



Analyzing the linkage between military spending, economic growth, and ecological footprint in Pakistan: evidence from cointegration and bootstrap causality

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Abstract

The ecological consequences of military spending is a hugely neglected area, and a veil of mystery surrounds this topic. The environmental threats posed by militaries remain insufficiently investigated in the name of national security. Prompted by the internal and external conflicts and prolonged military dictatorships, the Pakistani military assumes a role that goes beyond that of a traditional army. The current study addresses this significant gap in the literature by investigating the impacts of military spending on economic growth and the ecological footprint in Pakistan from 1971 to 2016 using the combined cointegration test and the bootstrap causality test. The findings of the study unveil a positive impact of military spending on the ecological footprint, while a negative impact on economic growth. The outcomes of the bootstrap causality test of Hacker and Hatemi-J (2012) highlight that economic growth Granger causes military spending, while causality runs from military spending to the ecological footprint. Energy consumption contributes to the ecological footprint and economic growth, whereas education expenditures do not influence economic growth and the environment in the long run. Further, the findings suggest a U-shaped link between GDP and footprint in Pakistan. The authorities should focus on resolving external and internal conflicts, on a priority basis, and reduce military spending to improve economic growth and the environment.

Keywords Bootstrap causality test · Bayer and Hanck cointegration test · Military spending · Pakistan · Ecological footprint · Energy consumption

Introduction

Militaries, comprised of sophisticated weapons, vast infrastructure, military bases, and personnel, represent one of the

important institutions in modern society (Clark et al. 2010). Military institutions are critical for the sovereignty of a nation; however, the operation of such institutions can influence economic growth and the natural environment. The current study aims to investigate the effect of military spending on economic growth and ecological footprint in Pakistan.

The relationship between military spending and economic growth has been a controversial subject with conflicting arguments. The classical school argues that military expenditures impede economic growth because high military expenditures can crowd out private investment by pushing interest rates up. The military expenditures are also associated with corruption. In fact, the arms industry is considered the most non-transparent and corrupt of all the industrial sectors (Erdoğan et al. 2020a). On the other hand, the Keynesian school advocates that high military spending increases aggregate demand, improves infrastructure, upsurges production, and reduces unemployment (Wijeweera and Webb 2011; Korkmaz 2015). However, it is not only the theoretical investigation that has failed to agree about the relationship between military

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spending and economic growth, empirical studies also provide mixed evidence for this relationship (Ahmed et al. 2019).

The ecological damage caused by militaries is a subject of concern over the past few decades. Singer and Keating (1999) argue that military activities defile the environment by depleting resources, extinguishing natural flora and fauna, and leaving radioactive elements and toxins. According to Solarin et al. (2018), military spending stimulates environmental damage because the movement of large military equipment, military personnel, and other resources, via land, sea, and air transportation, require fossil fuel consumption. Apart from this, military operations use a massive quantity of oil in planes, ships, and tanks, which increases CO₂ emissions. Bradford and Stoner (2014) suggest that military spending reduces the biocapacity of nations as it finances the operations that destroy the productive area (land and sea) and also refrains the productive uses of scarce resources. Jorgenson and Clark (2009) further add to the argument that militaries consume not only a massive amount of resources but also generate enormous waste because the testing, sustaining, and supporting of weapons generate deadly toxins that pollute the water and land. According to Jorgenson et al. (2010), militaries use vast areas of land for military bases and consume a huge chunk of non-renewable energy in transportation and infrastructure, which eventually degrades the environment. Military bases, buildings, houses, and other infrastructure reduce the productive area. Military exercises use energy and other resources, and military personnel require resources, such as food, uniform, energy, and others, which can increase the ecological footprint.

Besides, the weapons of mass destruction are even a more significant threat to the biosphere. The testing of nuclear bombs generates radioactive fallout. Production, transportation, and storage of biological and chemical weapons release toxins. However, the environmental damage linked to militarization is not limited to the conflicts, even during the peacetime, defense sector degrades the environment by consuming fossil fuels and other resources (Bildirici 2016). In contrast, Solarin et al. (2018) report that military spending mitigates environmental degradation. They argue that military spending has led to numerous technological breakthroughs in the field of information and communication technology, which has reduced environmental degradation through the dematerialization of production processes and promoting the less resource-intensive society.

It is immensely important to inspect the impact of military spending on the ecological footprint in Pakistan due to several reasons. Pakistan has a strong military force, comprising of about 617,000 personnel, and additional 500,000 reservists (Aguilar et al. 2011). Pakistan military possesses nuclear capabilities as well as other modern weapons, such as aircraft, tanks, submarines, which rely on fossil fuels. Unlike other countries, the role of the military in Pakistan is not only

confined to its sovereignty but also has expanded to internal security and governance. Internal threats, including violent separatist movement in the Balochistan Province and extremists' attack in the northwestern regions, have intensified the role of Pakistan's military, which has also ruled the country for more than 35 years (Wijeweera and Webb 2011). Pakistan has experienced three major wars against neighbor India since 1947, and it is required to keep a large number of troops on the eastern border due to Kashmir conflict with India. Historically troubled relations with India, the Kashmir's conflict, the Afghan war, and internal insurgencies have further heightened military spending. Pakistan allocates a substantial portion of its scarce resources to the defense sector in spite of having a weak domestic economy (Yildirim and Öcal 2006). Pakistan's defense expenditure remains very high, on average more than 5% of GDP from 1971 to 2016. The military expenditure of Pakistan in absolute terms has increased from 739 million (current US dollars) in 1971 to a significant amount of 10,063 million (current US dollars) in 2016 (SPIRI 2017). According to WDI, the military expenditures of Pakistan are approximately 3.60% of GDP in 2016, which are higher than the military spending of the USA (3.20% of GDP), China (1.92%), India (2.50%), and France (2.32%). However, these expenditures are lower than the military expenditures of Saudi Arabia (9.87%) and Israel (4.63%). Pakistan's military expenditures as a percent of total general government expenditures are over 18% in 2016, while this figure is around 9.16, 6.03, 9.08, and 4.11% in the USA, China, India, and France, respectively. On the one hand, high military spending, for a developing country like Pakistan, can reduce investment in more productive sectors, such as education and health. On the other hand, excessive reliance on non-renewable energy consumption in the military sector leads to environmental problems. Pakistan's ecological footprint has increased at a rapid pace due to growing per capita consumption. The country's biocapacity has reduced, causing an ecological deficit (Danish et al. 2019). Pakistan is already facing the consequences of global climate change. The Global Climate Risk Index (CRI) has ranked Pakistan among the top ten countries, which are most affected by global climate change (Kreft et al. 2016).

Several studies have investigated the effect of military spending on economic growth in Pakistan with varying results about the effect of military spending on economic growth and causal direction between variables (Wijeweera and Webb 2011; Anwar et al. 2012; Shahbaz et al. 2013; Amir-ud-Din et al. 2019). Further, the ecological consequences of military spending have not been analyzed in Pakistan. According to Polsterer (2015), militarization is the biggest cause of environmental degradation, but a considerably neglected area. Therefore, the current study examines the linkage between military expenditures, economic growth, and the ecological footprint in Pakistan.

