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Does fiscal decentralization curb the ecological footprint in Pakistan?

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This paper offers a new indulgence to the present literature by integrating the role of fiscal decentralization (FD) in affecting ecological footprint (EF). So, this study considered the effect of FD on EF in the existence of energy consumption (EC), technological innovation (TI), gross domestic product (GDP), and trade openness (TOP) from 1990 to 2018 in Pakistan. We employ econometric methods like Bayer & Hanck cointegration, fully modified ordinary least squares, dynamic ordinary least squares, and canonical cointegration regression for empirical analysis. Moreover, the frequency domain causality test is used to conclude the causal impact of FD, EC, TI, GDP, and TOP on EF. The regression results disclose that EC, GDP, and TOP boost EF in Pakistan; however, FD and TI promote the sustainability of the environment by reducing EF. Besides, the frequency causality outcomes indicate that FD, EC, TI, GDP, and TOP have insinuations for EF in the long term. As a policy recommendation, this research suggests that Pakistan could successfully integrate strategies to increase ecological quality by allowing the lower level of government to utilize eco-friendly technological innovations.

KEYWORDS

fiscal decentralization, ecological footprint, FMOLS, DOLS, Pakistan

1 Introduction

Since the World Earth Summit in Kyoto, Japan, in 1997, developing a sustainable atmosphere has become a major global concern. The meeting emphasized the importance of protecting our earth from worldwide environmental catastrophe. Roughly 80% of the planet's population resides in a nation that is beset by significant environmental challenges. Due to substantial economic advancement and affluence, human living requirements and well-being have soared substantially in recent generations (Majeed et al., 2021; Adebayo, 2022a; Adebayo et al., 2022; Ali et al., 2022; Kirikkaleli et al., 2022). This stresses the ecosystem, leading to pollution, biodiversity deterioration, and environmental disparity (Ahmed & Wang, 2019). As a result, developing and attaining long-term environmental goals has risen to the pinnacle of the critical global list.

Among these initiatives, some authorities and academics think fiscal decentralization (FD) is an impactful way to reduce emissions; they argue that FD can stimulate a "race to the top" between local authorities by creating greater ecological guidelines in order to

generate eco-friendly environments and, as a result, less pollution in damaged regions (Mu, 2018; Chen and Chang, 2020). However, in current years, there has been an emergent risk of the influence of FD on environmental performance (Khan et al., 2021). Advocates of this viewpoint assume that FD will precipitate a “race to the bottom” wherein local authorities will reduce their environmental guidelines in order to draw foreign businesses, thereby increasing pollution. These conflicting findings have caught the attraction of academics in the link between FD and environmental sustainability.

Therefore, the research’s main goal is to examine the impact of FD on environmental sustainability in Pakistan. Decentralization in Pakistan looks to be regarded as either a curse or a cure or an augmentation to the nation’s already massive pressures or a remedy for all wrongs (Shahzad and Younus 2018). Pakistan is an Islamic country ruled by the 1973s Constitution of Pakistan. The national government accumulates the majority of the nation’s earnings and then redistributes it among the various governmental strands of national and provincial administrations to rectify both horizontal and vertical fiscal imbalances. According to the 1973 constitution, the National Finance Commission (NFC) creates prudent and honest resource allocation decisions between the national and provincial authorities (Asghar, 2016). Nevertheless, the NFC did not always deliver indisputable grants, and the fiscal resource allocation process did not always perform admirably. Pakistan, on the other side, is presently experiencing macroeconomic imbalances, as well as a current account deficit, rising unemployment, and rising prices. Under these circumstances, efficient FD is anticipated to be a productive tool for achieving long-term economic development, macroeconomic consistency, and enhanced environmental conservation.

