

FOREIGN DIRECT INVESTMENT, GOVERNMENT SPENDING AND ENVIRONMENTAL QUALITY IN PAKISTAN

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Abstract

The study focuses on exploring the effects of Foreign Direct Investment (FDI) and government spending on environmental degradation in Pakistan. For empirical analysis, the data was collected from the World Bank Development Indicators and Economic Surveys of Pakistan. The regression technique of Auto Regressive Distributed Lag (ARDL) and Bound Test are adopted for the empirical analysis. Bound test confirmed the existence of long-term relationship. The outcomes of the regression analysis reveal that; FDI and government spending are holding damaging effects on the environmental degradation. In case of control variables, mixed results are found. The conclusion is clearly drawn from the findings that FDI which is mostly machinery oriented so do the government spending tend to damage the environment. As a policy option, it is recommended to invest on environmental rehabilitation in-line with the FDI and government spending which could not be adjourned due to carrying damaging role towards the environment quality. However, better management and latest technology together with investment on restoration of the environment is felt to be an appropriate strategy to have realized the macroeconomic objectives coupled with better state of environment.

INTRODUCTION

FDI is an important source of capital for promoting economic development and entrepreneurial activities. There are push and pull factors which are the main reasons behind outflow and inflow of FDI. Less environmental regulations, lower labor costs, big markets and subsidy packages in host countries work as pull factors. These factors attract the foreign investors to invest this country. While strict environmental regulations and relatively higher labor costs are

contributed as push factors. During the period of 1970-80, many pollutions intensive industries migrated from those countries which have strict environmental policies to those countries which have lower income and relatively less environmental regulations. Imposition of regulatory policies related to environment, also impose some costs on foreign investors and the host country also have to bear its cost in terms of low productivity growth.

In the last two decades; world has seen an intensive inflow of FDI towards the developing countries. More and more developing countries are competing with each other to attract this type of investment. Restrictions which were earlier in place of these investments are now being removed as the importance is being realized. The government is also coming out with new reforms and policies to promote more and more of this investment.

Sustained flow of FDI enables country like that of Pakistan to stabilize her economy particularly in the context of driving up government size. Taking into account Pakistan's prospective, not only it brings improvement in government size, growth of such indicators has universal positive impact on other sectors of Pakistan economy as well. To establish a FDI strategy for developing countries such as Pakistan to cope with poverty and economic crisis and provide an environment for foreigners to maintain a link with countries of origin through a complex network of cultural, economic, social and political relations, which can be sustained through new technologies and cheaper travel. System of FDI to become an important source of foreign exchange earnings, improve FDI for better contributed to economic growth in Pakistan and also improve the government regulation and supervision to explore new markets for manpower exports in order to get sustainable level of FDI.

Foreign Direct Investment (FDI) is a significant driver of economic growth, especially in developing countries like Pakistan. FDI brings much-needed capital, advanced technology, and managerial expertise, which can stimulate local industries and create employment opportunities. However, the environmental impact of FDI is a contentious issue. Zarsky (1999) highlighted the risks associated with FDI, noting that multinational corporations might exploit weaker environmental regulations in host countries, leading to environmental degradation. Conversely, Paziienza (2015) argued that FDI could introduce cleaner technologies and better environmental practices, potentially enhancing environmental quality.

In the context of FDI and government size on environmental degradation, the financial sector

development enhances the contribution of government to economic growth in Pakistan. In order to attract investor to make their investment decisions through keep an eye on the direction of the foreign capital inflows.

Various researches have been directed recently to discern the effect of FDI and government spending on economy but still there is a blend supposition about the association of FDI, government spending, and economic development. The FDI exchanges through right channels have come to \$440 billion in 2009. FDI influence economy in developing nations yet FDI is not the prerequisite for reasonable development in light of the reality that the majority of the FDI are depleted on consumption rather on sparing and speculation in this manner government ought to break the cycle of reliance on FDI for development and growth. FDI can be used efficiently to guarantee economic development (Mehmood et al., 2025) FDI and wealth inflows are admired just for long run economic development and the nations ought to expand exports rather than in-focusing FDI.

In Pakistan, FDI has been pivotal in sectors such as energy, infrastructure, and manufacturing, particularly through projects under the China-Pakistan Economic Corridor (CPEC). While these investments are essential for economic development, they also raise concerns about their environmental impacts. For example, large-scale infrastructure projects can lead to deforestation, water pollution, and increased carbon emissions if not managed sustainably (Rehman et al., 2017).

Globalization also becomes a reason for environmental degradation in developing nations. It effects on environment through two channels. First channel is pollution havens, through the globalization dirty industries move from developed countries to developing nations. It is because those developing countries have less environmental regulations than a developed country. So, it becomes a reason for environmental degradation. Second is the environmental Kuznets curve. It explains that there is inverse U shape relationship between country's income and pollution level. At first it causes to increase in pollution level then after

increasing income at reasonable level, the pollution level started to decrease.

Economic literature represents positive role of FDI as Afza and Nazir (2007) stated that FDI and economic growth are positively associated. FDI is to be attracted to those countries and sectors which have actual and potential comparative advantages. Pakistan witnessed a steady growth in FDI during past few years. The growth of FDI is due to macroeconomic reforms and political stability. This growth in FDI may be due to political stability and macroeconomic reforms by the government. FDI in Pakistan is increasing with the passage of time but it is still very low as compared to some other countries.

