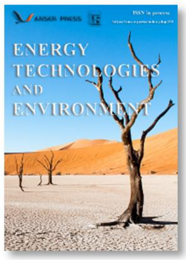
Energy Technologies and Environment

Homepage: https://www.anserpress.org/journal/ete



Unraveling the impact of energy demand and exports on environment and economy: A case study of South Asian Economies

Kiran Batool [a,*] Muhammad Adeel [b] Abdulhalim Musa Abubakar [c]

[a] *Beijing Key Laboratory of New Energy and Low Carbon Development, School of Economics and Management, North China Electric Power University, Beijing, China*
[b] *School of Mechanical Engineering and Automation, Beihang University, Beijing, China*
[c] *Department of Chemical Engineering, Faculty of Engineering, Modibbo Adama University (MAU), P.M.B 2072, Girei LGA, Adamawa State, Nigeria*

ABSTRACT

This study employs empirical analysis using an econometric model that examines the interdependence among environmental degradation, exports, and economic development with energy use. It also provides an environmental Kuznets curve (EKC) for selected South Asian economies utilizing time-series data. The findings reveal a long-term, stable equilibrium link between energy demand and pollution. There exists a positive relationship between structural factors and pollution. Moreover, this study constructs a model of exports and pollution from an interdependent perspective. The three perspectives are tested: the scale and structure of energy consumption considering the twin constraints of export-trade and pollution, and the scale of pollution in export-trade constraint. These results show that the increase in energy use leads to higher CO2 emissions amidst export volume. However, in the presence of income, the scale of effect lowers a little. The analysis also supports the presence of Kuznets curve for south-Asian economies. The results imply substantial scope for development in the energy use and pollution structure within South Asia's current export trade process. This development can be attained by regulating energy use and enhancing system efficacy without necessitating changes to the scale effect or structural effect.

KEYWORDS

Energy demand; South Asian economies; carbon emissions; econometric model; environment

---

* Corresponding author: Kiran Batool
E-mail address: kiranbatool@ncepu.edu.cn

ISSN 2972-4899
doi: 10.58567/ete02030003

Received 19 December 2023; Accepted 8 April 2024; Available online date 8 July 2024.

1. Introduction

In the recent boom of economies around the globe, export trade expansion has increased CO2 emissions, necessitating urgent attention to maintaining international trade advantages while achieving sustainable growth in the global economy, given the de-carbonization trend and the need for sustainable growth. South Asian countries, including Bangladesh, India, Pakistan, and Sri Lanka, have joined regional trade blocs to promote frictionless trade. However, the performance of these countries in world trade has been poor, and there is a need to investigate the effects of environmental rules and regulations on their food trade and agricultural production. The current state of green growth in South Asia shows that the region is still heavily reliant on unsustainable modes of production and consumption, leading to perpetually rising carbon emissions. India, as one of the emerging exporters of environmental goods, faces constraints such as weak infrastructure and institutions that hinder its full export potential. The link between trade and the environment in Asia has been highlighted, with trade policy being seen to influence the environment in other countries (Sun, Chen, and Wang 2023).

The situation in developing countries offers a striking juxtaposition in comparison to developed countries about the connection between economic activity and energy usage. According to empirical data, it is evident that developing countries experience an escalation in energy consumption because of enhanced production activities. As a result, it becomes essential for these nations to foresee and decide for the potential surge in energy requirements that may ensue if they opt for a development approach centered on augmenting economic intricacy. Consequently, it becomes crucial for these countries to anticipate and prepare for the growing energy demands that may arise if they choose to pursue a development strategy focused on increasing economic complexity.

Despite the presence of weak or non-existent formal regulation and enforcement mechanisms, it is worth noting that some clean production plants are operating within the developing countries of South Asia. It is crucial, however, to acknowledge that there are also a significant number of plants that rank among the most severe contributors to global pollution levels. The question that arises, therefore, is what factors can account for such a wide range of variation in terms of environmental impact among these plants. Furthermore, it is important to explore the relationship between energy demand and its effects on both the environment and the economy. In doing so, we aim to delve into the intricate dynamics of how the economy responds to any shocks that may arise from changes in the environment and energy consumption patterns. Additionally, this study also serves to examine the influence of export volume on both the environment and the economy, thus shedding light on the complex interplay between these factors.

The regional growth of South Asia for the last few years has been attributed to the export performances of India and Bangladesh; its implementation of reform and liberalization can be regarded as a remarkable occurrence within the realm of global economic development. Figures 1 to 5 show the relationship between energy use and other variables for each country. The narrow gap between energy use and its effect on pollution and GDP in the case of Pakistan and India indicates that there is a positive correlation between these factors. However, in all cases, a positive trend is exhibited. A clear positive export volume trend is found in the case of India and Bangladesh. On the contrary, Pakistan, Nepal and Sri Lanka have some staggered effects.

After this introduction section, the literature review is done in section 2; section 3 defines the model, data, and empirical methodology. Section 4 forwards results and discussion. Section 5 concludes.

2. Literature Review

The situation in developing countries presents a stark contrast when compared to developed countries in terms of the association between economic activity and energy use. Empirical evidence suggests that in developing countries, an increase in production activities leads to higher energy consumption.