We contribute to the existing literature in many ways. First, we investigate the long- and short-run effects of military spending on economic growth and the environment in Pakistan. As per our knowledge, the impact of military spending on the environment has not been explored in Pakistan, which represents a perfect sample to conduct such a study as this country reflects all the characteristics required to witness this relationship. Secondly, we employ the ecological footprint of consumption as an environmental indicator, considering the broader effects of militarization on the environment. Military spending harms the environment in several ways (Clark and Jorgenson 2012), and CO₂ emissions only reflect a small portion of environmental degradation (Charfeddine and Mrabet 2017). The ecological footprint captures the effects of human activities on nature in terms of water, soil, and air, and it is used in many recent studies because of its comprehensiveness and reliability (Destek and Okumus 2019; Ulucak et al. 2020). Also, we use some advanced econometric techniques, such as the combined cointegration methods of Bayer–Hanck and bootstrap corrected-causality test of Hacker and Hatemi-J (2012). Unlike other causality approaches, bootstrap causality approach is reliable irrespective of sample size, variables' order of integration, and even in the case of heteroscedasticity in the model. The combined cointegration test generates consistent and reliable results and eliminates indecisiveness caused by varying outcomes of different cointegration techniques. In addition, the ARDL approach is used to examine the long- and short-run relationship among variables, which is famous for its reliable performance in the case of small sample size and fractional integration.

Literature review

Military spending and economic growth

The influential studies of Benoit (1973) and Benoit (1978) have initiated an important debate regarding the role of defense spending in the economic growth of a country. The findings have disclosed a positive effect of defense spending on economic growth. These results oppose the general view that defense spending retards economic growth. The author suggests that it is not factual to assume that the income not spent on defense will go to more productive use. In fact, only a small portion of such income goes to productive use, and much of this income is spent on consumption and social investment. The defense sector contributes to economic growth in several ways. For instance, it provides medical care and education as well as technical and vocational training and also

participates in infrastructure development, such as airports, dams, roads, bridges, and communication networks. Moreover, the engagement of the military sector in technical and scientific specialties, and military research and development programs improve civilians' skills and promote economic growth.

After this initial work, numerous studies have investigated the effect of military spending on economic growth. Some scholars support the argument that military spending boosts economic growth. For instance, Alptekin and Levine (2012) for developed countries, Augier et al. (2017) for China, Chen et al. (2014) for high-income and middle-income countries, and Daddi et al. (2018) for Italy, report similar results. Further, Coutts et al. (2019) strengthen this argument by reporting that military spending does not crowd out government expenditure on other productive sectors in the MENA region.

Some scholars argue that military spending retards economic growth as it crowds out private and public investment. For instance, Korkmaz (2015) reports that military spending reduces economic growth and employment in 10 Mediterranean countries. He further argues that when the government allocates a significant share of GDP to the defense sector, it leaves fewer resources for education, infrastructure, and health. Using data from 197 countries, Fan et al. (2018) disclose that military expenditures crowd out investment in other sectors, such as health. Deger and Smith (1993) document that military spending impedes the economic growth of less-developed countries. Likewise, the negative relationship between military spending and economic growth has been reported by Chang et al. (2014) for the UK and Canada, Al-Hamdi and Alawin (2017) for most of the Middle East countries, d'Agostino et al. (2017) for different country groups, Ahmed et al. (2019) for Myanmar, Kentor and Kick (2015) for developed as well as less-developed nations, and Dunne and Tian (2016) for a panel of 97 countries.

However, in the case of Pakistan, Wijeweera, and Webb (2011) report a positive relationship between military spending and economic growth. Shahbaz et al. (2013) report a negative impact of military spending on economic growth, but causality from military spending to economic growth. In contrast, Khan (2004) report bidirectional causality between military spending and economic growth. He argues that defense spending does not hinder the economic growth of Pakistan. However, Yildirim and Öcal (2006) indicate no causality from defense spending to growth, while Anwar et al. (2012) report causality from economic growth to military expenditure in Pakistan. Nevertheless, in the opinion of Shahbaz et al. (2013), the results regarding the linkage between economic growth and military spending are inconclusive, and the findings depend on methodology, sample countries, and period under study.

Military spending and the ecological footprint

The impact of military spending on the environment has been a neglected area until Hooks and Smith (2005), who describe the destructing role of militaries as “treadmill of destruction” theory. The authors argue that militarism harms the environment during conflicts and peacetime. After this early work, some studies have analyzed the impact of military spending on CO₂ emissions (Bildirici 2016, 2017a, b). However, very limited studies have discussed the relationship between military spending and the comprehensive environmental indicator like the ecological footprint, even though the environmental damages caused by militaries are broader than the energy use and emissions (Gould 2007; Clark and Jorgenson 2012). The studies focusing on the linkage between military spending and the ecological footprint are discussed below.

Solarin et al. (2018) investigate the impact of military spending on the environment in the USA from 1960 to 2015. The results from different time series methods indicate that military spending reduces the ecological footprint. However, the impact of military spending on emissions remained mixed. The authors argue that military spending can reduce as well as increase environmental problems. Military research and development lead to the development of many key technologies that reduce energy consumption, whereas the use of fossil fuels and enormous resource consumption in the military sector increases environmental problems. Jorgenson and Clark (2009) analyzed the linkage between military spending and ecological footprint in developed and less-developed countries. The outcomes of the panel regression model support the argument that military spending increases the ecological footprint. However, their study has some limitations as it used panel data (1972–2005) with 5 years of interval, maximum of 6 observations per country and minimum of 3 observations. Likewise, Jorgenson et al. (2010) further strengthen this argument by examining the effect of military spending on ecological footprint and emissions. They report similar results using data set from 1970 to 2000 with similar limitations. Besides, Bradford and Stoner (2014), using panel data from 142 countries, suggest that military spending significantly reduces the biocapacity of nations.

From the above literature, it is clearly noticeable that research work on the linkage between military spending and the ecological footprint is insufficient. As per our knowledge, no previous study has explored this relationship in Pakistan. Also, the literature on military spending and economic growth report mixed results in Pakistan. The current work addresses this gap and analyzes the linkage between military spending, economic growth, and ecological footprint in Pakistan from 1971 to 2016.

Data and methodology

Models and data

The current research explores the influence of military spending on economic growth and the environment in Pakistan. To accomplish this objective, we use the ecological footprint of consumption as the proxy for environmental degradation which measures the effects of human activities on nature in terms of grazing land, crops land, forest area, oceans, and infrastructure footprint (buildup land) (Ahmed et al. 2020b). It is a widely accepted, reliable, and comprehensive indicator of environmental impact, and many international environmental institutions use it in their policy reports (Ahmed and Wang 2019).

Military spending can reduce as well as increase economic growth (Shahbaz et al. 2013) and the ecological footprint (Solarin et al. 2018). According to Zafar et al. (2018), energy consumption contributes to economic growth while Ahmed et al. (2019b) suggest that energy use increases EFP. The ecological footprint is a frequently used measure of environmental degradation in recent literature (Ahmed et al. 2020b). An increase in environmental degradation can reduce economic growth by negatively affecting human health and decreasing labor productivity (Ahmed et al. 2019). Also, an increase in the ecological footprint leads to resource depletion and climate change (Ahmed et al. 2019b), which may negatively affect the economic growth of a country. However, Uddin et al. (2017) reveal that economic growth stimulates the ecological footprint, while Uddin et al. (2016) suggest that environmental degradation is linked to the stage of economic development. Besides, investment in education promotes economic growth (Reza 2012; Liao et al. 2019) and reduces environmental degradation (Chankrajang and Muttarak 2017; Ahmed and Wang 2019).