Government spending, particularly done for environmental protection and sustainable development plays a crucial role in mitigating the adverse effects of economic activities. Effective government intervention through regulations, enforcement mechanisms, and investments in sustainable infrastructure can enhance environmental quality. Government spending can take various forms, including funding for environmental monitoring and enforcement, investment in green infrastructure, and subsidies for renewable energy projects. One of the primary roles of government spending in environmental protection is to fund regulatory agencies that monitor and enforce environmental laws. This includes ensuring that industries comply with pollution standards, managing protected areas, and overseeing the sustainable use of natural resources (OECD, 2017). Effective enforcement of environmental regulations is essential to prevent industries from externalizing their environmental costs, which can lead to significant ecological damage.

In addition to regulatory enforcement, government spending on infrastructure can have a substantial impact on environmental quality. Investments in public transportation, waste management systems, and water treatment facilities can reduce pollution and improve public health. For example, improved public transportation can decrease reliance on private vehicles, thereby reducing emissions of greenhouse gases and air pollutants (Litman, 2013). Furthermore, government subsidies and

incentives for renewable energy projects can promote the adoption of clean energy technologies. These financial supports can lower the costs of renewable energy sources such as wind, solar, and hydroelectric power, making them more competitive with fossil fuels. This transition to cleaner energy sources is crucial for reducing greenhouse gas emissions and mitigating climate change (IEA, 2019).

In Pakistan, government spending on environmental protection has been inconsistent and often overshadowed by other economic priorities. Historical challenges include inadequate waste management infrastructure, insufficient monitoring of industrial emissions, and weak enforcement of environmental laws. Nasir and Ur Rehman (2011) highlighted that limited financial resources have resulted in inadequate infrastructure for waste management, insufficient monitoring of industrial emissions, and weak enforcement of environmental regulations.

Additionally, the government has increased investment in renewable energy sources to reduce reliance on fossil fuels and improve environmental quality. Pakistan has set ambitious targets for renewable energy development, aiming to generate a significant portion of its electricity from wind, solar, and hydroelectric sources. These investments are critical for reducing greenhouse gas emissions and addressing the country's energy shortages (Javaid, 2017).

However, the effectiveness of these efforts largely depends on the level of government commitment and the availability of financial resources. Effective implementation of environmental policies requires sufficient budgetary allocations and institutional capacity to enforce regulations. Strengthening environmental governance and ensuring consistent funding for environmental protection initiatives are essential for achieving sustainable development in Pakistan.

Environmental quality refers to the condition of the natural environment, including air, water, and soil, and its ability to support healthy ecosystems and human well-being. High environmental quality is characterized by clean air and water, healthy ecosystems, and low levels of pollution and environmental degradation. Conversely, poor

environmental quality is marked by high pollution levels, degraded ecosystems, and adverse health effects on humans and wildlife. Several factors influence environmental quality, including industrial activities, urbanization, agricultural practices, and natural resource management. Industrial activities can lead to air and water pollution if emissions and effluents are not adequately controlled. Urbanization often results in habitat destruction, increased waste generation, and higher energy consumption, all of which can negatively impact environmental quality (UNEP, 2019). Agricultural practices, particularly the use of chemical fertilizers and pesticides, can lead to soil degradation and water pollution. Sustainable agricultural practices, such as organic farming and integrated pest management, can help mitigate these impacts and improve environmental quality. Effective management of natural resources, such as forests and water bodies, is also crucial for maintaining healthy ecosystems and ensuring the provision of ecosystem services (Food and Agriculture Organization, 2016).

In Pakistan, environmental quality has been a growing concern due to rapid industrialization and urbanization. The Environmental Protection Act of 1997 and subsequent regulations have laid the groundwork for environmental governance in the country. However, effective implementation and enforcement of these regulations have been hindered by financial constraints and institutional weaknesses (Siddiqui, 2010). Air pollution is a significant environmental issue in Pakistan, particularly in urban areas. Major sources of air pollution include vehicle emissions, industrial activities, and the burning of agricultural residues. High levels of particulate matter and other pollutants have adverse effects on public health, contributing to respiratory diseases and other health problems (Malik & Rana, 2020).

Water pollution is another critical issue, with industrial effluents, agricultural runoff, and untreated sewage contaminating rivers and groundwater. This pollution affects aquatic ecosystems and poses health risks to communities that rely on these water sources for drinking and irrigation. Efforts to improve water quality have been limited by inadequate infrastructure for wastewater treatment and insufficient

enforcement of environmental regulations (Nasir & Ur Rehman, 2011). Despite these challenges, there have been positive developments. The Billion Tree Tsunami afforestation project and increased investment in renewable energy sources reflect a growing recognition of the need to integrate environmental considerations into economic planning. These initiatives aim to improve environmental quality by enhancing biodiversity, sequestering carbon dioxide, and reducing reliance on fossil fuels (Qureshi et al., 2016).

This study aims to fill this gap by examining the relationship between FDI, government spending, and environmental quality in Pakistan. It seeks to understand whether FDI contributes to environmental degradation or improvement, and how government spending on environmental initiatives influences this relationship. By exploring these dynamics, the study provides insights into how Pakistan can achieve sustainable economic growth while safeguarding environmental quality. The findings inform policymakers on the necessary measures to balance economic and environmental objectives, ensuring that FDI and government spendings contribute positively to sustainable development.

The research objectives are readable as;

1. To analyze the impact of FDI on the environmental quality in Pakistan, assessing whether increased FDI contributes to environmental degradation or improvement.
2. To evaluate the role of government spending on environmental initiatives in mitigating the negative environmental impacts of economic activities, including FDI, in Pakistan.
3. To investigate the interplay between FDI, government spending, and environmental regulations in Pakistan, and how these factors collectively influence the country's environmental quality and sustainability efforts.

This study is divided into five sections such as Introduction, Literature Review, Methodology, Results and Discussions, and Conclusion and Policy Recommendations.