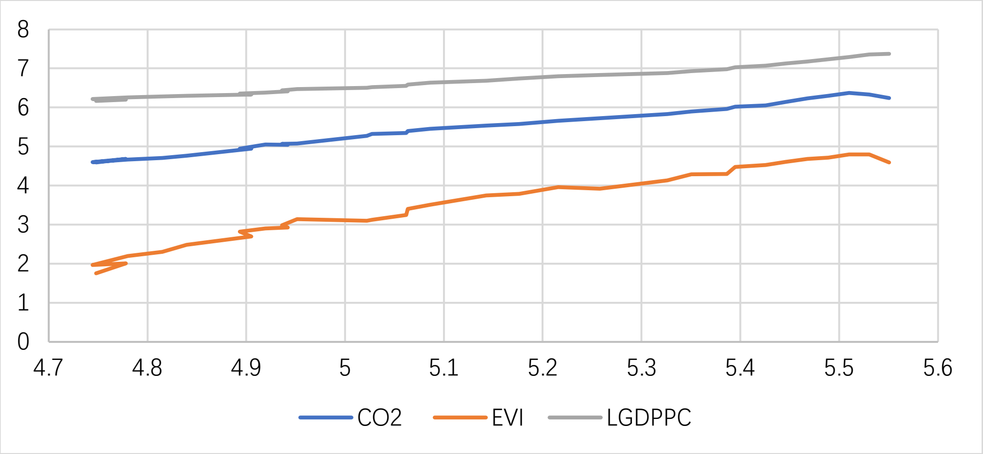


Figure 1. Energy Demand Effect on GDPPC, CO2, EVI (BGD).

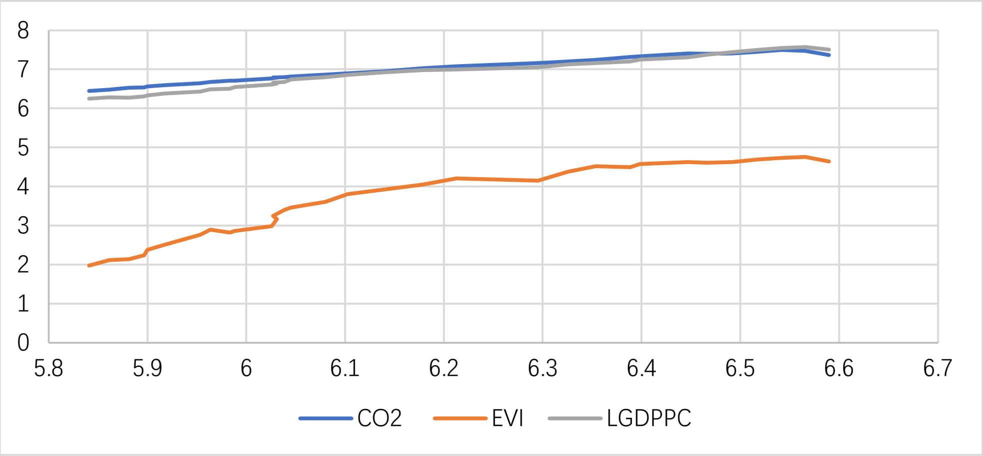


Figure 2. Energy Demand Effect on GDPPC, CO2, EVI (BGD).

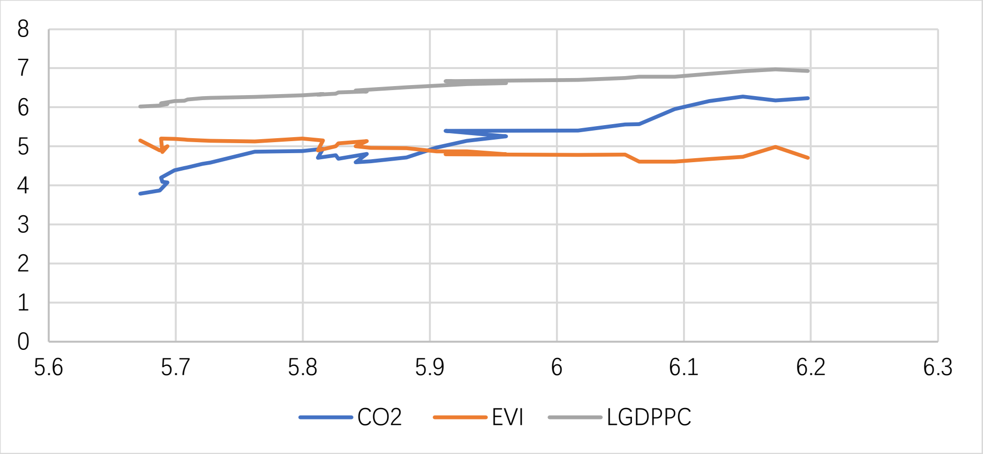


Figure 3. Energy Demand Effect on GDPPC, CO2, EVI (NPL).