Assessing the inconclusive debate on military growth nexus, this study has modeled the long-run determinants of economic growth for Pakistan economy by assuming following functional form of Cobb–Douglas production:

$$Y_t = A_t F(CA_t^{\alpha_1} N_t^{\alpha_2}) \quad (1)$$

where economic growth (Y) drives from inputs of capital (CA) and labor (N). Total factor productivity (A) determines the responsiveness and efficiency level of factors of production. Moreover, elasticities of inputs α_1 and α_2 are exhibiting constant returns to scale, where $0 < \alpha < 1$, after considering $(\alpha_1 + \alpha_2) = \alpha$. Due to unavailability of continuous data of labor force of Pakistan, this study has constructed estimated model without inclusion of output per worker. However, capital formation (CA), military spending (ME), energy consumption (ENG), and ecological footprints (F) have

added to the model to assess our objectives and transformed Eq. (1) to Eq. (2).

$$Y_t = A_t F(CA_t^{\alpha_1} \cdot ME_t^{\alpha_2} ENG_t^{\alpha_3} \cdot F_t^{\alpha_4}) \tag{2}$$

where

$$A_t = A_n e^{gt} \tag{3}$$

In Solow mode, the steady state of growth is equal to A that can empirically estimate with any change in technology or total factor productivity. However, A_t (which is function of A_n) is the stock of initial endowment related to knowledge and t is to measure time frame. This allows inclusion of education expenditures (ED) as an additional explanatory variable to translate the initial endowment related to knowledge. By normalizing all variables, we can have Solow growth function as:

$$Y_t = A_t F(CA_t^{\alpha_1} ME_t^{\alpha_2} ENG_t^{\alpha_3} F_t^{\alpha_4} ED_t^{\alpha_5}) \tag{4}$$

Knowing the fact that, steady state of economic growth, dependent on output per labor, contributes in factor productivity (g) it varies country to country with reference to literacy rate and skillset of labor force. Moreover, the economic growth function expands after applying the natural log specification on (4) and including (3) in production functions:

$$Ly_t = \alpha_0 + \alpha_1 LCA_t + \alpha_2 LME_t + \alpha_3 LENG_t + \alpha_4 LF_t + \alpha_5 LED_t + \mu_t \tag{5}$$

The growth model is used to explore the effect of military spending on growth. We used symbol G for economic growth instead of Y and rearranged variables in Eq. (6) for our final model.

$$LG_t = \vartheta_o + \vartheta_1 LENG_t + \vartheta_2 LME_t + \vartheta_3 LF_t + \vartheta_4 LED_t + \vartheta_5 LCA_t + \mu_t \tag{6}$$

In order to study the effect of military spending on the ecological footprint in Pakistan, we adapted the model used by Bildirici (2016) and Bildirici (2017a) to assess the relationship between military, growth, and emissions nexus in the USA and G7 nations, respectively.

$$LC_t = \vartheta_o + \vartheta_1 LG_t + \vartheta_2 LENG_t + \vartheta_3 LME_t + \mu_t \tag{7}$$

However, military spending can influence the environment through various channels (Clark and Jorgenson 2012), and CO₂ emissions are only useful in capturing the effects of energy consumption (Dogan et al. 2020). Also, Demir et al. (2020) argue that economic growth at an initial stage upsurges environmental deterioration due to an enormous surge in economic activities along with the prevalent tendency to achieve development. However, this relationship changes with more

development as the tendency toward a green environment grows followed by a better regulatory framework, environmental awareness, and innovation. Hence, a non-linear relationship and the EKC between LG and LF is quite possible (Ahmed and Wang 2019). Lastly, the classical school argues that military spending can crowd out investment in education and other sectors, and in a recent study, Ahmed et al. (2019) suggest considering education expenses in the model to better understand this nexus. Based on these arguments, we modified Eq. (7) by replacing CO₂ emissions with footprint (LF) and including non-linear term of growth (LG²) and education expenses (LED) in the model.

$$LF_t = \vartheta_o + \vartheta_1 LG_t + \vartheta_2 (LG_t)^2 + \vartheta_3 LENG_t + \vartheta_4 LME_t + \vartheta_5 LED_t + \mu_t \tag{8}$$

In Eq. (8), LF indicates the ecological footprint per capita, which is our dependent variable. LG is per capita economic growth, and LG² is the quadratic term of economic growth to examine the effect of a high level of economic growth on the environment. LENG, LME, and LED in Eq. (8) represent energy consumption, military spending, and education expenses, respectively. Variables, units of measurement, and data sources are explained in Table 1.

Following some previous studies, the variables are transformed into natural logarithms to compute reliable results (Charfeddine and Ben Khediri 2016; Shahbaz et al. 2018a, b). The period of the study, from 1971 to 2016, is selected on the bases of data availability for the ecological footprint. We collected the data on military spending from the

Table 1 Variables

Variables	Symbol	Measurement	Data source
Economic growth	LG	Gross domestic product measured in per capita constant 2010 US \$	World Development Indicators
Energy consumption	LENG	Energy consumption kg of oil equivalent per capita	WDI
Militarization	LME	Military expenditure (defense expenditure) as a percentage of GDP	Stockholm International Peace Research Institute (SIPRI)
Ecological footprint	LF	Ecological footprint of Consumption (measured in global hectares per capita)	Global Footprint Network
Educational expenses	LED	Government expenses on education, total (percentage of GDP)	WDI
Capital	LCA	Gross fixed capital formation (per capita 2010 constant US \$)	WDI

Stockholm International Peace Research Institute (SPIRI 2017). The data on the ecological footprint (LF) are acquired from the GFN.¹ The data on energy consumption (LENG), education expenditure (LED), economic growth (LG), and capital formation (LCA) are acquired from the World Bank.

Empirical strategy

The procedure to examine the cointegration requires testing the stationary properties of all variables (Gedikli et al. 2019; Erdoğan et al. 2020b). Current study employed the commonly used DF-GLS and ADF tests. However, these tests may provide biased results due to the presence of structural breaks. Therefore, the structural break unit root tests, including Zivot and Andrews (1992) and Perron (1997), are used which are appropriate in case of an unknown structural break.

There are various cointegration techniques available in the previous literature; however, different cointegration tests possess different strengths and weaknesses. Therefore, the results generated by cointegration tests often differ, causing confusion about the presence of a long-run equilibrium relationship. Bayer and Hanck (2013) provide a solution for such a situation by developing a combined cointegration method, which generates a Fisher statistics based on four cointegration methods. The application of the combined cointegration test produces two Fisher statistics, i.e., EG-JOH-BO-BDM and

EG-JOH, which are compared with the critical values presented by Bayer and Hanck (2013). Fisher statistics larger than the critical values imply a long-run equilibrium association. The combined cointegration test produces consistent results and unambiguous decisions because it combines four different cointegration tests. Based on these benefits, current work employed the combined cointegration method.