II Literature Review

Studies by Aschauer (1989) and Borensztein, De Gregorio, and Lee (1998) investigated whether public investment in infrastructure acts as a complement or substitute to private investment, including FDI. Analyzing extensive data from the United States, the study found that public investment, particularly in infrastructure, significantly complements private investment. High-quality infrastructure, such as transportation networks, energy supply, and communication systems, reduces operational costs and enhances productivity for businesses, making the host country more attractive for FDI. The presence of robust infrastructure signals to foreign investors that the host country is committed to providing a stable and efficient environment for business operations. Later study highlighted that FDI is a crucial driver of economic growth as it facilitates technology transfer and human capital development.

Zarsky (1999) addressed the environmental implications of FDI, discussing the "pollution haven" hypothesis, which suggested that multinational companies relocate to countries with lax environmental regulations to avoid stringent environmental standards in their home countries.

Hettige and Mani (2000) explored the study on economic development and industrial pollution. The authors used panel data from 1975 to 1994. Ordinary Least Square (OLS) techniques were used to estimate the results. Industrial data was used to investigate the association between industrial pollution and economic development. It was found that there are three factors which are responsible for pollution which are share of manufacturing in total output, sectorial composition, and pollution intensity. It was observed that share of GNP follows the Kuznets curve but others did not.

Chakrabarti (2001) examined the effect of various types of government spending on FDI in developing countries, using panel data from 46 developing countries between 1980 and 1998. The study found that government spendings on infrastructure and education significantly boost FDI inflows.

Campos and Kinoshita (2002) examined the impact of FDI on economic growth in transition economies of Central and Eastern Europe. Their study used panel data from 25 countries between 1990 and 1998 to analyze how FDI contributes to economic growth during the transition from centrally planned to market economies. The authors found that FDI has a positive effect on economic growth, particularly in countries with better institutional quality.

Gemmill and Reza (2002) delved into the intricate relationship between FDI, government spending, and economic growth. Their comprehensive study posited that government spending on infrastructure and human capital significantly enhance the positive effects of FDI on economic growth. Utilizing cross-country panel data from 1970 to 1995, the study discovered that the impact of FDI on growth is substantially higher in countries with significant government investment in education and infrastructure.

Alfaro et al. (2004) explore the role of local financial markets in enhancing the positive effects of FDI on economic growth. Using data from a panel of 47 countries over the period 1970-1995, the study found that countries with well-developed financial markets benefit more from FDI. The authors argued that efficient financial markets facilitate better allocation of resources, enabling local firms to absorb new technologies and practices introduced by foreign investors.

Trevino and Mixon (2004) investigated the impact of FDI on environmental quality in OECD countries. Using panel data analysis, the study found that FDI generally leads to improve environmental performance due to the higher environmental standards and technologies brought by multinational corporations. However, the study also noted that the positive impact is contingent on the host country's environmental policies and public spending on environmental protection.

Hoffmann et al. (2005) investigated FDI and pollution. The authors used data of 122 countries over 15-20 years. The authors used Granger causality test for causation. It was observed that in poor economies, CO₂ level Granger cause inward FDI flows. For middle income countries, inward FDI Granger causes CO₂ emissions. Finally, for

high income countries no Granger causality was found. The hypothesis of pollution heaven was only supported for low-income countries. The study did not find significant results for CO₂ emission and direction of FDI for high income countries. So, the authors rejected pollution heaven hypothesis for high income countries because these countries could afford implementing cost and have better infrastructure, which was an indicator of no pollution in these countries.

He (2006) worked on the impact of FDI on pollution and for pollution havens hypothesis a case study of industrial emission of Sulphur dioxide in case of China. Panel data of 29 provinces of China was used by author for empirical purpose during the period 1994 to 200. Sulphur dioxide was used as the proxy of pollution in China. It was concluded FDI had minute effect on Sulphur dioxide emission.

Liang (2006) explored whether FDI was harmful for host country environment in case of china. Panel data of major cities in China was collected and OLS method was used for estimating the results. Sulphur dioxide was the focus of this study because it caused many health problems in China. Acid rain 30% of China's total land area was observed due to this. The results showed that there is a correlation between FDI and local air pollution.

Cole, Elliott, and Fredriksson (2006) investigated how FDI influences environmental regulations in host countries. Using panel data from a range of countries, the authors found that FDI can lead to stricter environmental regulations when multinational corporations adhere to higher standards than those in the host countries. This dynamic often results in improved environmental quality due to the transfer of cleaner technologies and practices.

Merican et al. (2007) studied FDI and pollution in five ASEAN countries. Time series data and ARDL technique for the purpose of estimation. It was observed that in Malaysia pollution increased due to FDI and also in Thailand and Philippines but did not increase in Indonesia where this was negatively related and in case of Singapore it was found insignificant. Per capita GNI and manufacturing value added were also included in

the study to explain level of carbon dioxide in metric ton per capita in each nation.

Jorgenson et al. (2007) examined FDI dependency and environment an Eco structural structure approach. The authors used panel data of 39 less developed countries and Generalized Least Square (GLS) for estimating the results. This study examined the effects of FDI on four types of emissions such as Nitrogen oxide, Carbon mono oxide, volatile organic compounds and Carbon dioxide emissions. It was concluded that FDI had insignificant effects on other emissions while it was positively linked with CO₂ emissions.

Bao et al. (2008) explored the environmental consequences of FDI in China. Author used panel data (1992-2004) from 29 provinces of China. Non-Linear model was used to estimate the results. Pollution was taken as dependent, and FDI, scale effect, composition effect and technology effect independent variables. Industrial polluted water emission, chemical oxygen demand in water pollution, SO₂ emissions, smoke of industries emissions and solid waste of Industries were included as indicators of pollution emissions. Inverted u shape relation was found between FDI and pollution.