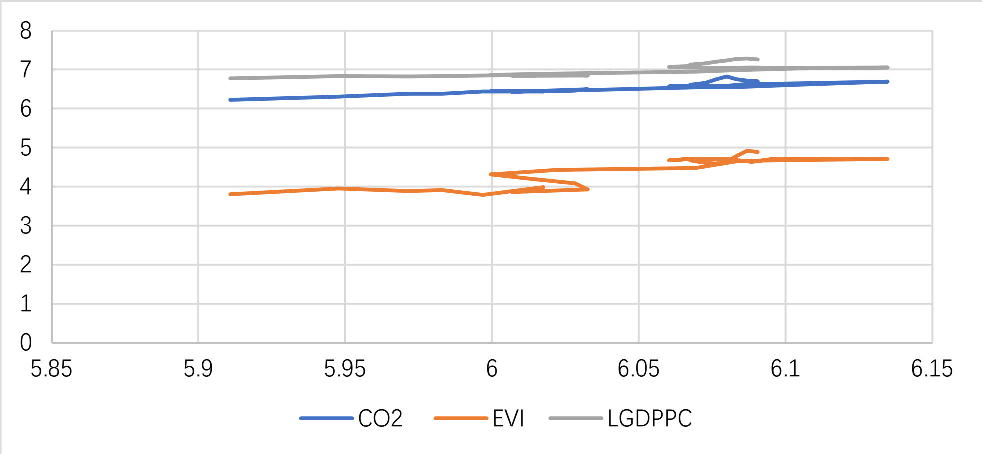


Figure 4. Energy Demand Effect on GDPPC, CO2, EVI (PAK).

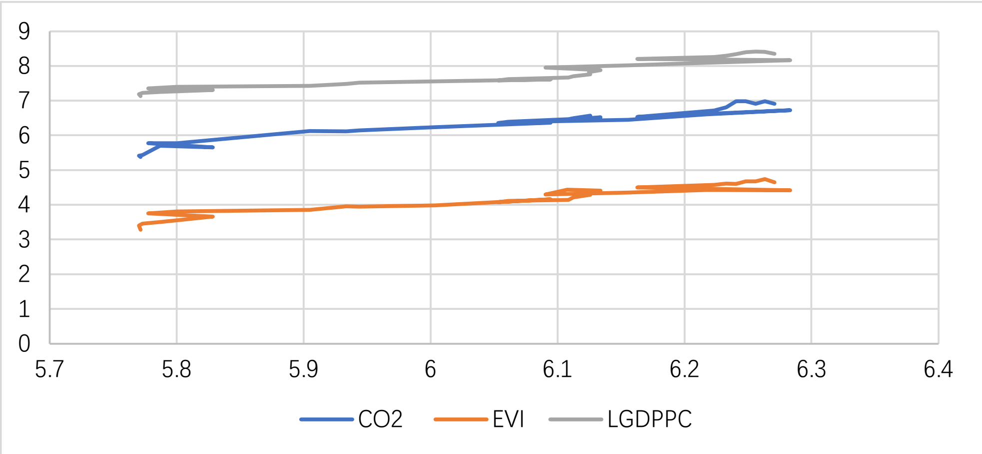


Figure 5. Energy Demand Effect on GDPPC, CO2, EVI (LKA).

Consequently, it becomes imperative for these countries to anticipate and prepare for the growing energy demands that may arise if they choose to pursue a development strategy focused on increasing economic complexity. This is primarily due to the fact that developing countries typically start their developmental journey at a lower level than developed nations (Rahman & Alam, 2022; Mahmood et al., 2022). To illustrate this point, it is necessary for them to initially shift their focus from the extraction of natural resources and agricultural production to energy-intensive goods like paper, machines, cement, and metal (Hettige, et al., 1996). Only once this transition has been made, the question arises can this progress to other intricate products that need lower use of energy (Mahood and Shahab, 2014; Zeren & Akkuş, 2020).

The outcomes of this research shed light on the significance of a worldwide plan to combat climate change in terms of decoupling economic expansion from its environmental effect. Developed countries must acknowledge the likelihood of a rise in future energy use in developing economies (Shahbaz et al., 2018). Consequently, international strategies that aim to reduce the interaction between energy use and economic difficulty in developing nations can prove to be beneficial. Additionally, other researchers have also emphasized the potential benefits of energy development subsidies in such countries (Groot & Oostveen, 2019). However, it is worth noting the results of Bhattacharyya et al. (2018) do not find evidence of a general impact of aid for energy-related products on emissions. Wijesinghe (2014) studies the implications of environmental regulation on South Asian food and agricultural commerce. Dahal, K., & Pandey (2018) mention that the trade of Environmental Goods in South Asia is primarily driven by rising imports, indicating a poor state of environmental industries in the region and trade in

Environmental Goods and Services can promote green growth with the necessity to comprehend WTO Agreement on Environmental Goods. The Hewison et al., (1997) show the impact of environmental policies on exports from developing countries and imply that developing countries should follow environmentally based standards. The paper discusses various aspects of trade, environment, and sustainable development in South Asia. Wang et al., (2023) discuss the relationship between pollution and export trade, structural changes of economy, and green-technology change. This study found a strong correlation between the structural effect and carbon emissions, highlighting the crucial role of export trade development in shaping industrial and product structures. It suggests that increased export commerce could significantly alter the composition and structure of companies and goods, potentially reducing carbon emissions.

