Environmental Impact Assessment Review 81 (2020) 106340

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

journal homepage: www.elsevier.com/locate/eiar

The impact of terrorism and FDI on environmental pollution: Evidence from Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen

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ARTICLE INFO

Keywords:
Economic Growth
Energy Consumption
Environmental Pollution
FDI
Terrorism
Trivariate Causality Test

ABSTRACT

In this study, the relationships among environmental pollution, terrorism, foreign direct investments (FDI), energy consumption and economic growth is investigated for Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen covering the 1975–2017 period utilizing Panel cointegration tests, ANOVA tests, long-run estimators and panel trivariate Causality tests. ANOVA results are in favor of evidence of homogeneity between the selected countries. Long-run estimators reveal that terrorism, FDI, energy consumption and economic growth have statistically significant effects on environmental pollution. Panel trivariate Causality test determines the causal relationship between the variables. Accordingly, one-way causal nexus from terrorism to Carbon dioxide (CO_2) emissions and from FDI inflows to CO_2 emissions are found in the short-run. In the long-run, with strong causality results, the evidence of bi-directional causality between CO_2 emissions and other variables, namely, terrorism, FDI inflow energy consumption and economic growth are detected.

1. Introduction

Environmental pollution and terrorism are the two main problems the world faced nowadays. Environmental pollution has strong impacts on sustainable development. Among the others, the main driver of environmental pollution is the consumption of non-renewable energy supplies for meeting energy demand increasing day by day. The energy is essential for industrial production, heating and cooling, foreign direct investments (FDI) inflows to the developing countries, as well as for terrorist activities. Terrorism has a harming effect not only on economic and social life but also on the environment. The environmental damages caused by terrorism include, but not limited to, terrestrial conflicts, terrorist camps and bases, training activities, the carbon dioxide emissions (CO_2) related to energy consumption.

Similar to official military forces, terrorists use a great deal of fossil fuel energy for armed vehicles including tanks and heavy weapon carriers, manufacturing arms and ammunition, sustaining their activities including heating, cooking, among others. Additionally, the employment of military weapons and equipment against terrorism consumes a large amount of energy. The effect of terrorism on the environment is not limited to CO_2 emissions, terrorists use also a large scale of various chemicals and heavy metals (iron, copper, steel, and depleted uranium) related to mass destruction weapons. The heavy metals possess toxic elements such as lead (Pb) and cadmium, zinc and copper. The chemicals and heavy metals contaminate soil, air and water, which cannot be easily purified. Bjerregaard and Andersen (2011), Bednarska et al. (2013) and Giżejewska et al. (2015) showed the impacts of metal pollution on ecosystems. There are many indirect impacts that are longer-lasting than the direct impacts. Moreover, the release of emissions from oil consumption and other chemicals have persistent effects on the environment.

In today's world, many countries make serious efforts to reduce environmental pollution, however, given the current state, CO_2 emissions have risen to irreversible levels. Accordingly, the world's CO_2 emissions grew from 17.78 billion tons in 1980 to 33.1 billion tons in 2018 (IEA, 2019). The level of CO_2 is an important variable that has strong environmental impacts which inclined both due to increased industrial production and as a consequence of terrorist attacks.

Foreign direct investment (FDI) is the main locomotive of economic growth for developing countries since it is a key source of capital and technological transfer. FDI brings know-how, modern management and communication systems to the host country, thereby cause to increase in productivity. However, FDI also can give rise to environmental degradation. There are two main hypothesizes regarding the influence of

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https://doi.org/10.1016/j.eiar.2019.106340
Received 19 July 2019; Received in revised form 3 October 2019; Accepted 19 November 2019
Available online 06 December 2019
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FDI inflow on environmental degradation: pollution haven hypothesis (PHH) and pollution halo hypothesis. Pollution halo hypothesis suggests that FDI can enhance environmental quality by transferring green technology to the country (Birdsall and Wheeler, 1993). However, according to Copeland and Taylor (1994) who conceptualized PHH, the companies in developed countries wish to found factories/offices in developing countries where the costs are cheaper in terms of labor and resources. Developing countries also generally have weak environmental regulations, which is another factor lowering costs and a source of comparative advantage, especially for pollution-intensive productions (Jensen, 1996). All these factors can attract FDI to developing countries. FDI helps to raise the growth of the receiving country, however foreign direct investments, especially those with polluting industries, inevitably have negative effects on environmental pollution.

Nevertheless, even if the costs in developing countries are lower, if these countries are threatened by terrorism, FDI will reduce as terrorism creates uncertain economic outlook and threatens the safety of life and property, which means a shrinkage on growth.

The impact of terrorism on economic growth and FDI has been investigated in many papers (e.g., Enders and Sandler, 1996; Blomberg et al., 2004; Gaibulloev and Sandler, 2011; Shahbaz, 2013; Shahzad et al., 2016; Mohamed et al., 2019, among others) but, to the best of our knowledge, the effect of terrorism on environment has not been analyzed. There are some studies on the effect of militarization on energy consumption and the environment (e.g., Jorgenson et al., 2012; Jorgenson and Clark, 2016; Bildirici, 2017a, 2017b, 2017c), but these papers did not focus on the relationship between environment and terrorist attacks. On the other hand, Bildirici (2018) tested the relationships between economic growth, FDI, terrorist attacks and energy consumption in Turkey in the period of 1970–2015. But she did not analyze the impacts on the environment. In order to fill this gap, this paper will analyze the impacts of terrorism, FDI, economic growth and energy consumption on environmental pollution in one scope and investigate the causality relationship between the mentioned variables in a single study. The relationship between the variables analyzed is very complex, as well as their contributing effects on each other. But, we will only analyze the effects on the environment of terrorist attacks and other variables in this paper.

This study contributes to the literature by filling above mentioned gaps by using some panel cointegration, long-run coefficient estimation methods and causality tests for an exemplary group of countries consisting of Afghanistan, Nigeria, Pakistan, Philippines, Iraq, Somalia, Syria, Thailand and Yemen. This paper can be considered as a complementary and bridge between energy and environmental literature and papers focusing on terrorism.

Country selection is based on the level of terrorism and growth level of real GDP. It should be taken into consideration the selected countries have experienced tremendous amounts of terrorist attacks and most of them are ranked in the top ten of the Global Terrorism Index (GTI) 2018 (IEP, 2018). In 2018, Iraq is the country most affected by terrorism and followed by Afghanistan and Nigeria, which rank second and third. Syria and Pakistan follow them in the 4th and 5th rank, respectively (GTI for selected countries is analyzed in the third section). The global economic impact of terrorism is estimated at 52 billion USD for 2017 (IEP, 2018). The economic impact of terrorism on Afghanistan is 12.8% of its GDP, which is the highest one in all countries. The impact on GDP of Iraq, Syria, Somali, Nigeria and Yemen is 10.8%, 5.8%, 5.0%, 2.6% and 0.7%, respectively. Iraq, Nigeria and Syria are rich in oil, the Philippines is rich in gold and other countries are also rich in natural resources. Natural resources are also attractive to terrorists, which is another factor in the high level of terrorism in these countries. Furthermore, all countries examined are developing/underdeveloped ones and very suitable for foreign direct investment in terms of labor and resource costs, but the high level of terrorism impedes the inflow of foreign direct investments because FDI requires stability and security. As these countries do not have sufficient internal resources, low-level FDI hinders economic growth, which is the main factor in the failure to break the vicious circle of poverty. However, foreign direct investment inflow into these countries brings polluting technology rather than green technology, which is another factor that increases environmental pollution. Despite the low level of FDI inflow, low-level industrial production, therefore, low-level growth of real GDP, the level of environmental degradation in the countries under study is very high and they face significant health problems. Therefore, the high levels of environmental pollution must be caused by other factors such as terrorism in these countries.