This study gives a fresh perspective on FD and environmental sustainability in the case of Pakistan. To the best of our understanding, there appears to be a research discrepancy in the context of Pakistan. Notwithstanding the study of Li et al. (2021), this study employed ecological footprint (EF) as an alternative to ecological performance. Due to the widespread use of carbon dioxide (CO₂) emissions as a measure, the existing literature has been criticized for neglecting to grasp all facets of a sustainable environment. This indicator has recently been called into the discussion because it is not inclusive, as the individual’s effect on the atmosphere is not studied. As a result, the emphasis has shifted to EF as an advanced measure (Charfeddine & Mrabet, 2017; Bello et al., 2018; Alola et al., 2019; Chunling et al., 2021). The EF integrates the two principles to confront the harm triggered instigated by human actions on the ground level as well as the destruction caused by unsolicited usage of all of the earth’s natural resources (Zahra & Badeeb 2022). Likewise, the current investigation also provides a deeper understanding of the roles of TI, GL, and GDP as substantial factors of EF. Besides, by applying contemporary time-series estimation methodologies to explore the impact of FD on EF, this research specifically adds to

the literature. Furthermore, policymakers, climate activists, and public representatives will benefit from the study’s findings, which offer better knowledge as well as vital information, effects, and proof of ecological safety.

The subsequent section covers the theoretical model, data, and methods. The third section discusses the outcomes founded on the methods employed. The last section designates the conclusion and prospect policy outline.

2 Theoretical model, data, and methods

2.1 Theoretical framework and model

To study the effect of FD on EF in the presence of control factors like EC, TI, GDP, and TOP during 1990–2018, the empirical equation is exhibited as:

$$\ln EF_t = \alpha_0 + \alpha_1 \ln FD_t + \alpha_2 \ln EC_t + \alpha_3 \ln TI_t + \alpha_4 \ln GDP_t + \alpha_5 \ln TOP_t + \varepsilon_t \quad (1)$$

where EF shows ecological footprint, FD is fiscal decentralization, EC denotes energy consumption, TI means technological innovation, GDP stands for gross domestic product, and TOP signifies trade openness. Ln demonstrates the natural log, ε symbolizes the error term, and t shows the time period.

FD increases the adequate allocation of confined resources by lowering the expense of providing local public products and improving the effectiveness of government spending. Local authorities may offer more beneficial public facilities with the incisive benefit of local desires under the FD mechanism. There are two distinct perspectives on FD that influence the atmosphere. The first one is the race to the top strategy, and the second is the race to the bottom strategy (Ji et al., 2021). The race to the top strategy encourages FD in the system, which helps to regulate or cut pollution levels in the environment. Besides, this process expedites sustainable development by strengthening economic performance, better utilization of fiscal resources, robust institutional performance, and normalization of environmental degradation externalities. Focusing on this strategy, FD is anticipated to have an adverse effect on EF, $FD_t < 0$. Most markets rely on industry sectors in the race to the bottom framework. These sectors are more polluting the atmosphere, with poor institutional quality, poor environmental laws, and easing constraints to attract foreign funding in order to establish extra-economic prosperity. This type of framework encourages the utilization of nonrenewable energy, which raises the intensity of pollution in the environment. In this situation, we anticipate that FD will have a favourable impact on EF, $FD_t > 0$. Furthermore, the EC is included in the model. A rise in EC due to the unneeded use of fossil fuels for growth

TABLE 1 Data description.

Variables	Description	Units	Data source
EF	Ecological footprint	global hectares per capita	GFN
FD	Fiscal decentralization	Percentage of provincial government expenditures to the total government expenditures	SBP
EC	Energy consumption	kg of oil equivalent per capita	WDI
TI	Technological innovation	the number of patent applications submitted each year	WIPO
GDP	Gross domestic product	Constant 2010 US Dollars	WDI
TOP	Trade openness	% of GDP	WDI

elevates pollution, culminating in a decrease in ecological performance (Yang et al., 2020a; Adebayo, 2022b; Qayyum et al., 2022; Yang et al., 2022). As a result, if the association between EC and EF is positive, we propose $EC_t > 0$. Technological innovations could have an effect on the environment by introducing energy improvements and energy-efficient facilities (Yang et al., 2021). Therefore, we assume $TI_t < 0$ if the association between TI and EF is negative. According to Qayyum et al. (2021) and Yang et al. (2020b), economic progress is the basic cause for rising contamination heights because GDP is reliant on heavy energy usage, which exponentially degrades environmental reliability. As a result, we anticipate $GDP_t > 0$ if the association between GDP and EF is positive. Lastly, trade could have harmful effects on the environment due to the use of extensive amounts of carbon-emitting capabilities and substantial transportation usage (Antweiler et al., 2001; Fan et al., 2020; Fareed et al., 2022). So, we suppose $TOP_t > 0$ if the connection between TOP and EF is positive. The sources of data, meanings, and variable units used in Equation (1) are shown in Table 1. Figure 1 portrays the estimation flow diagram used in this study.