Increased energy consumption has been identified as a driver of CO2 emissions, suggesting the need for countries to transition to more environmentally friendly types of production and renewable energy sources (Mahmood et al., 2022; Mahmoods et al., 2020; Wang et al., 2023). Additionally, exports have been found to have both positive and negative effects on CO2 emissions. While exports have been associated with an increase in CO2 emissions, they also have positive environmental spillover effects in neighboring countries (Mahmood, 2022). This indicates that the impact of exports on CO2 emissions is complex and depends on various factors. Overall, these findings highlight the importance of considering energy use and exports in efforts to mitigate CO2 emissions and address climate change.

The Kalirajan (2016) discusses the Indian case study of environment and energy circa and finds that India should focus on environmental goods exports to help support the idea of green growth. Brooks (1998) mainly discusses the linkages between trade and the environment in Asia, trade liberalization, and regional cooperation efforts for sustainable use of the environment. It concludes that due to uncertainty in the cost of pollution reduction, the trade policy can influence the environment in other countries - ISO 14000 standards promote better environmental management. The Bharucha (1997) focuses on the influence of international environmental regulations/ standards on Indian exports. The paper focuses on the trade and environmental issues related to India's leather exports. Products conforming to high environmental standards have a competitive advantage.

Sankar (2007) discusses the importance of trade for economic development in the South Asian region. He discusses the challenges faced by SAARC countries in trade liberalization and environmental protection and implies that regional cooperation is necessary for trade for economic development. Utkarsh (2001) discusses the historical migration and occupational specialization in South Asia, as well as the cultural traditions of ecological prudence and community efforts for sustainable use of the environment.

The literature on developing countries also discusses how trade can affect poverty; for example, Kapuria (2010) focuses on the effects of trade on poverty reduction and environmental protection in developing nations. South Asia has a society with occupational specialization, and collective efforts hold potential for sustainable use of the environment.

Ahsan and Chu (2014) found that Bangladesh did not reach its export potential in 2001 and 2007. Reducing 'explicit beyond the border' constraints aided export growth. Ahsan (2021) elaborates on the challenges and opportunities concerning exports of environmental goods (EGs) from Bangladesh. Gore & Annachhatre (2019) focuses on the trade-off between India's trade promotion and its environmental sustainability. They find that export industries contribute to pollution and environmental degradation. The paper by Goldar (2011) discusses prioritizing a green export portfolio for India. The paper discusses the linkages between trade, environment, and sustainable development. Mohanty (2014) focuses on the challenges and prospects of environmentally sensitive goods in India's trade.

Jomit (2014) explains that the gravity model can explain 70% of fluctuations in India's exports of environmental goods. Trade liberalization can increase India's exports by 5%. The paper discusses the connection between trade and the environment, the concerns of environmentalists, and the challenges of seeking sustainable development. He et al. (2015) shows that the impact of trade liberalization, which encompasses the reduction of both tariff and non-tariff trade barriers, on the exports of environmental goods (EGs) is a topic of great significance and conducted an empirical analysis using bilateral trade data from 20 member countries of the Asia-Pacific Economic Cooperation. Findings reveal that when it comes to exports, a reduction in tariffs in the exporting country has a more pronounced positive effect compared to a reduction in tariffs in the importing country.

Moreover, our results demonstrate that a decrease in non-tariff barriers in the importing country leads to an increase in imports of EGs. These insights contribute to a better understanding of the intricate relationship between trade liberalization and the trade of environmental goods. Azhar et al. (2007) discusses the potential negative impacts of trade liberalization on the environment and natural resources of developing countries, with a focus on Pakistan.

3. Model, Data and Methodology

The model employed for analysis in the present paper is derived and adapted from the extensive literature discussed in the preceding sections. Notably, it aligns closely with the research conducted by Mahmood et al. (2020), as well as the works by Chu (2014) and Sankar (2007). However, it deviates from these previous studies in two key aspects. Firstly, it adopts a specific-to-general approach when specifying the model, thus providing a more comprehensive framework for examining the Environmental Kuznets Curve (EKC) hypothesis in the context of the export volume index and energy demand. Secondly, it also investigates the structural stability of parameters related to energy demand for CO2 emissions, thereby enabling a more nuanced understanding of the relationship between these variables.

