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Financial Development, Institutional Quality, and Environmental Degradation Nexus: New Evidence from Asymmetric ARDL Co-Integration Approach

Farhan Ahmed [1], Shazia Kousar [2], Amber Pervaiz [3] and José Pedro Ramos-Requena [4,*]

[1] Department of Economics & Management Sciences, NED University of Engineering and Technology (NEDUET), Karachi City, Sindh 75270, Pakistan; fahmed@neduet.edu.pk
[2] Department of Economics, University of Jhang, Jhang, Punjab 35200, Pakistan; shaziabilal2002@gmail.com
[3] the Superior College Lahore, Lahore, Punjab 54000, Pakistan; amberlcwu1234@gmail.com
[4] Departamento de Economía y Empresa, Universidad de Almería, Ctra. Sacramento, S/N, 04120 La Cañada de San Urbano, Almería, Spain
* Correspondence: jpramosre@ual.es

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Abstract: The aim of this study is threefold; first, the study investigates the symmetric impact of trade openness, financial development, and institutional quality on environmental degradation and environmental sustainability. Second, the study examines the asymmetric relationship between financial development, institutional quality, and environmental degradation. Third, the study examines the asymmetric relationship between financial development, institutional quality, and environmental sustainability. For this purpose, the study utilized the data of Pakistan from 1996 to 2018. the study applied Augmented Dickey–Fuller (ADF), Phillips Parron (PP) and Zivote, and Andrews unit root test to check the properties of stationarity of the data. This study applied the Auto Regressive Distributive Lags (ARDL) model to investigate symmetric relationships while the Non-Linear Auto Regressive Distributive Lag Model (NARDL) approach is utilized to investigate the asymmetric relationship among variables. ARDL bounds testing approach utilized to investigate long-run co-integration while short-run dynamics have been investigated by applying the error correction method (ECM). This study found the significant long-run symmetric and asymmetric association of institutional quality (IQ) and financial development (FD) with environmental degradation (ED) and environmental sustainability. However, *IQ*- has an insignificant association with environmental sustainability. Moreover, dynamic multiplier analysis indicates that positive shock to *FD* and *IQ* has a stronger impact on environmental degradation while a positive or negative shock to *FD*; both have a stronger impact on environmental sustainability. However, a positive or negative shock to *IQ* has a smaller impact on environmental sustainability. Moreover, the study also found a significant long-run symmetric association of trade openness with environmental degradation and environmental sustainability. This study suggests that the quality of institutions, financial development, and trade openness is necessary to enhance the quality of the environment.

Keywords: financial development; quality of institutions; environment degradation; environment sustainability; NARDL; ARDL

1. Introduction

Environmental degradation is a fundamental issue in the field of economics and received a huge consideration from different economists and environmentalists. Nowadays, the world faces a major problem of global warming due to the rapid increase in Carbon Dioxide (CO_2) emissions. According to the energy statistical review report of British Petroleum, per capita, CO_2 emissions in Organization

of Economic Co-operation and Development (OECD) nations are reduced by 1.00%, while non-OECD nations released 62.4% of global CO_2 [1]. Among the developing economies, the increase in per capita CO_2 emissions is 8.5% in Pakistan, 6.3% in Malaysia, 7.6% in Indonesia, 8.2% in Ukraine, and 5.2% in Turkey. Evidently, over the past few years, both advanced and emerging nations have experienced increased environmental problems because of the adverse effects that CO_2 emissions imposed on the natural state of the environment [2]. There are many factors that tend to increase environmental degradation; the consumption of traditional energy sources along with unsustainable anthropogenic practices are the main contributors in CO_2 releases, which unsurprisingly resulted in serious climate changes (such as cyclones, heat waves, desertification, earthquakes, and droughts) along with lower living standards. Governments are gradually concerned about the need to tackle these environmental problems which continuously affect environmental sustainability [3]. Though the deterioration of environmental quality has continued, many nations have shown the high rated of economic growth; since financial development play important role in economic growth, so the effects of financial development on environmental quality require an investigation.