We did not prefer to give results based solely on a test methodology when analyzing the relationship between real GDP, terrorism, environmental pollution, FDI and energy consumption, because the findings suggesting long-run relationships between variables are crucial for determining economic policies and strategies for these countries. To this end, we used some cointegration, long-run coefficient estimation methods and causality test. As for the cointegration tests, we used Kao (1999), Panel Johansen-type test, and Panel Autoregressive Distributed Lag (PARDL) test. The tests aim at the determination of whether or not the terrorist activities, the FDI inflow, the economic growth, the environmental pollution and the energy consumption possess a stable long-term relationship over the entire period. PARDL method was applied to the data since Johansen and Kao tests do not produce long-run coefficients. In the meantime, the Johansen cointegration method was also utilized in order to clear off any reservation on the possibility of multiple cointegration vectors as the PARDL method presumes the presence of a single cointegration vector. We used the ANOVA test to test homogeneity between the selected countries. ANOVA test depends on two main presumptions; normal distribution of the predicted variable in all groups and the presence of homogeneous variances. After ANOVA tests, for long-run estimations, different methods such as PARDL, FMOLS, OLS, and DOLS were applied because of the importance of the determination of the long-run coefficients for economic policy suggestions. As determined by Kao and Chiang (2000), the estimators of OLS have a nonignorable bias in small samples. According to Pedroni (2001), the small sample size distortions can reduce significantly the power of the predictors of panel DOLS and FMOLS (Lee, 2007). Under these conditions, we simultaneously calculate the PARDL, OLS, DOLS and FMOLS estimators. And lastly, we utilize the panel trivariate causality test for exploring causal links between the variables.

This study proceeds as follows. After this introduction section, the interrelations among economic growth, FDI, energy consumption, environmental pollution, and terrorism are discussed in the second section. The related literature is given in the third section. The dataset and econometric methodology are presented in the fourth section. The fifth section contains empirical results and discussion. Lastly, policy implications and conclusions are evaluated in the sixth section.

2. The Status of economic growth, FDI inflow, terrorism and CO_2 emissions

In 2014, global CO_2 emissions reached 32.4 Gt, 0.8% higher than that of 2013 and one of the smallest values seen since 2000. In 2015, the average concentration of CO_2 emissions was 399 ppm, which is approximately 40% higher than that of the mid-1800s, with an average growth of 2 ppm/year in the last ten years (IEA, 2016). During 1800–2014 period, increasing environmental pollution came from worldwide industrial production, energy consumption, and terrorism. Fig. 1 shows CO_2 emissions during the 1974–2014 period for the countries under study.

Terrorism as the cause of environmental pollution has been increasing in recent years. According to GTI for the last three years[1] presented in Table 1, Iraq is the most affected country by terrorism,

[1] GTI index for the year of 2018 has not been published as of June 2019.

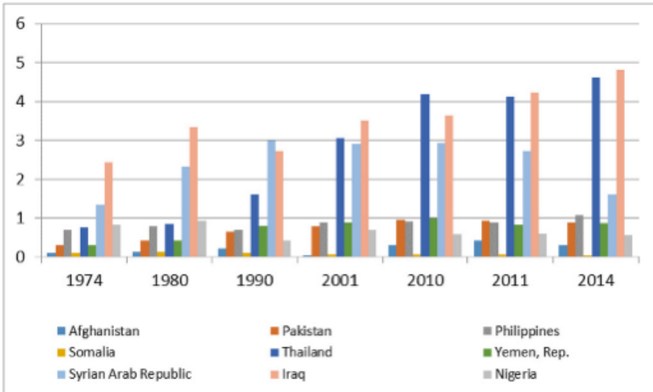

Fig. 1. The level of CO_2 in the analyzed countries, 1974–2014.

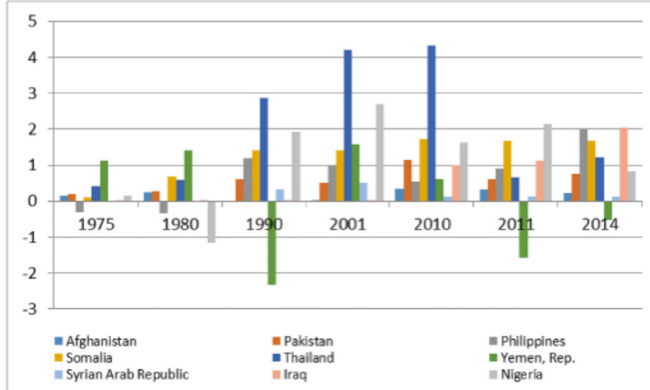

Fig. 2. Foreign direct investments, net inflows, 1975–2014.

Table 1
Global terrorism index.
Sources: IEP (2016, 2017, 2018).

2015			2016			2017		
Position	Country	Grade	Position	Country	Grade	Position	Country	Grade
1	Iraq	9.96	1	Iraq	10	1	Iraq	9.746
2	Afghanistan	9.444	2	Afghanistan	9.441	2	Afghanistan	9.391
3	Nigeria	9.314	3	Nigeria	9.009	3	Nigeria	8.660
4	Pakistan	8.613	4	Syria	8.621	4	Syria	8.315
5	Syria	8.587	5	Pakistan	8.4	5	Pakistan	8.181
7	Yemen	8.076	6	Yemen	7.877	6	Somalia	8.020
8	Somalia	7.548	7	Somalia	7.654	8	Yemen	7.534
12	Philippines	7.098	12	Philippines	7.126	10	Philippines	7.181
15	Thailand	6.706	16	Thailand	6.609	17	Thailand	6.252

followed by Afghanistan and Nigeria. Pakistan and Syria were ranked as fourth and fifth ones, respectively for 2015, but Syria has been taking the fourth position for the last two years. The position of the other countries presented in Table 1 has not almost changed over the last three years.

Total deaths from terrorism throughout the world fell 27% from 2016 to 2017 and Afghanistan became the country with the highest number of terrorism-related deaths in 2017. Iraq was the second-highest number of deaths from terrorism in the same year. In 2016, Iraq also witnessed the highest rise in terrorism and the deaths from terrorism increased by 40% relative to 2015. Approximately 9% of total terror deaths occurred in Nigeria, 2% lower than in the previous year. Somalia was one of the countries which experienced the largest increases in deaths from terrorism in 2017, with deaths increasing 93% relative to the previous year. The Philippines recorded the highest number of deaths from terrorism in 2017 since 2002 (IEP, 2018).

The effect of terrorism on the global economy was estimated at US $52 billion in 2017 that is 42% lower than in 2016 (IEP, 2018). The economic growth of the countries listed in Table 1 is closely linked to the country's terror attacks. Terrorist attacks reduce the growth level of real GDP by damaging the capitals such as public and private in addition to environmental pollution (Collier et al., 2003). In these countries, it creates many economic problems such as loss of human capital, demolition of infrastructure investments, the outflow of foreign direct investments, the relocating the public funds to counter-terrorism. When an emerging or developing country decreases FDI that is a crucial source of savings, economic growth reduces (Sandler and Enders, 2008). Fig. 2 shows a net inflow of FDI.

In these countries that live the economic development problems, the rate of economic growth is very low as shown in Fig. 3.

In these countries, the employment of military weapons and equipment against terrorism increases military expenditure, meaning that reallocating resources from the productive sectors supporting

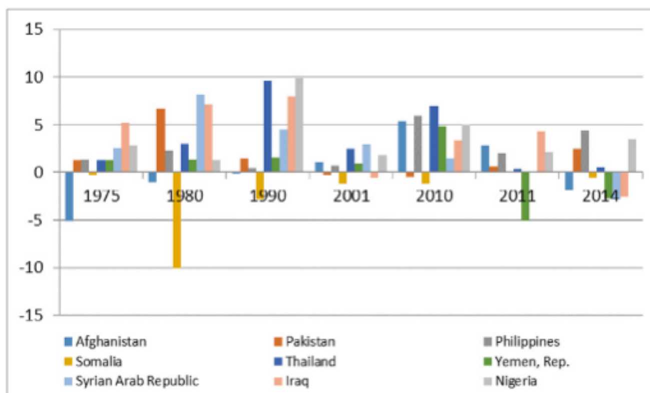

Fig. 3. Economic growth rates, 1975–2014.

economic development to military sectors (Blomberg et al., 2004). Additionally, the technological advances associated with the militarism increase the capability to transfer great volumes of equipment and warriors in these countries. Warfare machinery burns a huge amount of all energy. The activities of terrorists also cause to increase in energy usage as the crucial cause of environmental pollution (Fig. 4).