Moreover, the model under consideration facilitates the differentiation of the impact of energy and exports on GDP per capita, both in the presence and absence of pollution. This is particularly noteworthy as it allows for a comprehensive assessment of the various factors influencing economic growth and development. Consequently, the reduced-form econometric model utilized in this study encompasses a series of equations, specifically equations 1 to 6, which provide a robust and rigorous analytical framework for investigating the complex dynamics between energy demand, export volume, and their Impact on GDP per capita. By employing this model, researchers can gain valuable insights into the intricate relationships between these variables, thereby contributing to the existing body of knowledge in the field of environmental economics and sustainable development. To summarize, the model employed in this paper builds upon previous research while introducing novel elements that enhance our understanding of the relationship between energy demand, exports, and their implications for economic growth and environmental sustainability.

$$CO2_{it} = \beta_{11} ENERD_{it} + \varepsilon_{1t} \quad (1)$$

$$CO2_{it} = \beta_{21} ENERD_{it} + \beta_{22} EVI_{it} + \varepsilon_{2t} \quad (2)$$

$$CO2_{it} = \beta_{31} ENERD_{it} + \beta_{32} EVI_{it} + \beta_{33} GDPPC_{it} + \varepsilon_{3t} \quad (3)$$

$$CO2_{it} = \beta_{41} ENERD_{it} + \beta_{42} EVI_{it} + \beta_{43} GDPPC_{it} + \beta_{44} (GDPPC_{it})^2 + \varepsilon_{4t} \quad (4)$$

The estimated values of β11, β21, β31, and β41 are assumed to be positive and robust. To highlight the impact of energy demand on GDP we specify equations 5 and 6, below.

$$\mathrm{GDPPC_{it}} = \gamma_{11} \mathrm{ENERD_{it}} + \beta_{12} \mathrm{EVI_{it}} + \varepsilon_{3t} \quad (5)$$

$$\mathrm{GDPPC_{it}} = \gamma_{21} \mathrm{ENERD_{it}} + \beta_{22} \mathrm{EVI_{it}} + \beta_{23} \mathrm{CO2_{it}} + \epsilon_{3t} \quad (6)$$

3.1. Data and Methodology

To estimate the model, discussed above, this study has used time-series data of five South-Asian economies spanning 1989-2020. The main source of data is world development indicators. These economies include Bangladesh (BGD), India (IND), Nepal (NPL), Pakistan (PAK) and Sri Lanka (LKA). After applying the panel unit root test, it is found that all series are integrated into order one. Thus, the panel cointegration is applied under fully modified OLS (FMOLS) specifications.

4. Results and Discussion

4.1. Descriptive Statistics

Tables 1 & 2 present the insights of the recent data collected for South Asian economies. All data are used in natural log form. With lower values of standard deviations, however, all variables exhibit smoothness. The ranges of Skewness and Kurtosis show symmetry. However, the Jarque-Bera test indicates the absence of normality in all series. The possible reasons include the difference in the economic and demographic conditions of the SAARC economies. For example, India's energy use is much higher than that of Nepal and Sri Lanka. Similarly, the differences in population, GDP per capita, and emission level (which largely depend on industrial activities are also important factors).

Table 1. Descriptive analysis of selected variables.

Indicators	ENERD	CO_2	EVI	GDPPC
Mean	5.853182	6.043384	4.110009	6.951526
Median	5.983202	6.370078	4.387631	6.859706
Maximum	6.589442	7.493092	5.196544	8.410879
Minimum	4.744345	3.785941	1.754555	6.021041
Std. Dev.	0.421125	0.881511	0.834937	0.570568
Skewness	-1.070516	-0.618246	-0.970640	0.666570
Kurtosis	3.563429	2.429384	3.128664	2.986131
Jarque-Bera	32.67647	12.36345	25.23416	11.84969
Probability	0.000000	0.002067	0.000003	0.002672
Sum	936.5091	966.9415	657.6015	1112.244
Sum Sq. Dev.	28.19801	123.5528	110.8421	51.76205
Observations	160	160	160	160

Table 2 shows the covariance and correlations among the variables of the model. The correlation of energy demand with all other variables is significant. The CO2 emissions have the lowest correlation with the export value index (EVI). In contrast, the correlation between CO2 and energy demand is highest, indicating that pollution is mainly affected by inefficient energy use.

Table 2. Covariance and correlations among the variables.

Covariance Analysis: Ordinary
Sample: 1989 2020
Included observations: 160

Covariance Correlation	ENERD	CO2	EVI	GDPPC
ENERD	0.176238			
	1.000000			
CO2	0.251886	0.772205		

	0.682793	1.000000		
EVI	0.172274	0.011911	0.692763	
	0.493034	0.016285	1.000000	
GDPPC	0.128221	0.324374	0.142557	0.323513
	0.536988	0.648984	0.301127	1.000000

4.2. Empirical Findings and Discussions

Panel unit root test results are reported in Table 3. It indicates that the null of the unit root is accepted at level, but at the first difference, all series exhibit stationarity and are integrated in the same order. This also justifies the use of the Panel Residual Cointegration Test proposed by Pedroni, summarized in the appendix (Table A1).

Table 3. Unit Root Test Results.

	ENERD	EVI	CO2	GDPPC
ADF	-1.03	-2.277	-1.68	1.143
ΔADF	-4.102**	-7.53***	-6.27***	-3.706*
PP	-1.179	-2.19	-1.435	1.412
ΔPP	-3.948**	-5.350***	-6.27***	-3.706*
	Confidence Intervals (Critical Values)			
	ADF	PP		
1%	-4.29	-4.29		
5%	-3.57	-3.57		
10%	-3.22	-3.22		

*Note: ***P<1%, **P<5% and *P<1%.*

The results obtained from the analysis of equations 1 to 4 have been presented in Table 4. The findings depicted in this table clearly demonstrate that a positive relationship exists between energy demand and CO2 emission, specifically in the context of South Asian economies. It is worth noting that this positive relationship remains consistent and stable over the long term across all four cases. However, when the model incorporates the export value index, there is an observed increase in the magnitude of the parameter. Conversely, the inclusion of GDP per capita in the model leads to a further stabilizing effect of energy on the environment.