However, traditional cointegration methods do not account for the structural breaks in the data, and their outcomes are often not trustworthy in the case of the fractional order of integration and small sample size. Current research uses a small size (1971–2016) of merely 46 yearly observations, and series have structural breaks. This leads us to employ the famous ARDL methodology in the presence of structural breaks. The ARDL technique is widely used in energy and environmental research because of its unique advantages. This method offers the flexibility to include variables regardless of uniform or fractional integration (1(0) and, or 1(1)). However, the variables stationery at 1(2) cannot be estimated using the ARDL framework. The results of the ARDL are reliable for small sample sizes (Ari and Cergibozan 2017) and even in the presence of some endogenous variables. Apart from this, this technique produces both short-run and long-run results as the UECM integrates long- and short-run dynamics. The following ARDL models are constructed to achieve our objectives.

$$\begin{aligned} \Delta(LG)_t = & \beta_o + \beta_{DY}DY + \sum_{k=1}^p \beta_{1k} \Delta(LG)_{t-k} + \sum_{k=0}^p \beta_{2k} \Delta(LENG)_{t-k} + \sum_{k=0}^p \beta_{3k} \Delta(LME)_{t-k} \\ & + \sum_{k=0}^p \beta_{4k} \Delta(LF)_{t-k} + \sum_{k=0}^p \beta_{5k} \Delta(LED)_{t-k} + \sum_{k=0}^p \beta_{6k} \Delta(LCA)_{t-k} + \beta_G(LG)_{t-1} + \beta_{ENG}(LENG)_{t-1} \\ & + \beta_{ME}(LME)_{t-1} + \beta_F(LF)_{t-1} + \beta_{ED}(LED)_{t-1} + \beta_{CA}(LCA)_{t-1} + \mu_t \end{aligned} \quad (9)$$

$$\begin{aligned} \Delta(LF) = & \chi_o + \chi_{DY}DY + \sum_{k=1}^p \chi_{1k} \Delta(LF)_{t-k} + \sum_{k=0}^p \chi_{2k} \Delta(LG)_{t-k} + \sum_{k=0}^p \chi_{3k} \Delta(LG^2)_{t-k} \\ & + \sum_{k=0}^p \chi_{4k} \Delta(LME)_{t-k} + \sum_{k=0}^p \chi_{5k} \Delta(LENG)_{t-k} + \sum_{k=0}^p \chi_{6k} \Delta(LED)_{t-k} + \chi_F(LnF)_{t-1} \\ & + \chi_G(LG)_{t-1} + \chi_{G^2}(LG^2)_{t-1} + \chi_{ME}(LME)_{t-1} + \chi_{ENG}(LENG)_{t-1} + \chi_{ED}(LED)_{t-1} + \mu_t \end{aligned} \quad (10)$$

Equation (6) is transformed into Eq. (9), while Eq. (8) is transformed into Eq. (10) with dependent variables of economic growth and the ecological footprint, respectively. In these equations, short-run parts are written with (\sum) signs, Δ denotes first difference operator, DY represents dummy variable for the respective break in the dependent variable, and μ_t signifies error term.

The short-run parameters are articulated from β_1 to β_6 in Eqs. (9) and (10), followed by the long-run

portions. The null hypothesis of the bound test for Eq. (4) ($H_0: \beta_G = \beta_{ENG} = \beta_{ME} = \beta_F = \beta_{ED} = \beta_{CA} = 0$) implies no cointegration, and it is checked against the alternative hypothesis of cointegration ($H_1: \beta_G \neq \beta_{ENG} \neq \beta_{ME} \neq \beta_F \neq \beta_{ED} \neq \beta_{CA} \neq 0$). To analyze the presence of cointegration, F statistics computed by the bound test is compared with upper and lower critical bounds tabulated by Narayan (2005). The existence of the long-run equilibrium relationship requires the F statistics to exceed the upper critical bound. In case, the F statistics comes between lower and upper critical

¹ <https://www.footprintnetwork.org/> provides data on the ecological footprint.

bound, and the decision of cointegration is made based on negative and significant error correction term (ECT). The critical values computed by Narayan (2005) are increasingly used because of their suitability for small a sample size of 30 to 80 observations. After ensuring the presence of cointegration in both models, the ARDL approach is used to examine the long and short-run impact of each regressor on dependent variables by estimating Eqs. (9) and (10). In addition, some diagnostic tests, as well as parameter stability tests, are conducted to confirm the reliability of the analysis.

Long-run results are useful to explore the effect of each regressor on the dependent variables; however, causal directions are also vital for policy implications. The VECM and Toda and Yamamoto causality methods are widely used in the literature. After the unit root revolution, causality tests have been modified to achieve more reliable results. One such modification that attracts the attention of scholars is the Toda and Yamamoto (1995) technique, which combines optimum lag length (k) and variables' maximum order of integration (d_{\max}) to determine the maximum lag length ($K + d_{\max}$ = maximum lag length). The flexibility of this approach regarding no requirement for pre-testing of unit root and cointegration and simple application makes it a reliable technique to estimate causal relationships (Ahmed et al. 2019a).

However, Hacker and Hatemi-J (2006) report that MWALD test of Toda and Yamamoto is unreliable in the case of a small sample size because it is based on asymptotic distribution. Moreover, the study of Hacker and Hatemi-J (2006) provides a solution for this problem by suggesting the MWALD test based on bootstrap distribution, which reduces distortions caused by small sample size. According to Hacker and Hatemi-J (2012), an endogenized lag length increases the effectiveness of causality tests. Therefore, the bootstrap causality test is based on endogenous lag length choice, and the direction of causality is calculated by following a two-step bootstrapping process. In the first step, the optimum lag length is determined using bootstrapping. In the next step, the Wald statistic is computed for checking causality. Current study employs the bootstrap causality tests developed by (Hacker and Hatemi-J 2006, 2012) because of its advantages. The results of the bootstrap causality test are also verified by using the causality test of Toda and Yamamoto (1995). The bootstrap causality approach is reliable regardless of sample size and the order of integration, and even the presence of heteroscedasticity (ARCH) does not influence the validity of its outcomes (Ahmed et al. 2020a).

The null hypothesis of the bootstrap causality approach is checked by using the following modified Wald test statistics.

$$MWALD = (G\varphi)' \left[G \left((Z'Z)^{-1} \Theta \theta_U \right) G' \right]^{-1} (G\varphi)' \sim X^2_k \tag{11}$$

Table 2 Descriptive statistics

	LG	LENG	LME	LF	LED	LCA
Mean	6.6024	5.9856	1.6253	-0.3051	2.5794	4.9875
Median	6.6735	6.0326	1.7205	-0.2864	2.6011	5.0302
Maximum	7.0131	6.2610	1.9447	-0.0960	2.8541	5.2553
Minimum	6.1176	5.6531	1.1220	-0.4733	1.9660	4.5829
Std. dev.	0.2773	0.1970	0.2830	0.1171	0.1943	0.1753

where G is an indicator matrix $k \times n(1 + n(k + d))$ which identifies the restriction implied by the null hypothesis, Θ symbolizes the Kronecker product, θ_U indicates the computed variance-covariance residual matrix, and $\varphi = VEC(F)$ (where VEC = column stacking operator). The rejection of the null hypothesis of non-Granger causality requires a computed Wald statistics higher than the bootstrap critical bounds.