2.2 Methodologies

2.2.1 Unit root test

Before a cointegration process is conducted, the sequence of the integration must often be acknowledged by probing the unit root test. The global transition occurs during our study period, resulting in structural breaks. Unit root indicators that do not correspond to structural breaks may produce unsatisfactory outcomes. Hence, the Zivot and Andrews (2002) unit root technique is used to evaluate the stationary attributes of the variables and single structural breaks. The Zivot and Andrews unit root approach is superior to others because it considers structural breaks when evaluating the stationarity level.

2.2.2 Cointegration test

Bayer & Hanck's (2013) procedure is applied following the stationarity affirmation to examine the cointegration association

between the study elements. By combining several different test results, such as those of Engle and Granger (1987), Johansen (1991), Peter Boswijk (1994), and Banerjee et al. (1998), this newly customized cointegration approach offers a more proper findings. The following are Fisher's calculations for the Bayer & Hanck strategy:

$$EG - JO = -2[\ln(P_{PG}) + \ln(P_{JO})] \quad (2)$$

$$EG - JO - BO - BDM = -2[\ln(P_{PG}) + \ln(P_{JO}) + \ln(P_{BO}) + \ln(P_{BDM})] \quad (3)$$

The possible scores for each of the aforementioned cointegration tests are P_{EG} , P_{JO} , P_{BO} , and P_{BDM} . The creation of Fisher statistics determines the cointegration of the underlying factors.

2.2.3 Long-run estimates

To detect the long-run influence of FD on EF in Pakistan, with EC, TI, GDP, and TOP as controlled variables. We use the fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS), and canonical cointegration regression (CCR) techniques correspondingly. Phillips and Hansen (1990) developed the semi-parametric technique FMOLS to address the correlation issue, emphasizing that the approach is completely impartial and reliable asymptotically. Likewise, CCR, a process equivalent to FMOLS founded by Park (1992), is exploited to probe cointegration patterns in a sequence in which the sequence of the stationarity is I (1). The main difference between the FMOLS and CCR approximation strategies is that the FMOLS tends to focus on both data and variable transition. In contrast, the CCR centres on data modification (Wu et al., 2018). The DOLS procedure incorporates leads and lags to compensate for simultaneity and tiny sample bigotry. Both DOLS and FMOLS methodologies address the issue of endogeneity and serial correlation by interacting with disorderly parameters (Yildirim & Orman, 2018).

2.2.4 Breitung and Candelon causality

In addition, to check the causal effects of FD on Pakistan's EF and other factors at various frequency ranges. The frequency-domain causality test of Breitung and Candelon (2006) is utilized in this research. This methodology is built on