Kirkpatrick and Shimamoto (2008) discovered the relationship between FDI, public spending, and environmental quality across different countries. Using a large panel dataset, the study found that public spending on environmental protection and infrastructure significantly mitigates the negative environmental impacts of FDI. The study highlights that coordinated public and private sector efforts are essential for achieving environmental sustainability.

Pazienza (2015) worked on the link between carbon emission and FDI in fishing sector of OECD countries. OLS technique was used for the purposes of estimation. The study used panel data (1981 to 2005) for 30 OECD countries. This paper analyzed the link between the inflow of FDI in the fishing sector of OECD and CO₂ emissions. Estimation results concluded that increase in FDI caused to reduce CO₂ emissions. FDI played its positive role in the environmental quality of OECD countries.

Tang et al. (2015) examined the impacts of energy consumption, FDI, income, and GDP on CO₂

emissions in Vietnam. The authors used annual data (1976-2009). ARDL and Granger causality test was used in this study. The Object of this study was to explore the link among FDI, CO₂ and energy use. The empirical results showed that square of income had negative impact on CO₂ emission in Vietnam. EKC hypothesis proved to be true in Vietnam. It was concluded that the main contributors of CO₂ emission are FDI, income, and energy consumption.

Siddique and Majeed (2015) analyzed the environmental impact of FDI in Pakistan using sectoral data from 1980 to 2012. The study found that FDI in the industrial sector significantly increases pollution levels, whereas FDI in the services sector has a relatively lower environmental impact. The study emphasized the role of government spending on environmental protection in mitigating the negative effects of FDI.

Shahbaz, Solarin, and Mahmood (2015) investigated the role of FDI and government spending in promoting environmental sustainability in Pakistan. Using cointegration and causality analysis, the study concluded that FDI has a significant positive impact on carbon emissions in the long run, indicating that increased FDI leads to higher pollution levels. However, government spending on environmental protection and green infrastructure can mitigate these negative impacts.

Zhu et al. (2016) explored the effects of economic growth, FDI and energy consumption on CO₂ emission in ASEAN countries. Authors used panel data for estimation purpose from 1981-2011. The authors used panel unit root test, Johnson Fisher panel co integration test, OLS regression, panel quantile regression, robustness analysis and Wald test for the purpose of estimation. The conclusion was given that; use of energy consumption has positive effect in CO₂ emissions. FDI impacted CO₂ positively. Increase in FDI caused to increase in CO₂ emissions.

Bakhsh et al. (2017) explored the study on the release of CO₂, renewable waste, economic growth, and FDI link in Pakistan. The study used annual data set for 1980-2014. 3SLS used for the purpose of estimation. This study presented the effects of FDI on environment through the scale

technique and composition effect. It was concluded that scale effect revealed that physical capital stock and labor had positively affected GDP and pollution had negative effect on GDP. FDI had negative impacts on carbon emission. Road length and capital stock were positively related in composition effect with CO₂ while GDP per capita had negative effect.

Bokpin and Godfred (2017) explored the relation PHH in Africa. 24 years' panel data from (1990-2013) was used to show the impact of FDI inflows on the environmental sustainability in Africa. OLS estimation technique was used in this study. This study of Bokpin and Godfred (2017) investigated that governance and institutions regulate the impacts of FDI on environmental degradation. It was concluded that increase in FDI inflows have the negative impacts on the sustainability of the environment. If the governance of the government is proper and institutions are developed the FDI have positive impacts on environmental sustainability.

Abbas et al. (2020) studied the impact of socioeconomic variables on environmental degradation in Pakistan from 1984 to 2017. Governance, FDI, GDP per capita, industrialization, transport, urbanization, population growth, and agricultural land are the dependent variables, while governance, FDI, GDP per capita, industrialization, transport, urbanization, population growth, and agricultural land are the independent variables. To estimate, the study used the unit root test, bound test, serial correlation, heteroskedasticity, and stability test. The results showed that all three models have a negative and substantial impact on environmental degradation.

In conclusion, the literature review highlights the necessity of a balanced and integrated approach to managing FDI and government spending to ensure environmental sustainability. Effective governance, robust environmental regulations, and strategic public investments are critical to leveraging the benefits of FDI while mitigating its potential environmental costs. This holistic approach can drive sustainable economic growth and improve environmental quality, benefiting both current and future generations.

III Methodology

Data and Methodology

The data used in this research consists of an annual time series from 1980 to 2022, acquired from the World Bank's World Development Indicator Database (WDI), UNDP's Macro Trends Database, and Country Economy.

The effect of FDI, Government Spending on Environmental Degradation in Pakistan is examined using a variety of econometric methodologies. The following information provide an explanation of various methods:

Correlation Analysis

This analysis exhibits the association between two variables. The sign and magnitude of the correlation coefficient are important in examining the direction and strength of the correlation. The magnitude lies between -1 and +1. Value one explores exact, while value zero explores no correlation between two variables.

Unit Root Analysis

This analysis is imperative to check the level of stationarity of variables. This study could be used to determine the best technique to estimate the variables. Various panel unit root tests, including the Levin, Lin, and Chu (LLC), Im Pesaran and Shin (IPS), and Augmented Dickey-Fuller Fisher (ADF) tests, are used in this study. OLS is a suitable technique for long-run estimation if a subset of the model's variables is all stationary at the same level, panel ARDL is appropriate if some of the variables are stationary at the same level but others are at the first difference, and co-integration is appropriate if all the variables are stationary at the first difference.