Results and discussion

We present some descriptive statistics in Table 2. The minimum value of economic growth (LG) is 6.11, whereas the maximum value is 7.013, and the standard deviation is 0.27. The ecological footprint has a maximum value of -0.09 and the minimum value of -0.47 with a mean value of -0.30. Military spending has an average value of around 1.62 in logarithm form. Minimum deviations from mean value are noticeable in most of the cases.

Results of unit root tests

The analysis is started by conducting some unit root tests, namely Dickey–Fuller GLS and the augmented Dickey–Fuller test. The results reported in Table 3 suggest the evidence of non-stationary at the levels. Nonetheless, all variables, namely, economic growth, military spending, energy consumption, capital, education expenses, and ecological footprint, are stationary at 1(1) under DF-GLS and ADF tests.

Next, we use the Zivot and Andrews and Perron (1997) tests, which increase the reliability of results by allowing an unknown structural break in each variable. The estimations of the PP and ZA test given in Table 4 disclose unit root in all variables at levels, but each variable is stationary at 1(1). These tests also identify breaks in variables, and some breaks can be related to some environmental laws or economic reforms, etc. For instance, the ecological footprint has breaks in 1985 and 2001 under ZA and PP tests, respectively. The break of 1985 in the ecological footprint coincides with the Pakistan Environmental Protection Ordinance 1983 (Sohail et al. 2014). It was the first comprehensive environmental legislation in Pakistan, which lead to the establishment of

Table 3 The DF-GLS and ADF unit root tests

Variables	DF-GLS		ADF			
	Levels	Difference	Levels		Difference	
	<i>T</i> stat	<i>T</i> stat	<i>T</i> stat	<i>P</i> values	<i>T</i> stat	<i>P</i> values
LG	-1.7345	-4.6790*	-1.57601	0.4858	-5.7078*	0.0000
LENG	-0.3856	-5.4318*	-1.8796	0.3385	-5.1603*	0.0001
LME	-1.6198	-4.0332*	-0.7362	0.8263	-4.0344*	0.0031
LF	-2.3864	-8.0999*	-1.5119	0.5181	-7.9447*	0.0000
LED	-2.2885	-4.0019*	-1.6303	0.4584	-7.2723*	0.0000
LCA	-0.7396	-4.6916*	-1.4049	0.5716	-6.3624*	0.0000

* shows significance level of 1%. Critical values of DF-GLS test are as follows: - 2.89 (10%), - 3.19 (5%), and - 3.77 (1%)

environmental protection agencies in the country, and it may have influenced the natural environment in the succeeding years. We include dummy variables to account for the break independent variables. Nonetheless, the findings indicate that series are stationary at difference; therefore, we can scrutinize cointegration.

Results of cointegration tests

We apply the combined cointegration method because variables are stationary at 1(1). The findings in Table 5 reveal that the computed Fisher statistics (EG-JOH) is greater than the critical bound of 1% and 5% in model 1 and model 2, respectively.

Table 4 Structural break unit root tests

Variables	Perron unit root test		ZA unit root test	
	<i>T</i> Stat	Break year	<i>T</i> stat	Break year
LG	-3.4114	1979	-3.7509	1980
LENG	-2.6544	2007	-1.3074	2007
LME	-3.3954	1981	-3.4500	1981
LF	-3.4488	1988	-3.4951	1989
LED	-3.4887	1996	-2.8097	1988
LCA	-3.2555	1981	-3.1357	1982
ΔLG	-6.3466*	1992	-6.3973*	1993
ΔLENG	-7.2280*	2007	-6.3856*	2007
ΔLME	-4.9880***	1992	-6.0144*	1994
ΔLF	-8.4654*	2001	-5.5128*	1985
ΔLED	-5.7947**	1983	-5.9350*	1983
ΔLCA	-6.8964	2006	-6.4666*	0.2087

*, **, and *** show 1% and 5%, and 10% significance level, respectively. Critical values: Perron test: 1% (- 5.92), 5% (- 5.23), 10% (- 4.92). ZA test: 1% (- 5.34), 5% (- 4.93), 10% (- 4.58)

Likewise, the Fisher statistics based on EG-JOH-BO-BDM also surpasses the critical bounds, rejecting the null hypothesis of no cointegration. Therefore, the long-run equilibrium relationship exists in both models. Similarly, the results reported in Table 6 indicate that the *F* statistics of the ARDL bound is more than the upper critical bound (UCB) in model 1 as well as in model 2. Therefore, both cointegration tests employed in this study reject the null hypothesis of no cointegration. It is worth mentioning that the lag length selection is very important before starting the analysis. An over specification or under specification of lag length can generate biased outcomes. The best way to select a suitable lag length is to use the VAR lag selection criteria. The study relied on the AIC criterion and a minimum optimum lag length 2 under AIC is selected through the application of the VAR. It is also assured that the models are stable and free from autocorrelation at this lag length. The lag selection process followed in this study and the use of automatic AIC lag length 2 is consistent with the work of Ahmed et al. (2015), Shahbaz et al. (2016), Shahbaz et al. (2017a, b), Jayanthakumaran et al. (2012), and Dogan (2015).

Short- and long-run results (growth model)

The long-run and short-run effects of regressors on growth (LG) are presented in Table 7. Military spending (ME) reduces economic growth in the long run. This outcome contradicts the results of Wijeweera and Webb (2011) and Khan (2004) for Pakistan; however, it coincides with the finding of Shahbaz et al. (2013) for Pakistan. This evidence opposes the Keynesian school but supports the argument of classical school that military spending impedes economic growth as it crowds out private and public investment. Also, in a country like Pakistan, the allocation of a high defense budget leaves less resources for other productive sectors due to the

Table 5 Combined cointegration test

Models analyzed	Fisher stat		Decision
	EG-JOH	EG-JOH-BO-BDM	
(LG/LENG, LME, LF, LnED, LCA)	17.8639*	73.5102*	✓
(LF/LG, LG ² ,LENG, LME, LnED)	11.2401**	28.8740**	✓
Critical values	Models 1 and 2 EG-JOH EG-JOH-BO-BDM		
1% critical values	15.701	29.850	
5% critical values	10.419	19.888	
10% critical values	8.276	15.804	

* and ** indicate 1% and 5% significance levels, respectively

unstable economy. This result also supports the view of Korkmaz (2015) that high defense spending decreases economic growth by reducing investment in education, infrastructure, and health.

The coefficient of ENG is significant, indicating that energy consumption (ENG) stimulates economic growth. Energy consumption is an important driver of economic growth (Erdoğan et al. 2019), and Pakistan’s economy depends heavily on energy sources, particularly fossil fuels, i.e., oil, coal, and gas. This result is in line with Shahbaz et al. (2012) for Pakistan. The coefficient of *F* (ecological footprint) is negative and significant. The ecological footprint (LF) represents environmental degradation in this model; therefore, this result implies that an increase in environmental degradation reduces economic growth in Pakistan. This is because more than half of Pakistan’s ecological footprint comprises of carbon footprint, and according to (Ahmed et al. 2019), the increase in emissions reduces economic growth due to negative effects on human health and labor productivity. Also, the high level of ecological footprint causes resource depletion and climate change (Ahmed et al. 2019b), and Pakistan has been a victim of global climate change. According to Kreft et al. (2016), Pakistan has faced an enormous economic loss

(about 3.93 billion US dollars) because of extreme weather events, such as floods and earthquakes. Surprisingly, education expenditures do not influence the economic growth in Pakistan in the long run. This evidence supports the argument of Reza (2012) that educated people in Pakistan get less opportunities to contribute to the economic development of the country due to the high unemployment level. Therefore, education expenses alone, in the absence of a system that could utilize the talent of people, cannot contribute to economic development. Also, Hanushek and Wößmann (2007) suggest that mere education spending does not foster economic growth. In fact, cognitive skills and quality of economic institution matters for the economic development, and significant skill deficits exist in the developing countries.