In the countries under study, economic development rates are very low. These countries cannot attract FDI and have low levels of industrial production. And environmental pollution, terrorism, and energy consumption are relatively high. In these countries, terrorism and energy consumption caused by terrorism are basic sources of environmental pollution.

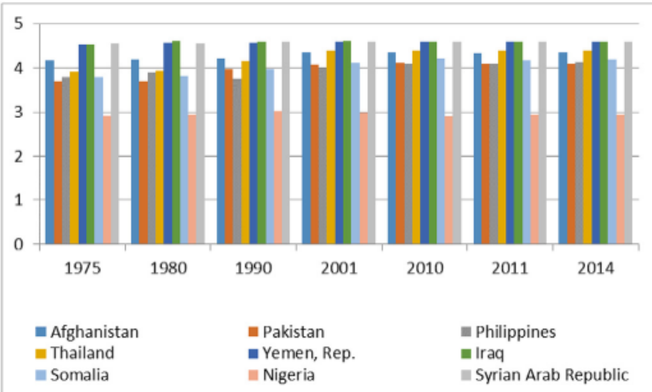

Fig. 4. Energy consumption.

3. Literature

The papers investigating the interrelationships between the variables mentioned above could be categorized into three sets. The first set probes the link among energy consumption, economic growth and environmental pollution. The second set examines the relation among environmental pollution, FDI and economic growth. The third set targets to model the relations among FDI, terrorism and economic growth.

3.1. Energy consumption, economic growth and environmental pollution

Grossman and Krueger (1991) tested the linkage between environmental damage and economic development, depending on the Environmental Kuznets Curve (*EKC*) *approach*. They found damaging effects of economic development on the environment and displayed that economic growth has a tendency to rise environmental degradation after a certain level. Following Grossman and Krueger (1991), many papers analyzed the link between industrial production and environmental pollution such as Shafik and Bandyopadhyay (1992), Tucker (1995), Cole et al. (1997), Bruyn et al. (1998). Following these papers, Richmond and Kaufmann (2006) for 36 countries and Omisakin (2009) for Nigeria analyzed the relationship between economic growth and CO_2 emissions. They did not find any causality nexus between environmental pollution and economic growth.

The results of the study differ according to countries under study, the econometric methodology utilized and the period. Ghosh (2010) for India, Alam et al. (2012) for Bangladesh and Govindaraju and Tang (2013) for India and China, Katrakilidis et al. (2016) for Greece determined causality nexus between CO_2 emissions and real GDP. Jalil and Mahmud (2009) for China, Pao and Tsai (2010) for BRIC countries, Ahmed and Long (2012) for Pakistan, Saboori et al. (2012) for Malasia, Ersin (2016) for 13 developed countries, Ahmad et al. (2017) for Croatia, Rehman and Rashid (2017) for emerging/frontier Asian countries, Bildirici and Ersin (2018) for USA, He and Lin (2019) and Liang and Yang (2019) for 30 provinces/cities of China, Zhu et al. (2019) for 73 cities of China found supporting results for EKC. However, some research revealed mix results when used different proxies for environmental pollution. One of them, Mrabet and Alsamara (2017) employed the ecological footprint (EF) and CO_2 as indicators for environmental pollution in Qatar for the period 1980–2011 and found that the EKC hypothesis did not hold when they used the CO_2 emissions, while it held when using the EF. In similar vein, Rasli et al. (2018) detected not supporting results for EKC for models containing CO_2, but supporting ones for the models containing nitrous oxide by using data for some developing and developed countries. Adu and Denkyirah (2018) found that, in the short run, economic growth increases CoWaste and emissions of CO_2 but, in the long run, the relationship is not significant, indicating the absence of EKC in West Africa. Besides, Almeida et al. (2017) for 152 countries, Özokcu and Özdemir (2017) for some emerging and OECD countries, Zambrano-Monserrate et al. (2018) for Peru and Mikayilov et al. (2018) for Azerbaijan could not find supporting results for EKC hypothesis. One of the sectoral level analyses, Moutinho et al. (2017) revealed an N-shaped relationship for Portugal, implying that pollution rises along with the development of the sector and declines when the threshold is reached and then begins growing again. For Spain, they found mixed results, both N-shaped and reversed N-shaped links. Balsalobre-Lorente et al. (2018) detected an N-shaped connection between economic growth and CO_2 emissions for EU-5 countries.

3.2. Environmental pollution, foreign direct investments, and economic growth

Although a great deal of research has been done about the interrelationship among environmental pollution, economic growth and FDI inflows, the results are inconclusive. Although the findings of some studies support the pollution halo hypothesis, others support the pollution haven hypothesis. The diversity may stem from the countries under analysis, the utilized econometric method, data sources, conceptual and theoretical framework and proxies used for pollution and FDI (Letchumanan and Kodama, 2000). As one of the pioneering studies, Jensen (1996) showed that FDI inflows may promote economic growth by causing environmental degradation. Frankel and Rose (2002) determined that FDI inflow can speed up real GDP and that it can cause environmental problems. Pao and Tsai (2011), for the BRIC countries, determined the evidence of the two-way causal nexus between CO_2 emissions and FDI inflow, and one-way causality nexus running from the growth of real GDP level to FDI inflow, thereby supporting results for pollution haven and halo pollution hypothesizes. Nguyen and Amin (2002) indicated that FDI causes the growth of the industrial and service sectors thereby the increase of wastes from these sectors and to increase the consumption of polluting goods such as automobiles with the effect of increasing income and economic growth. Peng et al. (2016) identified one-way causality between FDI inflow on environmental pollution for some regions and two-way one for other regions of China. Hoffmann et al. (2005) found causality running from CO_2 emission to foreign direct investments for low-income countries, one-way causality running from inward FDI to CO_2 emission which supports PHH for middle-income countries. Besides, for high-income countries, they could not find any causality. Kearsley and Riddel (2010) found that dirty imports were not correlated with CO_2 emission levels by using a data set of 27 OECD members along with bilateral trade data of 100 developing countries. Al-mulali and Tang (2013) inspected the PHH for the GCC countries and found that the growth of GDP level and energy consumption were the cause of ecological degradation in those countries but not the FDI inflows. Omri et al. (2014) identified two-way causal nexus between FDI and CO_2 for Latin American, Caribbean, sub-Saharan and MENA countries. Kivyiro and Arminen (2014), for the period of 1971–2009, analyzed the interrelationship among FDI, economic development, CO_2 emissions and energy consumption for 6 Sub Saharan African countries. They found supporting results for the EKC hypothesis for Kenya, Zimbabwe and the Democratic Republic of Congo. Their results also suggested that FDI leads CO_2 emissions to rise in some countries, whereas an inverse relationship in others. Shahbaz et al. (2015) investigated the association among energy consumption, FDI, economic growth, and environmental pollution using panel data consisting of 99 countries for the 1975–2012 period and demonstrated the presence of a reversed U shaped link between CO_2 emissions and FDI in the entire panel and the panel contains only middle-income countries. Moreover, their results revealed that FDI in the countries having high income causes CO_2 emissions to decrease, but the case is not valid for low-income ones. Zakarya et al. (2015) analyzed the nexus among FDI inflows, CO_2 emission, energy consumption and economic growth for the BRICS countries and revealed a unidirectional causal nexus from FDI inflows to carbon dioxide emission. Neequaye and Oladi (2015) conducted a study to test the EKC hypothesis by using GHG and CO_2 releases in industrial, waste and energy sectors as well as the validity of pollution halo hypothesis for 27 developing countries covering the 2002–2008 period. Accordingly, they found the more industrial production level rises the more emission level of CO_2 decrease, which possibly resulted from transferring environment-friendly production technologies to the host country by FDI, supporting the pollution halo hypothesis. This result was also supported by Shahbaz et al. (2015), conducted for 99 developing and developed countries. Moreover, when they used CO_2 data, their results showed supporting results for the EKC but not for nitrous oxide. Their findings also suggested evidence of EKC for GHG emissions for the industrial and energy sectors but not for the waste sector. By using data of 17 MENA countries for the 1990–2012 period, Abdouli and Hammami (2017) indicated foreign direct investment rises ecological pollution and supported the presence of the EKC. Moreover, they presented that the rise in trade openness and energy consumption leads to a rise in the emission levels of CO_2. More recently, Hanif et al. (2019) found supporting results for PHH hypothesis by indicating that FDI enhances economic growth at the cost of CO_2 emissions in 15 developing Asian countries by using the data covering the period 1990–2013. Similarly, for ASEAN countries (Singapore, Thailand, Malaysia, Philippines and Indonesia), the PHH hypothesis was confirmed by Nasir et al. (2019) for the period 1982–2014.