Consequently, it becomes evident that in the case of this study, both energy demand and income have a positive impact on pollution. This finding, however, contrasts with much of the existing literature (Wang et al., 2023; and Gore & Annachhatre, 2019). Interestingly, the inclusion of the export volume index in the model is shown to have a retarding effect on pollution. Thus, the results of this study provide valuable insights into the complex relationship between energy demand, income, and pollution (Batool et al. 2022; Batool, Zhao, Irfan, and Żywiołek 2023; Batool, Zhao, Nureen, and Irfan 2023).

The so-called environmental Kuznets curve (EKC) is vindicated after the inclusion of the squared term of GDPPC. Imaginary, one can think of an inverted U shape of EKC for these economies, based on the signs of the coefficients. Table 5 exhibits the findings that the influence of energy consumption on GDPPC is both statistically significant and robust, which aligns with most previous scholarly works. The manufacturing process is perceived as being more energy-efficient, albeit this effect diminishes when the pollution variable is incorporated into the model. The impact of the export volume index has been positive but lacks statistical significance in the model that does not incorporate CO2 emissions. Hence, the inclusion of CO2 emissions renders the model more reliable and consistent, indicating that an increase in pollution presents opportunities for economic growth, albeit accompanied by other detrimental consequences for society (Batool, Zhao, Irfan, Ullah, et al. 2023; Batool, Zhao, Sun, and Irfan 2023). The R2 value serves as an indicator of the overall fit of the model, demonstrating its adequacy.

Nevertheless, the incorporation of variables in the model leads to a reduction in the long-run variance, indicating the stability and efficiency of the model's parameters. Model 4 in Table 4 and Model 6 in Table 5 exhibit higher levels of consistency and efficiency compared to the other models in their respective tables. These results are consistent with those of Kalirajan (2016), Bharucha (1997), and Mahmood & Shahba (2014), among others.

To enhance the comprehensiveness and robustness of the analysis, we employed the Pairwise Dumitrescu Hurlin Panel Causality Test (as showcased in Table A2 within the appendix). Through this rigorous methodology, we can ascertain the presence of a unidirectional causality relationship between energy demand and pollution, exports, and pollution, as well as GDPPC (Gross Domestic Product per Capita) and energy demand. It is important to note that no causality pertaining to pollution and GDP is identified. However, a more complex pattern emerges when examining the connections between exports and GDP, as well as exports and energy demand, revealing the presence of a two-way causality dynamic. This elaborate relationship between exports, GDP, and energy demand necessitates further exploration and analysis to comprehend the underlying mechanisms and implications playfully.

Table 4. Dependent Variable (CO2).

Variables	Model 1	Model 2	Model 3	Model 4
ENERD	2.2572	3.219	2.540	2.074
	(15.89)	(16.294)	(6.467)	(4.552)
EVI	_	-0.329	-0.331	-0.331
		(-5.465)	(-5.61)	(-5.868)
GDPPC	_	_	0.395	2.911
			(1.94)	(2.585)
GDPPC2	_	_	_	-0.155
				(-2.239)
R^2	0.95	0.97	0.97	0.97
Long-run variance	0.105	0.064	0.06	0.0543

Note: t-stats in parentheses.

Table 5. Dependent Variable (GDPPC).

Variables	Model 5	Model 6
ENERD	1.67(25.17)	1.275(6.958)
EVI	0.021(1.07)	0.073(2.438)
CO2	-	0.118(2.305)
R^2	0.97	0.972
Long-run variance	0.033	0.031

Note: t-stats in parentheses

5. Conclusions and Policy Implications

The intricate link between economic and energy consumption in developing nations is a complex issue that requires careful planning and consideration. To mitigate the environmental impact of this growth, a global strategy is essential. The strategy should include financial support, training programs, and policy reforms, including energy reform subsidies. These strategies should align with earlier policy recommendations, which include provisions for financing, training, and policy reforms, but acknowledge that the effectiveness of these subsidies may vary and may not always result in the desired emissions reduction. Energy use and exports have been determined to exert significant impacts on the release of CO_2 into the atmosphere, a phenomenon closely associated with the worsening of global warming and climate change. The escalation in energy consumption has been identified as a principal catalyst for the surge in CO2 emissions. The EKC hypothesis is also vindicated through this empirical study of South Asian economies.

Exports have negative environmental impacts, especially in neighboring countries, due to territory-based CO2 emissions. This suggests that trade activities' environmental consequences extend beyond national borders, necessitating a comprehensive approach to environmental policymaking. Countries must consider both direct emissions and indirect emissions from export-oriented practices when assessing their environmental impact. In conclusion, energy use and exports have been identified as crucial factors that significantly influence CO2 emissions. The escalating energy consumption levels necessitate a transition towards more sustainable and environmentally friendly modes of production and renewable energy sources. Similarly, the association between exports and CO2 emissions underscores the importance of recognizing the potential environmental implications of trade activities.