The coefficient of capital (LCA) is significant which implies that capital contributes to increasing economic growth in Pakistan. This result coincides with the estimates of Dogan (2015) and Shahbaz et al. (2017a) for India. This result directs that boosting investment in Pakistan’s infrastructure upsurges economic growth. It is a reasonable outcome since an increase in capital is an indication of more fiscal investment in the country’s infrastructure, which contributes to economic growth in the long run.

Table 6 ARDL bound test

Models	<i>F</i> stat	χ^2 LM	χ^2 ARCH	χ^2 RESET
(LG/LENG, LME, LF, LED, LCA)	5.0814**	1.2684 [0.2684]	0.3202 [0.5746]	1.9077 [0.1768]
[1, 1, 0, 2, 0, 0]				
(LF/LG, LG ² ,LENG, LME, LED)	4.5612**	0.91873 [0.1497]	0.2420 [0.6148]	0.1796 [0.674]
(1, 0,0,1,0,0)				
Critical values	LCB 1(0)	UCB (1(1)		
1% critical values	3.657	5.256		
5% critical values	2.734	3.920		
10% critical values	2.306	3.535		

**indicate the significance level of 5%. AIC optimal lag length 2 is computed by applying the VAR lag order criteria in E-views 10. For robustness tests *p*-values given in brackets are not less than 0.10 indicating stability of models

Table 7 Long-run and short-run results of the ARDL

Model = (LG/LENG, LME,LF, LED, LCA)							
Long run results				Short run results			
Variables	Coefficients	T stat	P value	Variables	Coefficients	T stat	P value
LENG	1.1162***	1.7926	0.0822	LENG	0.5612*	3.9339	0.0004
LME	- 0.2877**	- 2.3140	0.0270	LME	0.0012	0.1551	0.8776
LF	- 1.1380**	- 2.1825	0.0363	LF	- 0.0762	- 1.2860	0.2074
LED	- 0.0574	- 1.2373	0.2247	LED	- 0.0072	- 1.1531	0.2571
LCA	0.3378***	2.0032	0.0534	LCA	0.0010	1.2453	0.2218
DY ^a	0.0973	1.4591	0.1540	DY ^a	0.0306**	2.1032	0.0431
C	- 7.7520*	- 4.4371	0.0001	cointEq(- 1)	- 0.1347***	- 2.5271	0.0165
Diagnostic test							
R ²	0.9979						
Adjusted R ²	0.9973						
DW statistics	2.2333						
χ ² ARCH	0.3202 [0.5746]						
χ ² LM	1.2684 [0.2684]						
J-B	1.6402 [0.4403]						
normality							
χ ² RESET	1.9077 [0.1768]						

*, **, and *** represent significance levels of 1, 5, and 10%, respectively

^a DY represents dummy variable used for break in economic growth

In the short-run path, energy consumption increases economic growth, while other variables have no contribution to the economic growth except dummy variable that is positive and significant. The coefficient of lagged

ECT (-0.13) indicates a very slow convergence procedure to the long-run equilibrium, whereas its negative and significant coefficient further verifies the cointegration.

Table 8 Long-run and short-run results of the ARDL

Model = (LF/ LG, LG ² ,LENG, LME, LED)							
Long run results				Short run results			
Variables	Coefficients	T stat	P value	Variables	Coefficients	T stat	P value
LG	- 12.1977**	- 2.2465	0.0361	LG	- 17.4511**	- 2.5127	0.0207
LG ²	0.8767**	2.2373	0.0368	LG ²	1.3910**	2.6508	0.0153
LENG	2.0583*	2.9235	0.0084	LENG	- 0.2116	- 0.7215	0.4789
LME	0.3509**	2.2268	0.0376	LME	0.1241**	2.3243	0.0308
LED	0.01164	0.1449	0.8862	LED	- 0.2387**	- 2.5004	0.0212
DY ^a	- 0.0132	- 0.3533	0.7275	DY ^a	- 0.0500***	- 1.9043	0.0714
C	28.9531***	1.9532	0.0649	cointEq(- 1)	- 0.9822*	- 6.5436	0.0000
Diagnostic test							
R ²	0.9696						
Adjusted R ²	0.9392						
DW statistics	2.0758						
χ ² ARCH	0.2420 [0.6148]						
χ ² LM	0.9187 [0.1497]						
J-B	1.4535 [0.4834]						
normality							
χ ² RESET	0.1796 [0.6764]						

*, **, and *** represent significance levels of 1, 5, and 10%, respectively

^a DY represents dummy variable used for break in the ecological footprint

Short- and long-run results (environmental impact)

Now proceeding to our main model, the results in Table 8 show the effect of military spending on the environment in Pakistan. The coefficient of ME is significant, indicating that military expenditures (LME) increase footprint (LF) in Pakistan. This result is consistent with the panel studies of Jorgenson et al. (2010) and Jorgenson and Clark (2009). However, it contradicts the findings of Solarin et al. (2018) for the USA, who argue that military expenditures can reduce footprint through technological development. This finding can be justified because military spending damages the environment by consuming a massive amount of resources and generating enormous waste that pollutes the water and land. Also, militaries use fossil fuels in military operations, transportation, and military exercises. The military infrastructure, such as military bases, buildings, and others, reduces the productive use of land. Apart from this, military conflicts directly damage biodiversity by destroying the productive area (land and sea). Pakistan's military relies on fossil fuels, and military bases cover a vast area of land. Moreover, there is no noticeable technological development associated with military research and development that could promote a less resource-intensive lifestyle in Pakistan's context. Energy consumption (LENG) increases the ecological footprint (LF). This result is consistent with the majority of previous studies that report a positive impact of fossil fuel consumption on LF (Ahmed et al. 2019b; Destek and Okumus 2019).

The coefficient of LG is negative, and the coefficient of the non-linear term (LG^2) is positive. Moreover, both economic growth and non-linear term of economic growth are significant, indicating a U-shaped relationship between LG and LF. This result implies that the EKC hypothesis between economic growth (LG) and the ecological footprint (LF) does not hold in Pakistan. Nonetheless, the U-shaped association between these variables is in line with many recent studies, for instance, Destek et al. (2018) for EU countries; Destek and Sarkodie (2019) for Turkey, India, Thailand, China, and South Korea; and Sarkodie (2018) for 17 African countries. This relationship is a worrying sign for Pakistan as it indicates that the increase in income, after a certain level, will intensify the ecological footprint, and current environmental policies are inadequate to reduce the ecological footprint. Education expenses do not influence the ecological footprint. This finding opposes the view that education reduces environmental degradation by promoting environmental awareness (Chankrajang and Muttarak 2017; Ahmed and Wang 2019). In a developing country like Pakistan, environmental awareness is uncommon, and even most of the educated people do not know about environment protection and sustainable lifestyle. Therefore, the relationship between education and the environment is insignificant in the long-run.