3.3. *Foreign direct investments, terrorism and economic growth*

Terrorist attacks can damage economic growth by giving rise to a decrease in tourism revenues and foreign direct investments, destroying the infrastructure, increasing the cost of doing business and reallocating the resource to struggle with terrorism (Enders and Sandler, 1996). Although there are comparatively more studies investigating the effect of terrorist attacks on economic growth and FDI owing to the rising terrorist attacks throughout the world, the studies examining the impact of terrorism on environmental pollution and energy consumption are scarce.

Regarding the link between economic growth and terrorism, several studies identify a significant negative effect of terrorism on GDP growth. One of them, Blomberg et al. (2004) determined the negative effect of terrorist attacks on GDP growth by investigating data of 177 nations for the 1968 2000 period. Abadie and Gardeazabal (2003) indicated that GDP per capita of the Basque region of Spain dropped roughly 10% after the terrorism outbreak in the late 1960s. Gaibulloev and Sandler (2008a), for 18 Western European countries covering the 1971–2004 period, analyzed the effect of terrorism on GDP per capita growth by distinguishing terrorism as domestic and transnational. Their results indicated that transnational terrorism had a more damaging effect on economic growth than the domestic one over the period. Gaibulloev and Sandler (2008b) also analyzed the influence of terrorism on GDP per capita growth for Asia covering the 1970–2004 period. The study arrived at the conclusion that transnational terrorism had a major growth hindering influence on developing countries in the short run but not on developed ones in Asia. In another study carried by Gaibulloev and Sandler (2011) in which conducted for 51 African countries covering the 1970–2007 period revealed that domestic terrorist events did not have any effect on economic growth while transnational one had an enormous effect on GDP per capita growth. In a similar vein, Sandler and Enders (2008) indicated that the influence of terrorist attacks on the economy differs according to the country's level of development. Unlike the developing one, developed countries are more diversified and have more powerful institutions to enforce required policies such as monetary, fiscal and security to recover from terrorist attacks, so they can rapidly absorb the harmful consequences of terrorism on the economy. In this line, Gries et al. (2011), for seven Western countries and the 1950–2004 period, investigated the links between economic growth and domestic terrorism by utilizing several causality tests. They found, in the bivariate setting, that economic growth was not affected by domestic terrorism except for Portugal whereas there was one-way causality from growth to domestic terrorism for entire countries. However, in the trivariate scenario in which trade openness indicator included, their results indicated none causal relationship running from terrorist attacks to economic growth for any country and a causality running from real GDP growth to domestic terrorism merely for Spain, Portugal and Germany. Their findings can be summarized as domestic terrorism does not have any impact on economic growth at the national levels. Shahbaz (2013) and Shahbaz et al. (2013b) found a one-way causal relationship running from economic growth to terrorism in Pakistan, coherent with the findings of Gries et al. (2011). Shahbaz (2013) also revealed that economic growth and inflation increased terrorism in the long term. Moreover, he found terrorism was positively affected by rising inflation and economic growth in the short term, but the latter one was statistically insignificant.

The influence of terrorism on FDI also differs depending on the development level of the country and the terrorism type (domestic or transnational). Enders and Sandler (1996) indicated the losses in FDI inflow in a period of terrorism during 1968 and 1991 for Spain and Greece. Terrorist attacks shrank FDI in Spain and Greece by 13.5% and 11.9%, respectively. Abadie and Gardeazabal (2008) found supporting results for Enders and Sandler (1996) by showing the deteriorating impacts of terrorism on FDI inflow. They found a 1% increase in terrorism leads to a drop in FDI about 5% of GDP. Blomberg and Mody (2005) indicated that the damaging impact of transnational terrorism is greater in developing countries than the developed ones. Enders et al. (2006) questioned the effect of transnational terrorist attacks on US FDI abroad for 1994Q1-2004Q4. They found that the effect of terrorism is very small in OECD countries except for Turkey and Greece. Accordingly, the FDI fell by 5.7% for Greece and 6.5% for Turkey. However, they could not find significant effects for non-OECD countries. Shahzad et al. (2016) indicated that terrorism in Pakistan has a deteriorating impact on foreign direct investment by using data covering the period 1988–2010. Among the others, Ali et al. (2017), Anwar and Mughal (2016), Haider and Anwar (2014), Ullah and Rahman (2014), Shahbaz et al. (2013b) and Rasheed and Tahir (2012) determined that terrorism has harming impacts on the FDI inflow to Pakistan. Bandyopadhyay et al. (2014) inspected the impacts of transnational and domestic terrorist attacks on FDI in 78 developing countries covering the 1984–2008 period and found that both kinds of terrorism have a depressing effect on foreign direct investments. However, they indicated that the negative effects can be mitigated by foreign aids. Their results further revealed that the effect of domestic terrorism is more than that of transnational one. Efobi et al. (2015) enhanced the study of Bandyopadhyay et al. (2014) by conditioning the alleviation influence of foreign help on the level of corruption control. They used the data of 78 developing countries for the 1984–2008 period and determined that the harmful influence of terrorism on foreign direct investments occurs merely when the corruption control level is high and foreign help alleviates the harming impact of terrorism on foreign direct investments only when the corruption control level is high. Shah et al. (2016) studied the causal nexus among terrorism, FDI inflow and economic growth for Pakistan for the 1980–2015 period and found that terrorism is negatively associated with GDP and FDI in Pakistan. Efobi and Asongu (2016) examined terrorism impacts on the flight of capital for l29 African nations for the 1987–2008 period and determined that terrorism steadily increases capital flight.

Bildirici (2018) tested the relationships between economic growth, FDI, terrorist attacks and energy consumption in Turkey in the period of 1970–2015. She determined FDI, terrorism and energy consumption have an impact on economic growth and the important causal relation between variables. She revealed an important relation between terrorism and energy consumption, between economic growth and energy usage, between economic growth and terrorist attacks, and between terrorist attacks and FDI. Mohamed et al. (2019) investigated, for France, both short and long-run relations among trade openness, economic growth, fossil/none fossil energy consumption and terrorism by using the data covering the 1980–2015 period. They determined long-run associations between all variables under study. They also found long and short-run two-way causal relationships between terrorist attacks and economic growth. They detected a negative effect of economic growth on terrorism and a positive one of terrorism on economic growth. Accordingly, a 1% rise in GDP leads to a reduction in terrorism by 24.43%, which is contrary to the findings of Shahbaz (2013) for Pakistan. The same amount of rising in terrorism reduces economic growth by 0.02%, which is consistent with the findings of Gaibulloev and Sandler (2008a, 2008b). Their results further revealed two-way causality among renewable/fossil energy consumption and terrorism and a 1% rise of renewable energy consumption gives rise to an increase in terrorism by 12.99% while a 1% increase in terrorism gives rise to increase renewable energy consumption by 0.02%.