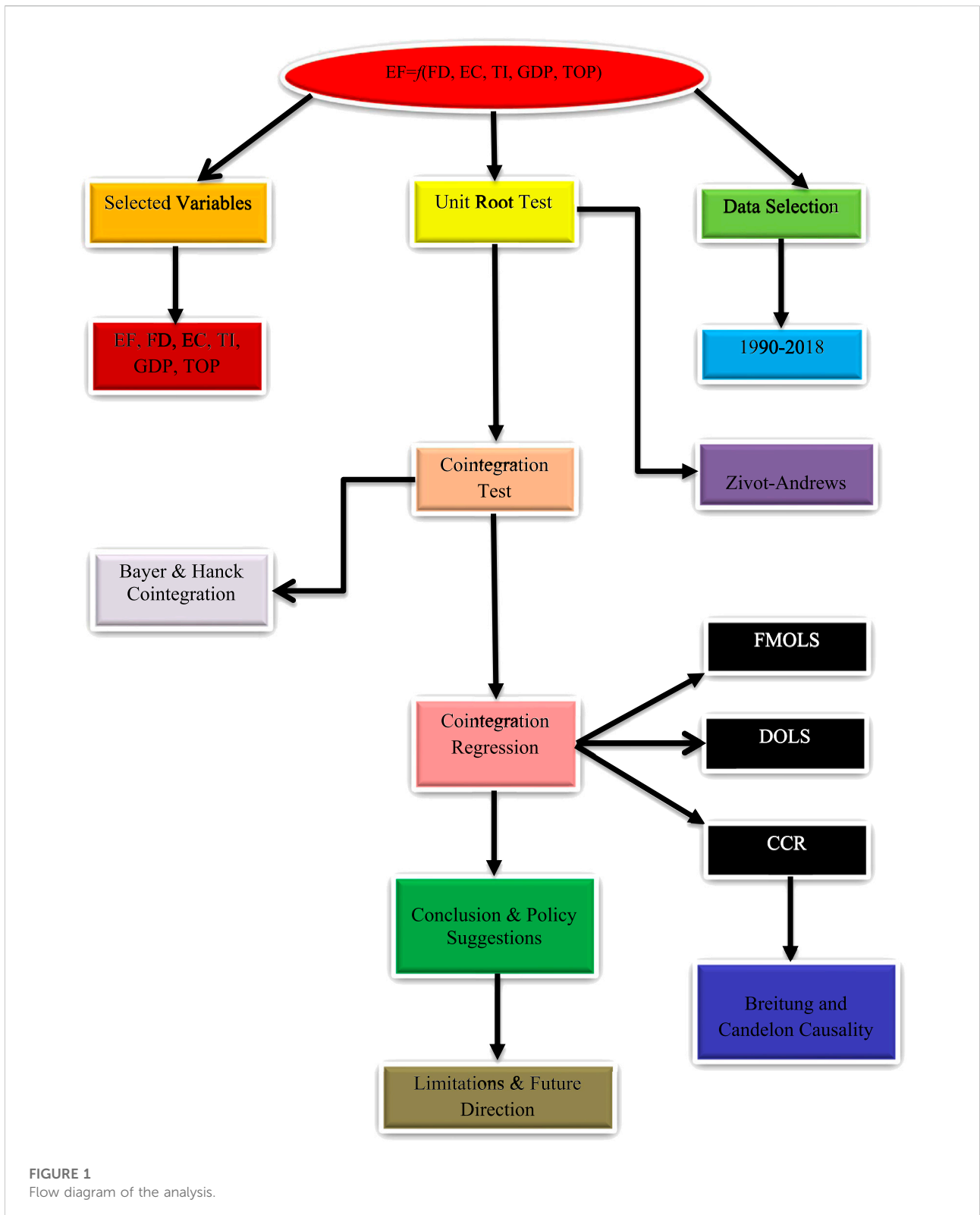


FIGURE 1
Flow diagram of the analysis.

primary investigation conducted by Geweke (1982) and Hosoya (1991). The decisive difference between time-domain and frequency-domain strategies, according to

Odugbesan and Adebayo (2020), is that the time-domain approach uncovers a certain change within a time set, while the frequency-domain procedure embodies the

TABLE 2 Unit root test results.

Variables	At level		At first difference	
	Test statistic	Time break	Test statistic	Time break
Level				
EF	-1.3221	1999Q2	-5.9711***	1993Q2
FD	-1.8291	2002Q1	-5.7644***	2000Q2
EC	-2.3474	1997Q2	-6.9702***	1994Q2
TI	-1.5416	1991Q4	-6.0117***	1998Q1
GDP	-2.1017	1993Q2	-5.6017***	2002Q2
TOP	-1.0502	1995Q4	-5.2119***	2001Q4
Critical value				
1%	-5.34			
5%	-4.93			
10%	-4.58			

*** display significance at 1% levels.

TABLE 3 Results of bayer and hanck cointegration.

	Fisher statistics	Fisher statistics	Cointegration
EF = f (FD, EC, TI, GDP, TOP)	EG-JO 16.9931	EG-JO-BO-BDM 28.4764	
	Critical value	Critical value	
5%	10.576	20.143	

density of distinctive adjustments inside a time sequence (Ali & Kirikkaleli, 2021).

3 Results and discussions

This paper intends to study the effects of FD on Pakistan’s environmental sustainability. As a first stage in estimating the model, the stationarity attributes of the data are examined by employing the Zivot and Andrews test for unit root. The unit root process has been used to determine a series of stationary factors resembling a structural break. As can be seen in Table 2, the unit root approach shows that none of the factors are stationary at the level. Besides, after the first difference, all of the elements become stationary.