ADF Test

To check the unit root (stationarity) of the variables, ADF test has been used. There are three stages of ADF test—one is without intercept and without trend, other is with intercept only and last one is with intercept and trend. If probability values of the variable are statistically significant in two or more stages of ADF test then the variable is stationary at level, that is, integrated of order zero, $I(0)$. On the other hand, if the p-values are insignificant in two or more stages of the ADF test then the variable is non-stationary at level. If it becomes stationary after taking first difference, then the variable is stationary at first difference,

that is, integrated of order one, $I(1)$. If all variables are stationary at level $I(0)$ then OLS is used. On the other hand, Johnson Cointegration is used when all the variables are stationary at first difference $I(1)$. In this study we use ARDL as there are mix results as some of the variables are stationary at level (i.e., integrated of order zero, $I(0)$) and some are stationary at first difference (i.e., integrated of order one, $I(1)$).

ARDL Bound Test

The Wald test (or F-test) is used to investigate the presence of a long-run correlation between the variables in equations, in which the joint significance of coefficients for lagged one variable is tested against the alternative hypothesis using F-statistics calculated under the null hypothesis that there is no co-integration.

The F-statistics obtained are then compared to the critical limit values provided by Pesaran et al (2001). The null hypothesis of no cointegration is rejected if the resulting F-statistics value exceeds the upper critical bounds. The null hypothesis of no cointegration is not rejected if the F-statistics are lower than the upper and lower critical limits. The test becomes inconclusive when the estimated F-statistics value goes below or is between the critical lower and upper bounds.

The short-run dynamics are investigated after the construction of a co-integrating link.

The existence of long run relationship is tested by ARDL test. If F-statistics value is greater than the upper limit at 5% and 10% then there is evidence of the existence of long run relationship.

Autoregressive Distributive Lags (ARDL)

To analyze the long-run relationship between FDI, government size and environmental degradation in Pakistan, this study employs the ARDL model technique prescribed by Pesaran et al. (2001). This method is useful for predicting long-run correlations between variables since it offers numerous advantages over other co-integration strategies. The first is that it may be employed whether the underlying regressors are just $I(0)$, merely $I(1)$, or mutually co-integrated (Pesaran and Shin, 1999).

Dynamic heterogeneous estimates of panel approach are biased and misleading. They did not clearly distinguish differences based on countries because of estimator's heterogeneity among the

countries. So ARDL method is best to check the long run as well as the short run results of FDI and environmental degradation. Some of the advantages of ARDL estimation technique are given as:

- Variables either it is stationary at level I(0) or stationary at first difference I(1) are the components of ARDL.
- For the case of small sample size it is optimum most approach.

- If dummy variables are part of the model than ARDL technique is also useful to measure co integration.
 - ARDL results are not reliable for the variables which is stationary at second difference I(2).
- Finally, run the CUSUM and CUSUMSQ tests to check that the configuration is stable.

ARDL Model Specification

General form of the model 1

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \beta_1(FDI)_{t-1} + \beta_2(INF)_{t-1} + \beta_3(LFPR)_{t-1} + \beta_4(POPG)_{t-1} \\ & + \beta_5(TS)_{t-1} + \beta_6(TR)_{t-1} + \sum_{i=1}^{b_1} \delta_1 \Delta(CO_2)_{t-i} + \sum_{i=0}^{b_2} \delta_2 \Delta(FDI)_{t-i} + \sum_{i=0}^{b_3} \delta_3 \Delta(INF)_{t-i} \\ & + \sum_{i=0}^{a_4} \delta_4 \Delta(LFPR)_{t-i} + \sum_{i=0}^{a_5} \delta_5 \Delta(POPG)_{t-i} + \sum_{i=0}^{b_6} \delta_6 \Delta(TS)_{t-i} + \sum_{i=0}^{b_7} \delta_7 \Delta(TR)_{t-i} + \cup t \end{aligned} \quad [1]$$

Long run equation of the model is

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \sum_{i=1}^{b_1} \rho_1(FDI)_{t-i} + \sum_{i=0}^{b_2} \rho_2(INF)_{t-i} + \sum_{i=0}^{b_3} \rho_3(LFPR)_{t-i} \\ & + \sum_{i=0}^{b_4} \rho_4(POPG)_{t-i} + \sum_{i=0}^{b_5} \rho_5(TS)_{t-i} + \sum_{i=0}^{b_6} \rho_6(TR)_{t-i} + \cup t \end{aligned} \quad [2]$$

Error Correction model equation of the model is

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \sum_{i=1}^{b_1} \zeta_1 \Delta(FDI)_{t-i} + \sum_{i=0}^{b_2} \zeta_2 \Delta(INF)_{t-i} + \sum_{i=0}^{b_3} \zeta_3 \Delta(LFPR)_{t-i} \\ & + \sum_{i=0}^{b_4} \zeta_4 \Delta(POPG)_{t-i} + \sum_{i=0}^{b_5} \zeta_5 \Delta(TS)_{t-i} + \sum_{i=0}^{b_6} \zeta_6 \Delta(TR)_{t-i} + \omega ECM_{t-1} + \cup t \end{aligned} \quad [3]$$