The papers analyzed the impacts of terrorist attacks on economic growth do not focus on environmental pollution. Some papers examined the existence of a link among environmental damage, militarization, economic growth and energy usage. One of them, Jorgenson and Clark (2016) analyzed the relationship among GDP, military expenditures, military personnel and CO_2 emissions for 81 nations during 1990–2010. They found the effect of militarization on environmental pollution is greater in the developed OECD countries than in the other OECD ones. Jorgenson et al. (2012), for 69 countries, tested the relation between environmental damages, militarization, and international trade over the 1960–2003 period. They found supporting results for the treadmill of destruction theory. Bildirici (2017a) analyzed the Granger causality between militarization, none renewable energy consumption, CO_2 releases and economic growth for the USA for the period 1960–2013. She demonstrated the evidence of one-way causality from militarization to CO_2 emissions. Bildirici (2017b) examined the causality between biofuel consumption, militarism, real GDP and CO_2 emissions. Bildirici (2017c) tested the links between CO_2 releases, militarization, energy usage and real GDP for G7 countries. She assigned a unidirectional causal effect moving from militarization and energy consumption towards CO_2 emissions.

4. Data specifications and econometric methodology

The annual data of Iraq, Nigeria, Pakistan, Philippines, Thailand, Yemen, Afghanistan, Somali and Syria were used in this study to analyze the impacts of especially terrorist attacks and additional variables consisted of energy consumption, FDI and economic growth on the environment for the 1975–2017 period. A large number of papers prove that CO_2 emissions are considered one of the most contributing to worsening environmental issues (Wei et al., 2017). Thus, the CO_2 emissions dataset was employed as a proxy variable for environmental pollution. For the analyzed countries, energy consumption, real GDP, CO_2 emissions and FDI were got from World Bank and IEA except for Afghanistan, Somali and Syria. Their data set was got from each country's Economic Statistics Database. Terrorism data covers the total number of deaths from terrorism including all victims and attackers and they were collected from the Global Terrorism Database (GTD). All data we used in this study are annual and are transformed to logarithmic form (ln) to lessen skewness and all variables are given in logarithms. The panel empirical model is constructed as follows:

$$co_{it} = \beta_0 + \beta_1 tr_{it} + \beta_2 fdi_{it} + \beta_3 c_{it} + \beta_4 y_{it} + \varepsilon_{it} \tag{1}$$

where β_0 is intercept, β_1, β_2, β_3 and β_4 are regression coefficients for estimation, *tr* is the natural log of terrorism, *fdi* is the natural log of FDI inflow, *c* is the natural log of energy consumption, *y* is the natural log of real GDP, *i* symbolizes the country *t* represents time, ε_{it} is the error term.

The econometric methodology includes three stages. At the first stage, cointegration tests to investigate long-run relations, namely, the Johansen, Kao and PARDL cointegration tests are evaluated. We prefer not to use the Pedroni test because some studies criticize it for not being powerful. In the second stage, FMOLS and DOLS methods are explained. At the third stage, the panel trivariate causality test which reveals causal relations between variables is explained.

4.1. Panel cointegration tests

4.1.1. Panel ARDL test

The Panel ARDL model can be written as follows:

$$\Delta co_{it} = \phi_i + \sum_{k=1}^{p} \gamma_{ik} co_{i,t-k} + \sum_{k=0}^{q-1} \mu_{ik} \Delta x_{i,t-k} + \delta_{1i} co_{i,t-1} + \delta_{2i} x_{it} + \varepsilon_{it} \tag{2}$$

$$\text{where} \quad \delta_{1i} = -\left(1 - \sum_{j=1}^{q} \lambda_{ij}\right), \quad \delta_{2i} = \sum_{j=0}^{q} \varpi_{ij}, \quad \gamma_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}, \quad \mu_{ij} = -\sum_{m=j+1}^{q} \varpi_{im}. \tag{3}$$

The group-specific constant term is ϕ_i, and ϖ_{ij} and λ_{ij} are *kx1* vectors for explanatory variables. The testing of the null hypothesis, $H_0: \ \delta_{1i} = \delta_{2i} = 0$ reveals important information regarding the long-run relations between the parameters. The null hypothesis could also be additionally indicated as $H_0: \ \varpi_{ij} = 0$ to be tested against the alternative $H_1: \ \varpi_{ij} \neq 0$.

The error correction model can be written as below:

$$\begin{aligned} &\Delta co_{it} = \phi_i + \textstyle\sum_{k=1}^{p} \gamma_{ik} co_{i,t-k} + \sum_{k=0}^{q-1} \mu_{ik} \Delta x_{i,t-k} + \vartheta_i (co_{i,t-1} - \varphi_i x_t) + \varepsilon_{it} \\ &\varphi_i = -(1 - \textstyle\sum_{k=1}^{p} \gamma_{ik}), \ \ \theta_i = \sum_{k=0}^{q} \mu_{ik} / (1 - \sum_k \gamma_{ik}), \\ &\gamma_{ik} = -\textstyle\sum_{m=k+1}^{p} \gamma_{im} \ \ k = 1, \ldots p-1 \\ &and\, \mu_{ik} = -\textstyle\sum_{m=k+1}^{q} \mu_{im} \ \ k = 1, 2, \ldots q-1 \end{aligned} \tag{4}$$

4.1.2. Kao cointegration test

Kao (1999) proposed the DF tests for the error term Lin and Li (2015). The test accepts which cointegrating vectors are assumed as homogeneous (Basile et al., 2005).

$$co_{it} = \alpha_0 + \beta_{1i} x_{it} + \varepsilon_{it} \tag{5}$$

The DF test procedure is applied to the residual as follows:

$$\hat{\varepsilon}_{it} = \gamma \hat{\varepsilon}_{it-1} + \sum_{i=1}^{k} \delta_i \Delta \hat{\varepsilon}_{it-i} + u_{i,tk} \tag{6}$$

The ADF test statistic is given as (Basile et al., 2005):

$$ADF = \frac{t_{ADF} + (\sqrt{6N\hat{\sigma}_v}/2\hat{\sigma}_0)}{\sqrt{(\hat{\sigma}_0^2/2\hat{\sigma}_v^2) + (10\hat{\sigma}_0^2)}} \tag{7}$$

where $\hat{\sigma}_u^2 = \sum_{ue} - \sum_{ue} \sum_e^{-1}$, $\hat{\sigma}_{0u}^2 = \Omega_u - \Omega_{ue}\Omega_e^{-1}$, Ω are the long run covariance matrix and t_{ADF} is the ADF *t*-test statistic. Kao determined that the ADF test approaches effectively to a normal distribution with *N* (0,1).

4.1.3. Panel johansen test

Johansen's Maximum likelihood procedure is given as follows.

$$\Delta co_{i,t} = \prod_i co_{i,t-1} + \sum_{s=1}^{n} t_s \Delta co_{i,t-s} + v_{i,t} \tag{8}$$

H_0: rank(Π) = $r_i \le r$ for all i from 1 to n
H_0: rank(Π) = r for all i from 1 to n

$$\text{and it is found as} \quad -2InQ_T\{H(r) \mid H(p)\} = -T \sum_{i=r+1}^{p} In(1 + \hat{\lambda}_i) \tag{9}$$

4.2. Long-run estimators

In this paper, different testing strategies are applied instead of being dependent on a single methodology to get robust results. In this direction, the OLS, DOLS and FMOLS methods are conducted to get the long-run coefficients.