The current study also uncovers the cointegration properties of parameters by utilizing the combined Bayer and Hanck cointegration test. Table 3 summarises the Bayer and Hanck test’s findings. At the 5% significance level, the outcomes specify that long-term cointegration continues between EF, FD, EC, TI, GDP, and TOP.

Results from Table 4 denote that FD reduces EF by 0.182% in FMOLS, 0.195% in DOLS, and 0.188% in CCR. It infers that

TABLE 4 Long-run results.

Variables	FMOLS	DOLS	CCR
FD	-0.1821*** (0.0032)	-0.1951*** (0.0009)	-0.1879*** (0.0071)
EC	0.2621*** (0.0021)	0.2949** (0.0413)	0.2748** (0.0214)
TI	-0.1591*** (0.0000)	-0.1782*** (0.0003)	-0.1967*** (0.0009)
GDP	0.2277*** (0.0075)	0.2537** (0.0145)	0.2726** (0.0361)
TOP	0.2811** (0.0352)	0.3027* (0.0619)	0.2968** (0.0247)
Constant	-2.2152*** (0.0000)	-2.3992*** (0.0000)	-2.4118*** (0.0000)
R ²	0.9314	0.9422	0.9488
Adjusted R ²	0.9521	0.9328	0.9247

*, **, and *** show significance at 10, 5, and 1% levels, correspondingly.

many ecological safety recommendations, like fiscal expenditures and environmental expenditures, are also executed through FD. According to the results, FD is linked with much more optimized and efficient monetary and fiscal practices, which may improve atmosphere sustainability via committed legitimacy. Wang & Lei (2016) contended that better FD enhances the ecological atmosphere because local authorities can devote more capably than the federal government due to the data benefit. These

TABLE 5 Results of Frequency domain causality test.

Direction of causality	Long-term		Medium-term		Short-term	
	$\omega_i = 0.01$	$\omega_i = 0.05$	$\omega_i = 1.00$	$\omega_i = 1.50$	$\omega_i = 2.00$	$\omega_i = 2.50$
FD →EF	5.5414* (0.0615)	5.6558* (0.0821)	0.1019 (0.4401)	0.1451 (0.8178)	0.1944 (0.4391)	0.1647 (0.7144)
EC→EF	6.6583** (0.0411)	6.7655** (0.0357)	6.9421** (0.0414)	6.8421** (0.0151)	2.2443 (0.4577)	2.6048 (0.2148)
TI→EF	8.8475** (0.0351)	8.9578** (0.0269)	0.5221 (0.7787)	0.5437 (0.3775)	0.5838 (0.4717)	0.6050 (0.6288)
GDP→EF	9.8474*** (0.0005)	10.0877*** (0.0000)	5.8226** (0.0411)	5.9942** (0.0442)	0.2214 (0.6724)	0.2588 (0.7337)
TOP→EF	7.5871** (0.0394)	7.7993** (0.0412)	0.2181 (0.4711)	0.2655 (0.52175)	0.1488 (0.7941)	0.1915 (0.6988)

The values within () show the p -value. → Specifies the path of causality. *, **, and *** specify significance at 10, 5, and 1% levels, correspondingly. SIC, defines the lag lengths for the VAR models.

outcomes are analogous to those of Tufail et al. (2021) and Yuan et al. (2022). Overall, present estimates indicate that FD can be utilized as a productive tool to reduce EF. The empirical findings of the study show that FD decentralisation enhances ecological quality. Therefore, for ecological sustainability, a higher level of FD is necessary. As a result, it is crucial to explain roles at various stages of authority to attain the goal of lower pollution successfully.

As per the EC outcomes, a 1% increase in EC raises EF by 0.262, 0.295, and 0.275%, respectively. Energy creation from fossil resources noticeably worsens environmental performance in Pakistan by raising pollution. Our findings are akin to those of Yang et al. (2021) and Shabir et al. (2022). It is hard to ignore the use of energy for a higher quality atmosphere because it is a necessary component of economic progression. Economic evolution raises the energy requirements by establishing new industries or expanding established ones, resulting in a rise in the country's pollution levels. Besides this, there is an urgent consideration to establish clean and advanced energy sources in order to reduce pollution without negatively impacting the ecosystem or economic progress.