The intricate link between exports and CO2 emissions necessitates a comprehensive approach to environmental policymaking, considering both direct and indirect emissions from energy consumption and trade activities. Addressing the environmental impacts of energy use and exports is crucial for a sustainable, low-carbon future, necessitating an integrated approach.

Funding Statement

This research received no external funding.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

Author contributions

Kiran Batool: Conceptualization, Methodology, Formal analysis, Writing – original draft. Muhammad Adeel; Investigation, Writing – review & editing. Abdulhalim Musa Abubakar: Writing – review & editing.

Appendix

Table A1. Pedroni Residual Cointegration Test.

Series: CO2 ENERD EVI GDPPC
Sample: 1989 2020
Included observations: 160
Cross-sections included: 5
Null Hypothesis: No cointegration
Trend assumption: No deterministic intercept or trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.080190	0.4680	1.203025	0.1145
Panel rho-Statistic	-1.031818	0.1511	-1.411908	0.0790
Panel PP-Statistic	-1.680612	0.0464	-1.709868	0.0436
Panel ADF-Statistic	-2.055196	0.0199	-1.765354	0.0388

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	-0.891405	0.1864

Group PP-Statistic	-1.602029	0.0546
Group ADF-Statistic	-1.624392	0.0521

Table A2. Pairwise Dumitrescu Hurlin Panel Causality Tests.

Sample: 1989 2020 Lags: 1			
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
ENERD does not homogeneously cause CO2	2.48826	1.95361	0.0507
CO2 does not homogeneously cause ENERD	1.47853	0.55592	0.5783
EVI does not homogeneously cause CO2	6.55428	7.58193	3.E-14
CO2 does not homogeneously cause EVI	1.77627	0.96807	0.3330
GDPPC does not homogeneously cause CO2	1.95418	1.21433	0.2246
CO2 does not homogeneously cause GDPPC	1.28746	0.29143	0.7707
EVI does not homogeneously cause ENERD	3.63632	3.54280	0.0004
ENERD does not homogeneously cause EVI	2.48837	1.95377	0.0507
GDPPC does not homogeneously cause ENERD	3.36452	3.16657	0.0015
ENERD does not homogeneously cause GDPPC	0.52409	-0.76525	0.4441
GDPPC does not homogeneously cause EVI	2.31433	1.71286	0.0867
EVI does not homogeneously cause GDPPC	3.09558	2.79428	0.0052

References

Ahsan, M. R. (2021). Challenges and opportunities concerning Environmental Goods (EGs): a case study and business perspective. *Society and Business Review*, 16(2), 184-200. https://doi.org/10.1108/SBR-07-2020-0088

Ahsan, M. R., & Chu, S. N. (2014). The Potential and Constraints of the Exports of Environmental Goods (EGs): the case of Bangladesh. The Australian National University, Australia South Asia Research Centre.

Azhar, U., Khalil, S., & Ahmed, M. H. (2007). Environmental effects of trade liberalisation: a case study of Pakistan. *The Pakistan Development Review*, 645-655. http://dx.doi.org/10.30541/v46i4IIpp.645-655

Batool, Kiran, Zhen Yu Zhao, Faraz Atif, and Azer Dilanchiev. (2022). Nexus Between Energy Poverty and Technological Innovations: A Pathway for Addressing Energy Sustainability. *Frontiers in Environmental Science* 10(July), 1–18. http://dx.doi.org/10.3389/fenvs.2022.888080

Batool, Kiran, Zhen Yu Zhao, Muhammad Irfan, and Justyna Żywiołek. (2023). Assessing the Role of Sustainable Strategies in Alleviating Energy Poverty: An Environmental Sustainability Paradigm. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-023-27076-0

Batool, Kiran, Zhen Yu Zhao, Muhammad Irfan, Sami Ullah, et al. (2023). Assessing the Competitiveness of Indian Solar Power Industry Using the Extended Five Forces Model: A Green Innovation Perspective. *Environmental Science and Pollution Research*, 1–25. http://dx.doi.org/10.1007/s11356-023-28140-5

Batool, Kiran, Zhen-Yu Zhao, Huaping Sun, and Muhammad Irfan. (2023). Modeling the Impact of Energy Poverty on Income Poverty, Health Poverty, Educational Poverty, and Environmental Poverty: A Roadmap towards Environmental Sustainability. *Environmental Science and Pollution Research* 30(36), 85276–91. https://doi.org/10.1007/s11356-023-28238-w

Batool, Kiran, Zhen-Yu Zhao, Naila Nureen, and Muhammad Irfan. (2023). Assessing and Prioritizing Biogas Barriers to Alleviate Energy Poverty in Pakistan: An Integrated AHP and G-TOPSIS Model. *Environmental Science and Pollution Research*. https://doi.org/10.1007/s11356-023-28767-4

Bharucha, V. (1997). The Impact of Environmental Standards and Regulations set in foreign Markets on India's Exports. In Trade, Environment & Sustainable Development: A South Asian Perspective (pp. 123-142). London: Palgrave Macmillan UK.