OLS estimator for co_{it} is given as

$$co_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{it} \tag{10}$$

and Panel OLS estimator for the β_i coefficient is calculated by

$$\underset{i}{\widehat{\beta}} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - x_i^*)^2 \right)^{-1} \sum_{i=1}^{N} \sum_{i=1}^{T} (x_{it} - x_i^*)(co_{it} - co_i^*) \tag{11}$$

Further, the Pedroni FMOLS t statistic is

$$\widehat{\beta_i} = N^{-1} \sum_{i=1}^{N} \left(\sum_{i=1}^{T} (x_{it} - \bar{x}_i)^2 \right)^{-1} \left[\sum_{t=1}^{T} (x_{it} - \bar{x}_i) \right] co_{it}^* - Tc\widehat{o}_i \tag{12}$$

where $\bar{x}$ and $c\bar{o}_i$ are the arithmetic mean of X and CO_2. Note that co_{it} is the endogenous variable in the model. Further, $co_{it}^* = (co_{it} - co_t^*) - [(\widehat{\Omega}_{21i}/\widehat{\Omega}_{22i})\Delta X_{it}]$ where $\widehat{\Omega}$ is the covariance. Because of heterogeneous dynamics in the short-run process determining co and x, $c\widehat{o}$ performs as correcting the impact of serial correlation.

Pedroni developed a between-dimension, group-means PDOLS estimator by including lead and lag dynamics:

$$co_{it} = \alpha_i + \beta_i x_{it} + \sum\nolimits_{j=-k}^{ki} \gamma_{ik} \Delta X_{i,t-k} + \varepsilon_{it} \tag{13}$$

$$\widehat{\beta}_i = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{i=1}^{T} \theta_{it} \theta_{it}^* \right)^{-1} \left(\sum_{t=1}^{T} \theta_{it} \widehat{\theta}_{it} \right) \right] \tag{14}$$

where $\widehat{\beta}_i$ shows DOLS estimators, θ_{it} is the 2(K + 1)x1, $\widehat{\theta}_{it}$ is $(x_{i,t} - \bar{x}_i)$.

4.3. Panel trivariate causality test

The trivariate Granger causality method is given as (see Odhiambo, 2009; Bildirici, 2017a)

$$\Delta co_{it} = \lambda_{1j} + \sum_{k=1}^{m} \alpha_{ik} \Delta co_{it-k} + \sum_{k=1}^{m} \vartheta_{ik} x_{it-k} + \zeta_0 ecm_{t-1} + \varepsilon_{1t} \tag{15}$$

$$\Delta x_{it} = \lambda_0 + \sum_{k=1}^{m} \alpha_{2ik} \Delta x_{it-k} + \sum_{k=1}^{m} \vartheta_{2ik} \Delta co_{it-k} + \zeta_1 ecm_{t-1} + \varepsilon_{2t}, \tag{16}$$

where ε_t is i.i.d and $\sigma^2 \varepsilon(0,\infty)$; and ζ is a parameter defining the long-run *speed of adjustment* to *equilibrium* after a shock. The short-run Granger causalities are tested as $H_0 : \vartheta_{ik} = 0$ and $H_1 : \vartheta_{ik} \neq 0$ for Eq. (15) for all *i*. The long-run Granger causalities are tested as $H_0 : \zeta_0 = 0$ for Eq. (15). And lastly, strong causality is examined by $H_0 : \vartheta_{ik} = \zeta_0 = 0$ in Eq. (14).

5. Empirical results

The results of descriptive statistics tests are shown in Table 2. The H_0 hypothesis of non-normality is rejected by denoting the $(\varepsilon_t)s \sim N(0,\sigma^2)$.

The *p*-values of J-B are > 10%. The *co, c and y* are negatively skewed and the future data points of the three variables will be less than the mean. The other variables that have a positive skewness determined that estimation of the future data points of these variables will be more than the mean.

5.1. Panel unit root and cointegration test results

IPShin and LLChu unit root tests are applied to the variables, *y, tr, fdi, co* and *c*. The results are provided in Table 3. The table constitutes of two sections; column 1 representing the results for the levels (*lev.*) and column 2 representing the results obtained for first differences (*1st dif.*).

For the levels, the results indicate that the null hypothesis cannot be rejected and all series become stationary once first differenced.

Tables 4–6 report the results of panel cointegration tests. The results of PARDL, Johansen and Kao's ADF t statistics indicate the possibility of cointegrating relations between the selected variables. In particular, Johansen's trace and maximum-eigenvalue tests indicate one cointegrating equation. The necessity for the PARDL methodology is the presence of a single cointegration vector, and the results eliminate doubts regarding the presence of multiple cointegration vectors.

In Table 4, Kao's test suggests the rejection of the null of no cointegration at 1% significance level.

Table 4 shows the results of four tests employed by Kao (1999). These test results indicate panel cointegration with a 1% significance level that means the changes in CO_2 emissions are linked with terror and other macroeconomic variables in the long-run.

Although the Panel ARDL method assumes the presence of a single cointegrated vector, the Kao test does not supply information regarding this assumption. Therefore, the results of the Johansen's panel cointegration test are presented in Table 5.

The Johansen test methodology aims at testing no cointegration (r = 0) against single or more cointegration vectors within an iterative testing approach. Accordingly, the Johansen test determines the null of $r = 0$ is rejected against the alternative of $r = 1$. At the further stages, the null of r = 1 is tested against the alternative of $r = 2$. The test results suggest the existence of a maximum one cointegrating vector (r ≤ 1) whereas the alternative $r \leq 2$ cannot be accepted according to the calculated trace and max-eigen test statistics. The Johansen test results confirm the presence of a single cointegration vector, therefore, satisfying the assumption expected for the Panel ARDL method.

Table 2
Descriptive statistics.

	co	*c*	*fdi*	*tr*	*y*
Mean	4.227887	−2.569400	3.443394	1.511377	4.384078
Median	4.645872	−2.170803	1.440012	1.977121	4.780070
StdDev	0.889973	0.806703	3.825159	0.88655	0.88841
Skewness	−0.806552	−0.747530	0.264795	0.862808	−0.806434
Kurtosis	2.024105	1.950980	1.175139	2.321566	2.085406
Jarque-Bera (JB)	0.30163	0.48692	0.59262	0.48268	0.53972

Table 3
Panel unit root test.

	Lev.		1st dif.	
	LLLChu	IPShinS	LLLChu	IPShinS
y	1.14	1.03	−9.91	−8.63
tr	1.46	1.43	−6.95	−7.35
fdi	−0.61	−0.55	−6.91	−9.58
co	−1.06	−0.82	−4.53	−6.71
c	2.32	−1.03	−6.45	−8.34

Table 4
Kao test results.

	DF ρ	DF t ρ	DF ρ star	DF t ρ star
ADF	−5.274	−8.257	−11.365	−3.256

Notes: For the ADF test, the lag order is set to one.

Table 5
Johansen cointegration results.

	Fisher Stat. (trace test)	Fisher Stat. (max-eigen test)
r = 0	82.26	53.85
$r \leq 1$	27.75	18.09
$r \leq 2$	19.94	15.73
$r \leq 3$	5.26	4.53
$r \leq 4$	2.70	2.70

5.2. Long-run coefficients

The estimation of long-run coefficients is given in Table 6. PARDL, FMOLS, DOLS and OLS results point out that energy consumption, terrorism, FDI, and real GDP have significant and positive effects on CO_2 in Nigeria, Pakistan, Afghanistan, Iraq, Philippines, Somalia, Syria, Thailand and Yemen.

FMOLS, DOLS, OLS and PMG results determine that a 1% increase in the FDI increases CO_2 emissions by 0.028%; 0.052%, 0.087% respectively, except for the PMG results which suggest a decrease by 0.143%. These findings are consistent with the studies conducted for China (Baek and Koo, 2009; Zhang, 2011 and Peng et al., 2016 for the eastern part of China), for Kenya and Zimbabwe (Kivyiro and Arminen, 2014). Our results are also in line with Omri et al. (2014) in case of 54 countries, Shahbaz et al. (2011) for 110 countries, Abdouli and Hammami (2017) for MENA countries, Hanif et al. (2019) for Asian developing countries.

