributing efficiently to economic growth. Governments should enhance energy efficiency, invest in renewable energy, improve energy management, diversify energy sources, and encourage industries to adopt more efficient energy technologies. These actions will optimize energy use for economic growth without increasing the carbon footprint.

Authors' Contribution

Atiq ur Rehman: Designed the study framework, led data collection, and contributed to the manuscript's revision.
Talat Anwar: Contributed economic and environmental expertise and assisted in hypothesis formulation and analysis interpretation.
Jahanzaib: Conducted data preprocessing and econometric modeling, ensuring result robustness.
Huzaifa Khizar: Managed data visualization, citations, and assisted with manuscript editing and formatting.

Conflict of Interests/Disclosures

The authors declared no potential conflict of interest w.r.t the article's research, authorship and/or publication.

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