General form of the model 2

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \beta_1(GNE)_{t-1} + \beta_2(INF)_{t-1} + \beta_3(LFPR)_{t-1} + \beta_4(POPG)_{t-1} \\ & + \beta_5(TS)_{t-1} + \beta_6(TR)_{t-1} + \sum_{i=1}^{b_1} \delta_1 \Delta(CO_2)_{t-i} + \sum_{i=0}^{b_2} \delta_2 \Delta(GNE)_{t-i} + \sum_{i=0}^{b_3} \delta_3 \Delta(INF)_{t-i} \\ & + \sum_{i=0}^{a_4} \delta_4 \Delta(LFPR)_{t-i} + \sum_{i=0}^{a_5} \delta_5 \Delta(POPG)_{t-i} + \sum_{i=0}^{b_6} \delta_6 \Delta(TS)_{t-i} + \sum_{i=0}^{b_7} \delta_7 \Delta(TR)_{t-i} + \cup t \end{aligned} \quad [4]$$

Long run equation of the model is

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \sum_{i=1}^{b_1} \rho_1(GNE)_{t-i} + \sum_{i=0}^{b_2} \rho_2(INF)_{t-i} + \sum_{i=0}^{b_3} \rho_3(LFPR)_{t-i} \\ & + \sum_{i=0}^{b_4} \rho_4(POPG)_{t-i} + \sum_{i=0}^{b_5} \rho_5(TS)_{t-i} + \sum_{i=0}^{b_6} \rho_6(TR)_{t-i} + \cup t \end{aligned} \quad [5]$$

Error Correction model equation of the model is

$$\begin{aligned} \Delta(CO_2)_t = & \alpha + \sum_{i=1}^{b_1} \zeta_1 \Delta(GNE)_{t-i} + \sum_{i=0}^{b_2} \zeta_2 \Delta(INF)_{t-i} + \sum_{i=0}^{b_3} \zeta_3 \Delta(LFPR)_{t-i} \\ & + \sum_{i=0}^{b_4} \zeta_4 \Delta(POPG)_{t-i} + \sum_{i=0}^{b_5} \zeta_5 \Delta(TS)_{t-i} + \sum_{i=0}^{b_6} \zeta_6 \Delta(TR)_{t-i} + \omega ECM_{t-1} + \cup t \end{aligned} \quad [6]$$

Table 1

Model 1,2 Expected Relationship of Independent Variables with Dependent Variable

Dependent variable: CO₂

Independent Variables	Description	Expected Sign	Measurement Unit	Source
FDI	Foreign direct investment, net inflows	Positive	(% of GDP)	WDI
LFPR	Labor force participation rate, total	Positive	(% of total population ages 15+) (national estimate)	WDI
TR	Tax Revenue	Negative	(% of GDP)	WDI
TS	Trade in services	Positive	(% of GDP)	WDI
GNE	Gross national expenditure	Negative	(% of GDP)	WDI
INF	Inflation, GDP deflator	Negative	(Annual %)	WDI
POPG	Population growth	Positive	(Annual %)	WDI

IV Results & Discussions

The summary of descriptive statistics is given in Table 2. Apart from GNE, rest of the variables show less diversity since minutely differ in their respective mean and standard deviation.

Moreover, mixed results are found in case of skewness and kurtosis. From Jarque-Bera statistics, it is found that CO₂, POPGS, and TR are exhibiting normal distribution.

Table2: Important Statistics of Key Variables (1980-2022)

	Mean	Max	Min	Std. Dev.	Skew	Kurt	J.B	Prob.
CO ₂	0.77	1.10	0.41	0.20	-0.13	2.25	2.25	0.32
FDI	0.99	3.67	0.10	0.79	1.78	6.07	39.66	0.00
INF	8.19	20.29	2.53	3.67	0.67	3.93	4.77	0.09
GNE	0.77	1.10	0.41	3.67	0.67	3.93	4.77	0.09
LFPR	50.00	52.03	32.20	2.93	-5.35	33.14	32.63	0.00
POPGS	2.57	3.36	1.75	0.50	0.11	1.76	2.86	0.24
TR	12.09	15.18	9.26	1.98	-0.07	1.51	4.01	0.13
TS	32.11	32.89	38.49	25.05	3.79	-0.40	2.18	2.39

Correlation among the variables is presented in Table 3 which shows the association between two variables that may be positive or negative. It also

shows the strength of the relationship as weak, moderate or strong.

Table 3
Correlation of Important Variables (1980-2022)

Correlation	CO ₂	INF	LFPR	PGR	TR	GNE	FDI
CO ₂	1.00						
INF	0.068	1.00					
LFPR	0.339	-0.054	1.00				
POPGS	-0.981	-0.049	-0.349	1.00			
TR	-0.589	0.063	-0.224	0.631	1.00		
GNE	0.006	0.189	0.019	0.025	0.120	1.00	
FDI	0.578	0.358	0.133	0.156	0.386	0.097	1.00

Table 3 highlights that strong evidences of correlation are found between CO₂, PGR, and TR. However, moderate correlation is found between CO₂, FDI, POPGS, INF, and LFPR. And, GNE, INF, and CO₂ exhibit weak correlation. Stationarity of variables is checked through ADF unit root test and PP test to know that either the variables are stationary at I(0) or at I(1). The three

stages of ADF are shown in Table 5. If p-value of two or more stages is significant at conventional levels (i.e., lies between 0.00-0.10), the variable is stationary at level. Same as if the p-value is insignificant then first difference has been taken and in our case almost all variables are stationary at levels or at first difference. The results of ADF test are given below in Table 5.