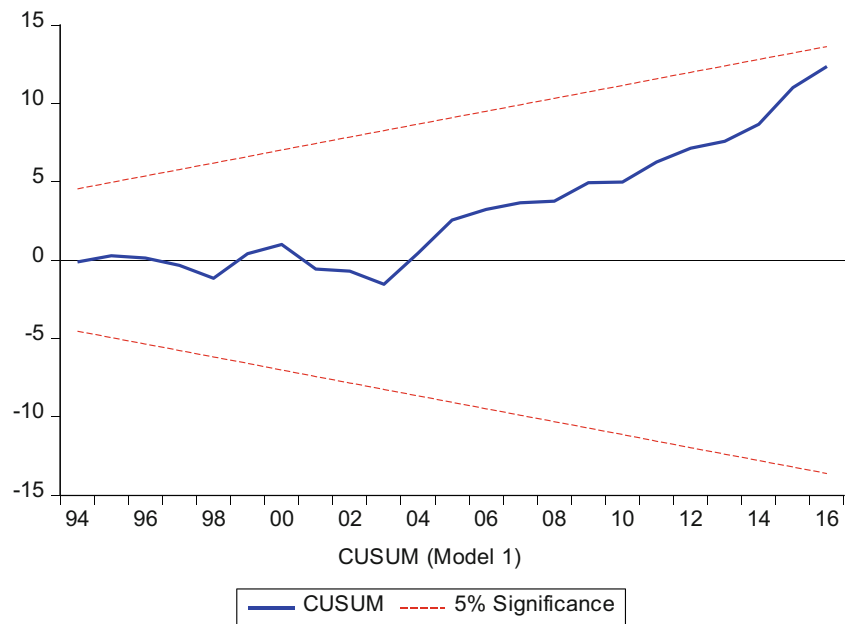
Proceeding to short-run estimates, military spending increases environmental degradation in the short run. Similar to the long run, the U-shaped relationship between income and environment exists in the short run. Besides, education expenses reduce environmental degradation in the short run; hence, there is some evidence of environmental awareness based on education only in the short run. The dummy variable (DY) is significant and negative in the short run and long run. Lastly, the error correction term (-0.98) with the right sign and significance indicates a fast convergence process (just over 1 year).

The results of diagnostic tests are given in Table 7 (model 1) and in Table 8 (model 2). The χ^2 RESET test's (Ramsey's test) results show that models are well specified and the χ^2 LM test indicates no autocorrelation in residuals. The ARCH test suggests no heteroscedasticity in the model, and the normality test, which investigates kurtosis and skewness of residuals, indicates normally distributed residuals. We used the CUSUM and CUSUMSQ tests to analyze the stability of the ARDL model. The plot of CUSUM and CUSUMSQ for model 1 (Figs. 1 and 2) and model 2 (Figs. 3 and 4) are within critical bounds, showing the stability of models.

Bootstrap causality test

The results of the bootstrap causality test of Hacker and Hatemi-J (2012) and Toda and Yamamoto test are reported in Table 8. The outcomes of bootstrap causality for our environmental model indicate that economic growth Granger causes military spending, which contradicts the results of Shahbaz et al. (2013) for Pakistan. However, this result further strengthens the argument that the military sector is a non-productive sector, and military spending leaves less resources for other productive sectors. Military spending Granger causes energy use (LENG) and the ecological footprint (LF), indicating that reduction in military expenses can reduce energy use and improve the environment. Energy consumption (LENG) and economic growth (LG) Granger cause LF. The Toda and Yamamoto causality test also supports causality from growth to military spending and from growth to footprint. Besides, the Toda and Yamamoto test indicates causality directing from economic growth (LG) to energy consumption (LENG), indicating only a partial evidence of conservation hypothesis as no causality between economic growth (LG) and energy consumption (LENG) is observed under bootstrap causality test. Likewise, some partial evidences of causality from economic growth to education expenses and military spending to education show that an increase in economic growth boosts investment in education, and military spending crowds out investment in education (Table 9).

Fig. 1 CUSUM (model 1)



Conclusion and policy implications

In the previous literature, the ecological consequences of militarization in Pakistan have not been investigated. In addition, the studies on the relationship between military expenditures and economic growth report varying results as a whole and also in the context of Pakistan. Therefore, current study adds to the previous literature by scrutinizing the effect of military spending on the ecological footprint and economic growth in Pakistan, which has continuously been facing many internal and external conflicts.

Following the previous literature, some unit root tests are used including unit root methods without breaks as well as unit root methods with structural breaks. Next, we studied this relationship by constructing two models. In the first model, we examined the effect of military spending on economic growth. In the second model, we analyzed the influence of military spending on the ecological footprint. After satisfying that, the variables' order of integration fulfills the basic requirement, we applied two cointegration methods to check whether there is a long-run equilibrium relationship in the models. The results of the cointegration tests indicate cointegration between variables. This outcome fulfills the obligatory condition for

Fig. 2 CUSUMSQ (model 1)

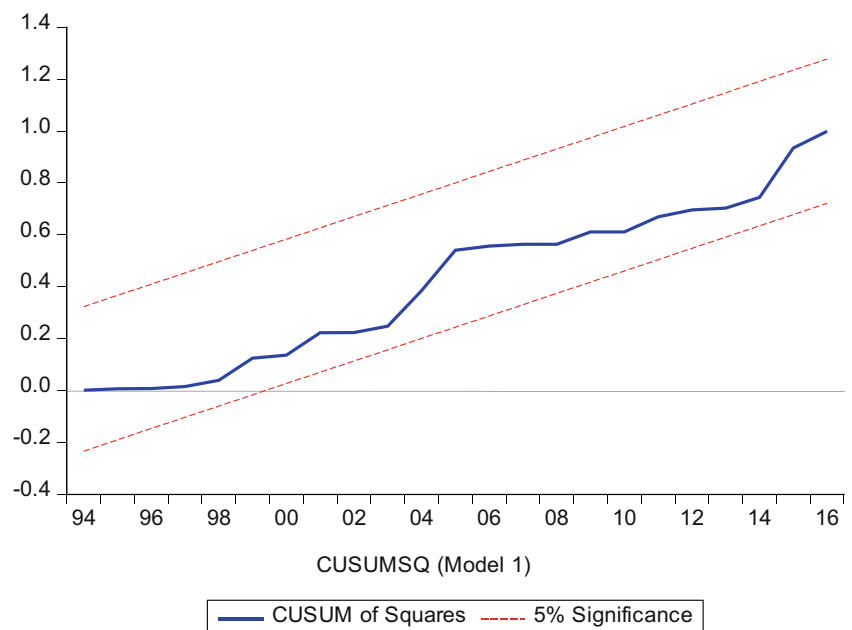
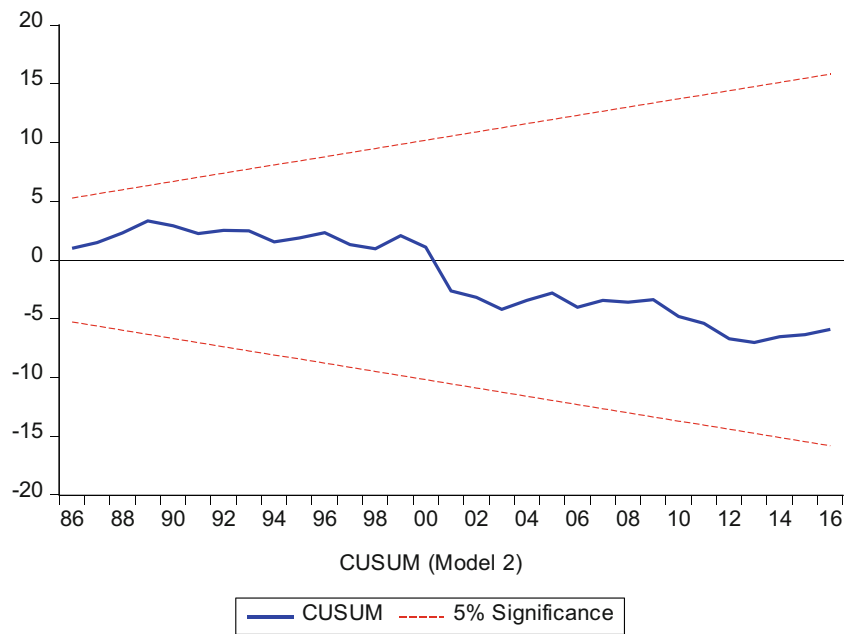