The coefficient values of TI had a negative indication, implying a pollution-mitigation impact. A 1% rise in TI substantially lowers EF by 0.159, 0.178, and 0.197%, respectively. Implementing eco-friendly, greener technologies to increase energy efficiency is the most effective way to address environmental contamination. Environmental innovation is a strategy for promoting economic expansion and advancement while preventing ecological deterioration and biodiversity loss. Numerous empirical investigations have found that energy technology advancement is shifting toward greener and more innovative energy sources (Du et al., 2019). Similarly, Cantner et al. (2019) have revealed that factories and government entities are now creating significant financing for research and development to obtain workable remedies in sustainable and clean energy to acquire greener economic development and the atmosphere. Our findings undermine the conclusions of Chunling et al. (2021) and Awosusi et al.

(2022), who contended that TI utilizes energy sources to strengthen economic operations, which increases rather than decreases EF.

Table 4 also demonstrates that a 1% augmentation in GDP will lead to a 0.228, 0.254, and 0.273%, respectively, rise in EF. This demonstrates how growing GDP is preceded by surging EF in Pakistan. It must be mentioned that an expansion in a nation's GDP amplifies a powerful push on the atmosphere, and ongoing and inadequate consumption of natural resources in a region further damages environmental protection. So, the rate of EF will ultimately surge. This indicates that as the GDP upswings, countries will move their concentration to more industries, further hovering demand for high energy usage. Because of the high demand for consumption, the industry's use of nonrenewable energy is increasing. This type of energy usage is hazardous and inevitably raises the level of EF. The outcomes corroborate those of Kalmaz and Kirikkaleli (2019), Ji et al. (2021), Abid et al. (2022), and Akadiri et al. (2022).

Furthermore, at a 1% statistical level, TOP is positively connected to EF. The value of TOP denotes that a one percent rise in TOP raises EF by 0.281, 0.303, and 0.297%, respectively. The TOP outcomes are consistent with the findings of Danish et al. (2018) and Hashmi et al. (2020); they affirm the authenticity of a substantial relationship between TOP and environmental quality. The results revealed that the level of economic advancement is spreading due to the scale effect, which may exacerbate environmental pollution. The manufacturing of pollution-intensive goods causes more pollution. In recent times, the investigation of driving force has confirmed that trade density is the main factor in expanding emissions events (Wu et al., 2005).

A frequency-domain causality technique is utilized in this paper to assess the causal association among variables (see Table 5). The outcomes show that FD, TI, and TOP emit EF in the long term. Besides, EC and GDP contribute to EF in both the long and medium term. Hence, any policy change in FD, EC, TI, GDP, or TOP has aftermaths for EF in the long term. Similarly, any plan modification in EC and GDP also affects EF in the medium term.

4 Conclusion and policy recommendations

Given the ongoing dialogue over the reasons for environmental deterioration, this paper backs to the present literature by probing the effect of FD on the EF in the existence of EC, TI, GDP, and TOP in the case of Pakistan from 1990 to 2018. The econometric strategies provide significant results: i) all parameters are integrated to the same order of I (1); ii) long term cointegrating associations exist among variables; iii) FD and other control variables such as EC, TI, GDP, and TOP are crucial elements in the context of ecological footprint; iv) an increase in FD, and TI decrease EF in Pakistan; v) EC, GDP, and TOP are unfavorable for environmental performance; vi) there is confirmation of a long term causality between FD and EF, EC and EF, TI and EF, GDP and EF, TOP and EF.

Regarding policy concerns, this research implies that Pakistan could effectively incorporate policies to boost ecological performance by permitting a lower level of government. As a result, confirmation of duties at various stages of government is required to attain the energy-saving capabilities of fiscal spending. Moreover, an enhancement in technological innovation can help reduce ecological footprint efficiently; therefore, it is essential to pay attention to environment-conscious, highly developed innovations that transform economic development contributing factors aside from nonrenewable energies and toward green and clean energy sources. These eco-friendly developments have far-reaching ramifications for the environment and climate change. Besides that, economic structures in Pakistan must be amended to promote innovation.

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Future work on Pakistan should concentrate on other combinations of accessible factors relating to fiscal decentralization and environmental quality. In addition, in the case of Pakistan, the future could also concentrate on determining the threshold level of FD that optimizes economic development. Another issue is that we only utilized Pakistan as a test example. In the upcoming investigation, the study's results can be applied to different groups of nations, like the G20.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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