FMOLS, DOLS, OLS and PMG long-run estimators also indicate that a 1% rise in energy consumption brings about a rise in CO_2 by 0.343%, 1.146%, 0.98% and 0.713% with the respected estimators. Similarly, Al-mulali and Tang (2013) indicated the positive effect of energy consumption on CO_2 emissions for the Gulf Cooperation Council (GCC) countries. It is also in line with Kivyiro and Arminen (2014) who found the same effect for South Africa and Zimbabwe, Shahbaz et al. (2015) for 99 developed and developing countries, Solarin et al. (2017) for Ghana, Hanif et al. (2019) for Asian developing countries.

According to FMOLS, DOLS, OLS and PMG long-run estimators, a 1% rise in economic growth leads to a rise in CO_2 by 0.678%, 1.046%, 0.76% and 0.64%, respectively. In the same vein, Peng et al. (2016) detected that GDP growth has a positive effect on CO_2 emissions in Central and Western parts of China and Al-mulali and Tang (2013) reached the same result for GCC countries. Similar results have been revealed by Kivyiro and Arminen (2014) for Democratic Republic of Congo, Kenya and Zimbabwe, Shahbaz et al. (2015) for 99 developed and developing countries, Hanif et al. (2019) for Asian developing countries, Nasir et al. (2019) for ASEAN-5 countries.

Lastly, FMOLS, DOLS, OLS and PMG long-run estimators suggest that a 1% increase in terrorism gives rise to 0.135%, 0.1453%, 0.2536% and 0.574% increases in the CO_2 emissions, respectively.

We also estimated long-run coefficients of the models where dependent variables are terrorism, energy consumption, economic growth, and FDI. However, as the focus of the study on the impact of terrorism, energy consumption, economic growth and FDI on environmental pollution, we did not present the results which can be provided upon request. Accordingly, it was determined that FDI promotes economic growth and causes an increase in environmental degradation, which confirms the pollution haven hypothesis. The findings are consistent with Jensen (1996) and Frankel and Rose (2002), Pao and Tsai (2011) who found that FDI inflow can accelerate economic growth while causing environmental problems.

The long-run estimators of the model where the dependent variable was economic growth determined the negative impact of terrorist attacks on economic growth. Blomberg et al. (2004) for 177 countries, Gaibulloev and Sandler (2008a), Abadie and Gardeazabal (2008), Sandler and Enders (2008) for developed and developing countries; Ullah and Rahman (2014) and Shah et al. (2016) for Pakistan obtained the similar results.

The long-run estimators of the model where the dependent variable was FDI revealed negative impacts of terrorism on FDI inflow. These results are similar to the results determined by Blomberg and Mody (2005); Enders and Sandler (1996); and Bandyopadhyay et al. (2014); Rasheed and Tahir (2012), Shahbaz et al. (2013b) and Ali et al. (2017).

PARDL results display evidence for the existence of a statistically significant association between CO_2 and terrorism, between real GDP and CO_2 and between energy consumption and CO_2. The coefficient of ECM indicating a mechanism to correct the disequilibrium between the variables was estimated as -0.1038, which determines a rather slow speed of adjustment of the disequilibrium occurring in the short-run from the long-run equilibrium.

5.3. ANOVA and causality test results

The results found by PARDL, OLS, FMOLS and DOLS approaches exhibit that terrorism and energy consumption have a significant and positive impact on CO_2. Since producing policy recommendations is highly important, the results are investigated for the existence of strong results with various ANOVA tests. The ANOVA test results are shown in Table 7. Both the F and Welch F test statistics have probabilities close to zero suggesting that the dependent variable is normally distributed in each group, and there is a homogeneity of variances. The determination of the strong results is confirmatory for the results obtained with the long-run coefficients and cointegration tests at the previous stages.

The equality of variances between the analyzed series is further tested with the Bartlett, Levene and Brown-Fosythe tests. Additionally, the equality of medians between the series is tested with Chi, Adjusted Chi, Kruskal-Wallis and van der Waerden tests. The results are shown in Table 8. The results suggest the equality of variances and medians between the analyzed series at conventional significance levels.

The coefficient of ECM is estimated as -0.1038 which suggests a slow speed of adjustment towards the long-run equilibrium. The results

Table 6
FMOLS, DOLS, OLS and PMG results.[a]

	Dependent Variable: co				
	FMOLS	DOLS	OLS	PMG	PMG
tr	0.135 (3.8)	0.1453 (3.43)	0.2536 (2.35)	0.574 (5.1)	0.336 (1.79)
c	0.343 (2.14)	1.146 (2.5)	0.98 (2.12)	0.713 (2.69)	0.0171 (2.08)
y	0.678 (3.6)	1.046 (2.91)	0.76 (2.89)	0.64 (3.12)	0.2066 (2.601)
fdi	0.028 (2.61)	0.052 (2.99)	0.087 (1.82)	−0.143 (2.37)	0.489 (2.56)
ecm					−0.1038 (−2.253)
R^2	0.869	0.91	0.85	0.77	0.73
$\bar{R}^2$	0.862	0.89	0.79	0.71	0.70

[a] Some studies suggest that the results of DOLS method are more robust than others while other studies maintain FMOLS or OLS methods are superior to other. Thus, we prefered to use all of the methods mentioned above in order to avoid doubts about the results.

Table 7
ANOVA test.

	Value	Probability
A.F-test(Anova)	666.4655	0.0000
F-test*(Welch)	1404.264	0.0000
Test allows for unequal cell variances		
Source of Variation	SSq.	Mean Sq.
Between	12,267.00	3066.750
Within	4808.581	4.601513

Table 8
Tests between the series.

Equality of variances between series			Equality of medians between series		
Method	Value	Probability	Method	Value	Probability
Bartlett	363.9692	0.00	Med. X^2	711.7458	0.00
Levene	63.94900	0.00	Adj. Med. X^2	704.4312	0.00
Brown-Forsythe	18.93317	0.00	Kruskal-Wallis	719.3994	0.00
			van der Waerden	667.7413	0.0000

Table 9
The results of short-run causality.

Test Direction	Result	Direction of the causality
$\Delta y \rightarrow \Delta tr$	6.235	$tr \leftrightarrow y$
$\Delta tr \rightarrow \Delta y$	5.336	
$\Delta y \rightarrow \Delta fdi$	6.856	$fdi \leftrightarrow y$
$\Delta fdi \rightarrow \Delta y$	5.569	
$\Delta y \rightarrow \Delta co$	3.896	$co \leftrightarrow y$
$\Delta co \rightarrow \Delta y$	4.086	
$\Delta y \rightarrow \Delta c$	0.115	$c \rightarrow y$
$\Delta c \rightarrow \Delta y$	2.986	
$\Delta tr \rightarrow \Delta co$	2.356	$tr \rightarrow co$
$\Delta co \rightarrow \Delta tr$	0.245	
$\Delta tr \rightarrow \Delta c$	3.445	$tr \rightarrow c$
$\Delta c \rightarrow \Delta tr$	0.296	
$\Delta tr \rightarrow \Delta fdi$	0.856	*None*
$\Delta fdi \rightarrow \Delta tr$	0.007	
$\Delta fdi \rightarrow \Delta co$	2.896	$fdi \rightarrow co$
$\Delta co \rightarrow \Delta fdi$	1.003	
$\Delta fdi \rightarrow \Delta c$	3.963	$fdi \rightarrow c$
$\Delta c \rightarrow \Delta fdi$	0.563	
$\Delta c \rightarrow \Delta co$	16.701	$c \leftrightarrow co$
$\Delta co \rightarrow \Delta c$	2.896	

Notes: → shows the direction of causality. When the test statistics in Table 9 are compared to the bootstrap critical values of Dumitrescu and Hurlin (2012), it is observed that these test statistics are significant.

so far confirm the outcome determined by PMG estimator. In the state of statistical significance of the ECM, a change in one variable should influence the other variables and therefore the investigation of Granger causality nexus among the variables deserves special importance. The short-run Granger causality nexus is evaluated in Table 9 and the long-run and strong causality results are presented in Table 10, respectively.