Table 5
Augmented Dickey Fuller (ADF) Unit Root and Phillips Peron (PP) Test Results

Var.	ADF				Outcome	PP				Outcome
	At Level		At Difference			At Level		At Difference		
	Intercept	Intercept & Trend	Intercept	Intercept & Trend		Intercept	Intercept & Trend	Intercept	Intercept & Trend	
G N E	t-statistics (-2.16) Prob (0.22)	t-statistics (-2.14) Prob (0.50)	t-statistics (-6.69) Prob (0.00)	t-statistics (-6.73) Prob (0.00)	1(1)	t-statistics (-2.74) Prob (0.07)	t-statistics (-2.65) Prob (0.26)	t-statistics (-6.17) Prob (0.00)	t-statistics (-6.05) Prob (0.00)	1(1)

C O 2	t-statistics (-0.72) Prob (0.82)	t-statistics (-4.62) Prob (0.00)	t-statistics (-8.03) Prob (0.00)	t-statistics (-7.96) Prob (0.00)	1(0)	t-statistics (-1.51) Prob (0.51)	t-statistics (-2.50) Prob (0.32)	t-statistics (-4.00) Prob (0.00)	t-statistics (-3.94) Prob (0.02)	1(1)
I N F	t-statistics (1.09) Prob (0.99)	t-statistics (-3.27) Prob (0.09)	t-statistics (-4.88) Prob (0.00)	t-statistics (-5.07) Prob (0.00)	1(1)	t-statistics (0.97) Prob (0.99)	t-statistics (-1.75) Prob (0.69)	t-statistics (-4.95) Prob (0.00)	t-statistics (-5.12) Prob (0.00)	1(1)
T R	t-statistics (-1.90) Prob (0.39)	t-statistics (-1.73) Prob (0.71)	t-statistics (-7.23) Prob (0.00)	t-statistics (-7.31) Prob (0.00)	1(1)	t-statistics (-1.84) Prob (0.35)	t-statistics (-1.65) Prob (0.75)	t-statistics (-7.23) Prob (0.00)	t-statistics (-7.31) Prob (0.00)	1(1)
T S	t-statistics (-1.72) Prob (0.32)	t-statistics (-1.73) Prob (0.71)	t-statistics (-4.23) Prob (0.00)	t-statistics (-7.34) Prob (0.00)	1(1)	t-statistics (-1.85) Prob (0.35)	t-statistics (-1.65) Prob (0.75)	t-statistics (-7.23) Prob (0.00)	t-statistics (-7.31) Prob (0.00)	1(1)
P O P G S	t-statistics (-0.91) Prob (0.77)	t-statistics (-4.24) Prob (0.00)	t-statistics (-3.39) Prob (0.01)	t-statistics (-3.28) Prob (0.08)	1(0)	t-statistics (-0.01) Prob (0.95)	t-statistics (-2.96) Prob (0.15)	t-statistics (-3.39) Prob (0.01)	t-statistics (-3.28) Prob (0.00)	1(1)

L F P R	t-statistics (-1.42) Prob (0.55)	t-statistics (-7.48) Prob (0.00)	t-statistics (-2.62) Prob (0.09)	t-statistics (-2.61) Prob (0.00)	1(0)	t-statistics (-5.48) Prob (0.00)	t-statistics (-33.03) Prob (0.00)	t-statistics (-4.88) Prob (0.00)	t-statistics (-5.07) Prob (0.00)	1(0)
F D I	t-statistics (-2.83) Prob (0.06)	t-statistics (-3.39) Prob (0.06)	t-statistics (-4.41) Prob (0.00)	t-statistics (-4.36) Prob (0.00)	1(0)	t-statistics (-2.09) Prob (0.24)	t-statistics (-2.06) Prob (0.54)	t-statistics (-3.10) Prob (0.03)	t-statistics (-3.02) Prob (0.14)	1(1)

The F-test is used to test the importance of the measurements for a delayed factor with F-data calculated below zero assumption to explore the presence of a long-run relationship among the

variables used inside the model, i.e., FDI, government spending and environmental degradation. The results of the F statistics are shown in Table 5.5.

Table 6
Bound Test



Test Statistic	Value	K
F-statistics	14.03	7
Critical Value Bounds		
Significance	1(0)	1(1)
10%	1.92	2.89
5%	2.17	3.21
2.5%	2.43	3.51
1%	2.73	3.9

Table 6 shows the results of the Bound analysis. The applied test revealed that there is a long-time association among dependent and descriptive variables since the assessed F-value of 14.03305

which is over the critical values of the upper and lower bounds in distinct significant phases. The ARDL representation of the Remittances and Government Size Expansion Model is presented in Table 7.

Table 7
Short Run Relationship

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.72	0.18	3.93	0.00
D(FDI)	0.03	0.01	3.73	0.00
D(GNE)	0.00	0.00	1.89	0.07
D(POPGS)	0.06	0.07	0.82	0.42
D(TS)	0.00	0.00	-0.24	0.81
D(TR)	0.00	0.00	-0.97	0.34
D(INF)	0.00	0.00	-1.76	0.09
D(LFPR)	0.00	0.00	-1.36	0.19
CointEq(-1)*	-0.73	0.11	-6.41	0.00

Source: Author's Calculations

Table 7 shows the short-run results of the FDI, government spending and environmental degradation models. The coefficient of error correction term is -0.726. It is found to exist within the definite range of 0 to -1 and indeed significant. Therefore, the short run disequilibrium is corrected in the long term. FDI emissions have a strong and substantial short-term effect on CO₂, with a 1 unit increase in FDI leading to a 0.0263 unit increase in CO₂. In case of GNE, TR, INF, and LFPR, minute and insignificant relationships are found.

The Table 8 presents the ARDL long-run estimates of the impact of FDI, Government Spending on Environmental degradation in

Pakistan. The dependent variable used in a study is Environmental degradation (CO₂), while independent variables are gross national expenditure (GNE), population growth rate (POPGS), tax revenue (TR), trade in services (TS), labor force participation rate (LFPR), FDI, and inflation rate (INF). It is found that the inflation, labor force participation rate, and population growth rate are negatively associated with environmental degradation while the variable FDI, gross national expenditure, tax revenue and trade openness are positively associated with environmental degradation in Pakistan.