Fig. 3 CUSUM (model 2)



long-run estimation; hence, we move toward the estimation of long-run results. The outcomes of the first model (growth model) show a negative effect of military spending on economic growth in Pakistan. Likewise, there is an adverse effect of environmental degradation on the economic growth in Pakistan, while a positive effect of energy consumption on economic growth. The results of the second model (environment model) show that military expenditures increase the ecological footprint in Pakistan. Energy consumption stimulates ecological footprint, and a U-shaped association exists between economic growth (LG) and footprint. In the long run, education expenses do not affect the ecological footprint and

economic growth. The results of the bootstrap causality test disclose causality from economic growth to military expenditures (LME) and from LME to footprint.

These findings can be used to design and implement the following policies. For instance, military expenditures impede economic growth in Pakistan, and causality runs from growth to military expenditures. Also, military spending degrades the natural environment. Therefore, it is in the interest of the country to reduce military spending and invest in other productive sectors. In the defense expenditures, there are a lot of non-combat expenditures that can be immediately reduced to decrease the burden on the economy. The non-combat

Fig. 4 CUSUMSQ (model 2)

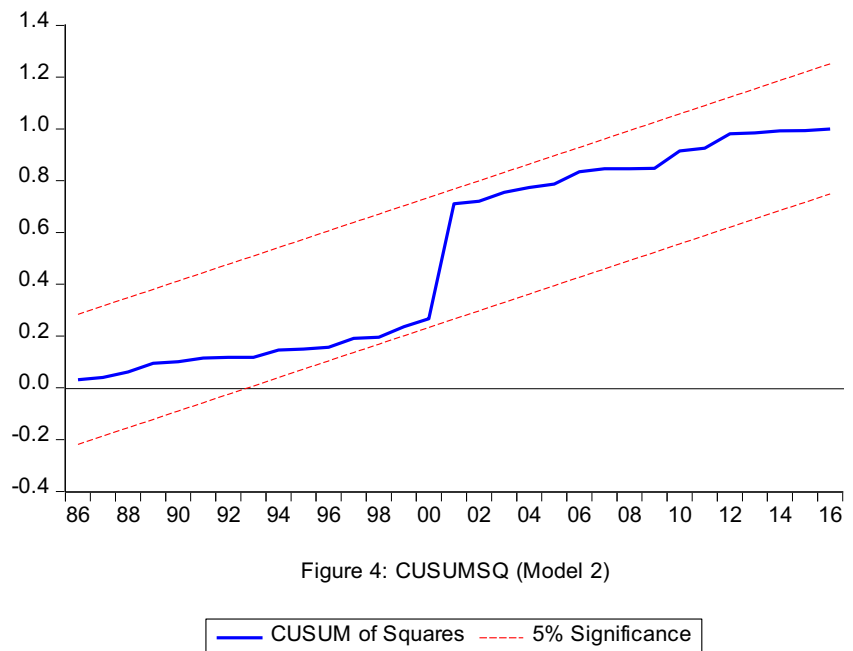


Figure 4: CUSUMSQ (Model 2)

Table 9 Causality tests

Null hypothesis	Bootstrap causality test of Hacker and Hatemi-J (2012)				Toda and Yamamoto test
	MWALD statistics	1%	5%	10%	Chi-sq [p values]
LENG → LG	4.778	11.195	6.976	5.219	1.5436 [0.4622]
LME → LG	1.747	11.402	7.220	5.387	0.7161 [0.6990]
LF → LG	0.592	7.458	4.129	2.879	1.3919 [0.4986]
LED → LG	0.299	7.013	4.020	2.840	1.1364 [0.5665]
LG → LENG	0.601	12.590	7.678	5.752	5.1010*** [0.0780]
LME → LENG	10.063*	7.837	4.131	2.888	0.8620 [0.6498]
LF → LENG	0.010	7.435	4.158	2.842	0.2011 [0.9043]
LED → LENG	0.208	7.401	4.161	2.886	4.5326 [0.1037]
LG → LME	5.211***	12.030	7.410	4.631	7.2561** [0.0266]
LENG → LME	0.535	7.298	4.159	2.840	1.8789 [0.3908]
LF → LME	2.774	7.952	4.306	2.921	3.8373 [0.1468]
LED → LME	0.346	11.479	6.994	5.207	2.8449 [0.2411]
LG → LF	2.881***	7.164	4.100	2.848	5.4143*** [0.0667]
LENG → LF	6.068**	7.411	4.129	2.849	1.5332 [0.4646]
LME → LF	5.933**	6.952	4.044	2.872	1.9092 [0.3850]
LED → LF	1.228	7.413	3.967	2.850	0.5017 [0.7781]
LG → LED	1.938	7.133	4.139	2.913	6.0972** [0.0481]
LENG → LED	2.053	7.175	4.164	2.948	2.7933 [0.2474]
LME → LED	0.970	10.973	6.878	5.267	13.6248* [0.0011]
LF → LED	1.962	7.259	4.177	2.895	3.7525 [0.1532]

*, **, and *** represent significance levels of 1%, 5%, and 10%, respectively

expenditures have also significantly expanded over the years; thus, it is important to analyze the defense expenditure carefully with a view to cut down unnecessary expenditures.

However, the part of defense expenditures related to combat will be difficult to reduce unless some major conflicts are resolved. Therefore, the implementation of such policies

requires efforts to resolve internal and external conflicts, on priority bases, for the stability of the economy and environmental sustainability. Another serious issue that needs the attention of policy-makers is the insignificant effect of education on economic growth and the environment. Investment in education should be enhanced, and the quality of educational institutions should be improved. Moreover, environmental awareness should be enhanced through education. The increase in income level will not automatically reduce the environmental problems in the case of Pakistan because no EKC is found in the analysis; therefore, environmental policies should be redesigned, as current policies are insufficient to curb the environmental problems. In addition, the share of renewable energy consumption should be gradually increased to reduce the use of fossil fuels.

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