Brooks, D. H. (1998). Challenges for Asia's trade and environment.

Dahal, K., & Pandey, P. R. (2018). Green growth and trade in environmental goods and services: a south Asian perspective (No. wp/18/01).

Feix, R. D., Miranda, S. H. G. D., & Barros, G. S. A. D. C. (2008). Environmental regulation and international trade patterns for agro-industrial under a South-North perspective (No. 725-2016-49633).

Goldar, A., Bhanot, J., & Shimpo, K. (2011). Prioritizing towards a green export portfolio for India: An environmental input–output approach. *Energy Policy*, 39(11), 7036-7048. https://doi.org/10.1016/j.enpol.2011.08.008

Gore, M., & Annachhatre, M. (2019). Trade-off between India's trade promotion and its environmental sustainability.

European Journal of Sustainable Development, 8(3), 405-405. https://doi.org/10.14207/ejsd.2019.v8n3p405
He, Q., Fang, H., Wang, M., & Peng, B. (2015). Trade liberalization and trade performance of environmental goods: evidence from Asia-Pacific economic cooperation members. *Applied Economics*, 47(29), 3021-3039. https://doi.org/10.1080/00036846.2015.1011319
Hettige, H., Huq, M., Pargal, S., & Wheeler, D. (1996). Determinants of pollution abatement in developing countries: evidence from South and Southeast Asia. *World development*, 24(12), 1891-1904. https://doi.org/10.1016/S0305-750X(96)00076-9
Hewison, G., Jha, V., & Underhill, M. (Eds.). (1997). Trade, environment and sustainable development: A South Asian perspective. Springer.
Jomit, C. P. (2014). Export potential of environmental goods in India: A gravity model analysis. *Transnational Corporations Review*, 6(2), 115-131. https://doi.org/10.1080/19186444.2014.11658386
Kalirajan, K. (2016). Export of environmental goods: India's potential and constraints. *Environment and Development Economics*, 21(2), 158-179. https://doi.org/10.1017/S1355770X15000224
Kapuria, P. (2010). Shrimp exports, environment and human well-being in the Sundarbans, West Bengal. Vulnerable Places, Vulnerable People, 63.
Mahmood, H. (2022). Consumption and Territory Based CO 2 Emissions, Renewable Energy Consumption, Exports and Imports Nexus in South America: Spatial Analyses. *Polish Journal of Environmental Studies*, 31(2). https://doi.org/10.1016/j.eneco.2019.104632
Mahmood, M. T., & Shahab, S. (2014). Energy, emissions and the economy: empirical analysis from Pakistan. *The Pakistan Development Review*, 383-400. https://www.jstor.org/stable/24398726
Mahmood, M. T., Shahab, S., & Hafeez, M. (2020). Energy capacity, industrial production, and the environment: an empirical analysis from Pakistan. *Environmental Science and Pollution Research*, 27(5), 4830-4839. https://doi.org/10.1007/s11356-019-07161-z
Mahmood, M. T., Shahab, S., & Shahbaz, M. (2022). The relevance of economic freedom for energy, environment, and economic growth in Asia-Pacific region. *Environmental Science and Pollution Research*, 29(4), 5396-5405. https://link.springer.com/article/10.1007%2Fs11356-021-15991-z
Mohanty, S. K. (2014). Environmentally Sensitive Goods in India's Trade: Emerging Challenges and Prospects. Globalization and Standards: Issues and Challenges in Indian Business, 61-100.
Pedroni, P. (2001). Purchasing power parity tests in cointegrated panels. *Review of Economics and statistics*, 83(4), 727-731. http://dx.doi.org/10.35866/caujed.2019.44.1.004
Rahman, M. M., & Alam, K. (2022). CO2 Emissions in Asia–Pacific region: do energy use, economic growth, financial development, and international trade have detrimental effects?. *Sustainability*, 14(9), 5420. https://doi.org/10.3390/su14095420
Sankar, U. (2007). Trade and environment: a study of India's leather exports. Oxford University Press.
Sun, Huaping, Tingting Chen, and Christoph Nedopil Wang. 2023. Spatial Impact of Digital Finance on Carbon Productivity. *Geoscience Frontiers*: 101674. https://www.sciencedirect.com/science/article/pii/S167498712300141X.
Utkarsh, G. (2001). South Asian Studies: Environment.
Wang, S., Pan, M., & Wu, X. (2023). Sustainable Development in the Export Trade from a Symbiotic Perspective on Carbon Emissions, Exemplified by the Case of Guangdong, China. *Sustainability*, 15(12), 9667. https://doi.org/10.3390/su15129667
Wijesinghe, W. P. A. S. (2014). Effects of environmental regulations on South Asian food and agricultural exports: A gravity analysis (No. 139). ARTNeT Working Paper Series.
Zeren, F., & Akkuş, H. T. (2020). The relationship between renewable energy consumption and trade openness: New evidence from emerging economies. *Renewable Energy*, 147, 322-329. https://doi.org/10.1016/j.renene.2019.09.006