Table 8
ARDL Long Run Analysis

Dependent Variable: Environmental Degradation (CO ₂)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FDI	0.09	0.01	7.42	0.00
LFPR	-0.01	0.00	-1.84	0.14
GNE	0.01	0.00	3.96	0.02
INF	-0.02	0.00	-4.45	0.01
TR	0.02	0.00	6.58	0.00
TS	0.01	0.00	2.03	0.11
POPGS	-0.41	0.02	-24.59	0.00
C	1.43	0.24	5.95	0.00

Source: Author's Calculations

First, exploring the association between FDI and environmental degradation, it is known that FDI is positively and significantly linked to environmental degradation. The coefficient value of LFPR, though insignificant, displays that as LFPR upsurges by one-unit, environmental degradation declines by -0.008370 units. As LFPR in a country upsurge, the income level of the people also increases, which in turn brings inverse impacts the environmental degradation level. These outcomes are also matched by the studies of Nahar & Arshad (2017).

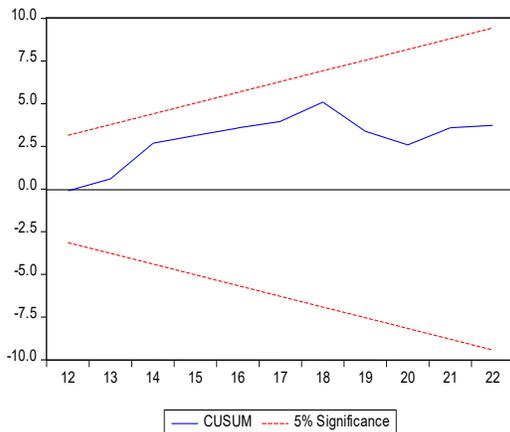
It is found that gross national expenditure is positively and significantly associated with environmental degradation. The coefficient value of GNE exhibits that as gross national expenditure increase by one unit, causes 0.005245-unit increase in the environmental degradation. However, gross national expenditures support economic growth and alleviate pollution by boostings income, easing credit restrictions, speeding up investment, and advancing human development by funding improved healthcare and education (Jongwanich, 2007). These outcomes are also matched by the studies of Peković (2017); Faridi & Mehmood (2014).

It is instigated that the inflation rate is negatively and significantly linked with environmental degradation. The coefficient value of INF displays that as the inflation rate increases by one unit, the environmental degradation level decreases by -0.018175, units. An increase in the inflation rate declines people's purchasing power, so they cannot meet the basic needs of their life due to the high inflation rate. These outcomes are also matched by the studies of Nahar & Arshad (2017); Faridi & Mehmood (2014).

Moreover, trade in services is positively and significantly linked to the environmental degradation. The coefficient value of TS exhibits that as trade in services rises by one unit the level of environmental degradation is increased by 0.005194 units. Increase in trade is important in providing low priced items and also creates employment opportunities for the people so this leads to increase in purchasing power of the people and also boosts the level of income, this in turn spells out in raising the level of environmental degradation in a country. These outcomes are also matched by the studies of Abduvaliev & Bustillo (2020); Tsaurai (2018).

It is found that tax revenue is positively and significantly connected with environmental

degradation. The coefficient value of TR exhibits that as tax revenue increases by one unit, the environmental degradation increases by 0.015098 units. An increase in the population growth rate level can significantly influence the level of environmental degradation because educated people have more skills and efficiency and they have higher income opportunities however, leads to positively influence the level of environmental degradation (Rebello, 1991). These outcomes are



also matched by the studies of Tsaurai (2018); Abduvaliev & Bustillo (2020).

Finally, the CUSUM and CUSUM squared results are given in Figure 2. The analyses accomplish the stable regression estimates with structural stability in both models.

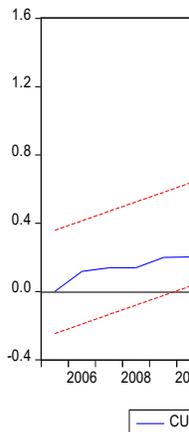
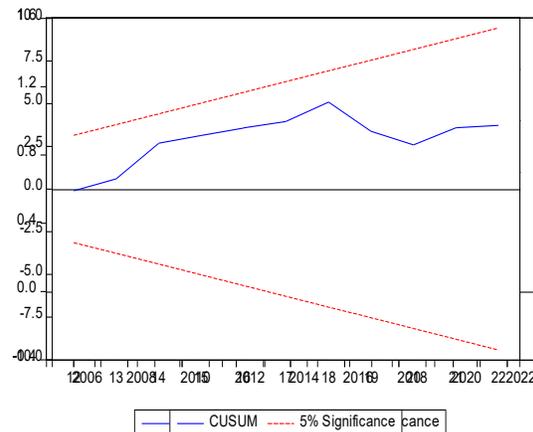


Figure 2
CUSUM-CUSUM Squared

V Conclusion and Policy Recommendations

The objectives of the study were to see the dominant impact of carbon dioxide emission structure in Pakistan by measuring the impact of various factors on carbon dioxide emission in Pakistan and to devise suggestions and policy recommendations.

The study found a positive relationship between FDI, GNE and environmental degradation. It means with the increase of FDI and GNE the environment gets degraded.

As a policy narrative, GNE which causes environmental degradation to rise must be nurtured in a way that environmental hazards are addressed. FDI is also harmful for the environment. The policy makers may not decide to reduce FDI to control environmental degradation rather to facilitate the plans to improve the environmental status by investing in green FDI and government expenditure policies.



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