We found short and long-run and strong causality between the variables. As our focus is on the impact of terrorism, energy consumption, economic growth and FDI on environmental pollution, we only discuss the causality relations of CO_2 emissions with other variables.

While we found strong bi-directional causality between CO_2 emissions and other variables, namely, terrorism, FDI inflow energy consumption and economic growth in the long-run, we found bi-directional causality between CO_2 emissions and economic growth and between CO_2 emissions and energy consumption and unidirectional one from terrorism to CO_2 emissions and from FDI inflows to CO_2 emissions in the short-run. There is no deviation between the long and short run for the relation CO_2 emissions and economic growth and energy consumption due to the economic growth problems related to structural problems in these countries. Moreover, the causality relationship of terrorism and FDI with CO_2 emissions differs depending on the long-run and the short-run. One possible explanation for the difference is that FDI inflow brings pollutant industries to these countries and the impact on the environment is immediate due to the weak environmental regulations, but the feedback effect appears after a long time. Similarly, terrorists use huge amount of fossil energy, which has immediate and long-lasting effects on the environment but it takes time the feedback effect to occur.

According to the results of short and long-run and strong causality tests;

1- There is bidirectional causality between real GDP and terrorism, between FDI inflow and real GDP, between CO_2 releases and real GDP, and between energy usage and CO_2 releases in both the short and long run. It is determined the evidence of one-way causal link running from energy usage to real GDP, from FDI inflow to energy usage, from terrorism to CO_2 releases, from FDI inflow to CO_2 releases and from terrorism to energy usage in short run. Causality results support the coefficients obtained from PMG, DOLS and FMOLS models. The result of one-way causality from FDI inflow to CO_2 releases is similar to Zakarya et al. (2015) for BRICS countries; Hoffmann et al. (2005) for 50 middle-income countries; Baek and Koo (2009) for India; Kivyiro and Arminen (2014) for DRC, Kenya and South Africa. The result of unidirectional causality from terrorism to CO_2 releases is similar to Jorgenson and Clark (2016); Bildirici, 2017a, 2017c, 2017d.

2- According to the results of the long-run, and strong Granger causality, there is the evidence of bi-directional causality between all variables. The results of causal nexus between energy usage and CO_2 releases are similar to the findings of Shahbaz et al. (2013a), Shahbaz et al. (2015), Ullah and Rahman (2014) and Shahzad et al. (2016), Mensah et al. (2019). The bi-directional causality between CO_2 releases and FDI is supported by the results of Pao and Tsai (2011) for BRIC countries, Al-mulali and Tang (2013) for GCC countries, Omri et al. (2014) for Latin America and the Caribbean panel and the Middle East, North Africa, and sub-Saharan Africa panel, Shahbaz et al. (2015) for 99 countries, Hakimi and Hamdi (2016) for Tunisia and Morocco. The results for the relationship between real GDP and CO_2 releases are similar to Omri et al. (2015), Dogan et al. (2017), Inglesi-Lotz and Dogan (2018), Adams and Nsiah (2019).

6. Conclusions and policy recommendations

The relationships among environmental pollution, terrorism, foreign direct investments (FDI), energy consumption and economic growth were tested by different cointegration methods including Johansen, Kao, PARDL and trivariate causality tests for a dataset covering the 1975–2017 period for Afghanistan, Nigeria, Pakistan, Philippines, Somalia, Iraq, Syria, Thailand and Yemen.

According to the results of this paper, terrorist attacks defined as any act causing fear and anxiety in the world do not only have significant effects on economic, social and political problems but also on environmental pollution. The results determined that FDI, real GDP, and terrorism contributed significantly to CO_2 emissions. More critically, terrorism played a crucial role in CO_2 releases, FDI, energy consumption and economic growth. Nevertheless, these factors require vast amounts of energy and therefore contribute to the advance of CO_2 releases in the atmosphere. Moreover, the energy demand for terrorism is increasing day by day as a result of the usage of high-tech equipment.

Environmental pollution and terrorism are not only domestic problems but also international ones. Terrorism cannot be terminated by

Table 10
Long-run and strong causality results.

Dependent variable	Independent variables					
	Long-run	Strong				
	ECM	Δyand ECM	Δ*tr* and ECM	Δ*c* and ECM	Δ*co* and ECM	Δ*fdi*and ECM
Δ*y*	12.28	–	16.16	20.53	6.46	8.73
Δ*tr*	18.76	19.56	–	12.89	7.85	6.35
Δ*c*	8.35	21.05	18.91	–	5.11	10.25
Δ*co*	9.56	22.96	19.98	26.85	–	11.36
Δ*fdi*	8.63	9.58	5.36	8.23	6.69	–

Causality direction.

Strong causality results					
Δ*y and ECM* →Δ*tr*	Δ*y and ECM* →Δ*c*	Δ*y and ECM* → Δ*co*	Δ*y and ECM*→Δ*fdi*	Δ*tr and ECM* →Δ*c*	Δ*tr and ECM* →Δ*co*
Δ*tr and ECM* →Δ*y*	Δ*c and ECM* →Δ*y*	Δ*co and ECM* → Δ*y*	Δ*fdi and ECM* →Δ*y*	Δ*c and ECM* →Δ*tr*	Δ*co and ECM*→Δ*tr*
y ↔ *tr*	*c* ↔ *y*	*y* ↔ *co*	*y* ↔ *fdi*	*tr* ↔ *c*	*tr* ↔ *co*
Strong causality results					
Δ*tr and ECM* →Δ*fdi*	Δ*c and ECM*→Δ*co*	Δ*c and ECM*→Δ*fdi*	Δ*co and ECM*→Δ*fdi*		
Δ*fdi and ECM*→Δ*tr*	Δ*co and ECM*→Δ*c*	Δ*fdi and ECM*→Δ*c*	Δ*fdi and ECM*→Δ*co*		
tr ↔ *fdi*	*c* ↔ *co*	*c* ↔ *fdi*	*co* ↔ *fdi*		

focusing on only one country and the fight against terrorism requires international cooperation. The world is experiencing increasing environmental problems and terrorism is damaging the environment. These problems can be solved by addressing them internationally. However, there is no unique recipe for each country to combat terrorism. Yet, the provision of social and economic prosperity is the common factor that prevents participation in terrorist activities. To this end, it is important to establish the rule of law, to implement democratic institutions and to increase the level of education.

The concentration of the FDI on high-emission industries is one of the important causes of CO_2 releases. The low level of awareness for pollutant industries and the lack of legislative measures towards environmental pollutants have significant roles in the accumulation of emissions. The governments of the countries under analysis must pay more attention to the policies aimed at reducing pollutants and establishing strict environmental regulations to prevent the inflow of foreign direct investment into pollutant sectors. These countries have structural problems and they need to attract FDI for economic growth. Besides the implementation of policies that will end terrorist activities, these countries can attract FDI having high-cost green technology provided that they establish political stability and democratic institutions such as the rule of law and the prevention of corruption. In addition to these countries, and generally all over the World, FDI, energy consumption, economic growth and terrorism have a deteriorating effect on environmental pollution. If the governments of these countries make decisions to reduce CO_2 emissions, they must focus on terrorism and FDI inflows in addition to the level of energy consumption.

The results of this paper revealed three important outcomes in the perspective of environmental damage. Firstly, policymakers should have strong struggle to decrease environmental damage. FDI inflow should be in line with enhancements in environmental quality. The governments must focus on the effect of terrorism and FDI inflows on environmental indicators. Secondly, the CO_2 releases may be decreased by the advance of responsiveness of the governments. And lastly, renewable energy sources are important for the decrease of environmental damage.

Declaration of Competing Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgments

The authors would like to thank anonymous reviewers for their valuable suggestions and helpful comments which have greatly enhanced the quality of this paper.

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