Policymakers and other observers have shown considerable interest in the relationship between financial development and CO_2 emissions [4,5]. Numerous researchers showed a positive relationship between financial development and environmental quality deterioration [4]. According to these researchers, financial development tends to increase carbon emissions for the following reasons: First, financial development may attract foreign direct investment, which in turn boosts the economic growth that leads to environmental degradation. Second, the development of the stock market helps the listed organizations to reduce financial costs, increase sponsoring channels, scatter operational risk, and enhance the liability structure, to buy new installations. These installations tend to increase the consumption of energy, which increases CO_2 releases. Third, affluent financial intermediation seems helpful to consumer's loan activities, which makes it accessible for the buyers to purchase luxurious items such as refrigerators, automobiles, washing machines, and refrigerators, etc., which releases more toxic gases like CO_2, Nitrogen Oxide(NO_X), Sulfur dioxide (SO_2), etc. However, other stands of researchers showed the negative association between financial development and environmental quality deterioration [6,7]. These researchers believed that financial development positively contributes to environmental quality as it tends to increase energy efficiency (i.e., replacement of traditional energy with renewable energy), which results in emission reduction [8]. Financial development also makes the ease provision of advanced technologies that are less significant to environmental pollution. It is argued that financial development significantly contributes to environmental sustainability [2].

In addition to financial development, trade openness is another important factor that requires an investigation about environmental degradation and environmental sustainability because the findings of existing studies on the trade–environment nexus are not consistent. Many researchers believed that trade openness positively contributes to the deterioration of environmental quality because advanced progress in emerging nations is enthused by trade openness, which results in industrial pollution and environmental degradation in the form of carbon emissions [9]. the production process for exports is also the main contributor to Green House Gases (GHG) emissions, which adversely affected the environmental sustainability of all nations across the world. While others believed that trade openness is one of the important factors which positively contribute to environmental quality through composition, trade, and technique effect [10]. A country can get access to innovative technologies through trade openness that may provide a cleaner way for the production of goods [11]. Besides financial development and trade openness, institutional quality is another important factor that significantly contributes to the quality of the environment. Generally, the environmental problems in developing economies are linked with the inefficient quality of political institutions because the poor quality of institutions weakens the environmental regulations by presenting a bias in the adaption and implementation of environmental regulation policies.

Therefore, a closer look at the literature reveals several gaps and shortcomings, which the present study wishes to address: First, the literature shows contradictory findings on the relationship between

trade openness and environmental degradation. For instance, some studies like Khobai and Le Roux [12] and Zamil, Furqan, & Mahmood, [13] found a positive relationship while others found a negative relationship [14,15]. Second, the findings of the previous studies on the relationship between financial development and environmental degradation also provide mix results i.e., some studies suggest the positive relationship [16], others suggest the negative relationship [17], while some evidence reveals the presence of non-linearity/asymmetric relationship [10]. Third, as far as we know, a limited number of studies have been done on the relationship between financial development and environmental sustainability [2]. Fourth, the present study determines that the literature does not reveal any empirical evidence on the relationship between institutional quality and environmental sustainability, specifically in the context of developing nations like Pakistan. Fifth, to the best of our knowledge, the relationship between trade openness and environmental sustainability is still not investigated in the case of developing economies. Sixth, most of the existing studies used the inappropriate measures of financial development as they were highly correlated and provided biased results [5]. Therefore, the contributions of the study are threefold. First, the study investigates the symmetric impact of institutional quality, trade-openness, and financial development on environmental sustainability and environmental degradation. Second, the study examined the asymmetric relationship between financial development, institutional quality, and environmental degradation. Third, the study examines the asymmetric relationship between financial development, institutional quality, and environmental sustainability. All the relationships are investigated in the context of Pakistan. the study creates an index of financial development and institutional quality to get more accurate and precise results. the contributions of the present study significantly enhance the existing literature of the environment. This study also helps policymakers in making sound policies to tackle serious environmental problems in Pakistan.

The present study focuses on Pakistan due to the following reasons: First: Pakistan is one of the participants among 196 nations that significantly contribute to CO_2 emissions by releasing 192.7 million tons per year [12]. Figure 1 shows the annual pattern of carbon emissions (per capita) for 1996–2017. On *X*-axis, there are years, while on *Y*-axis, there is per capita CO_2 emissions.

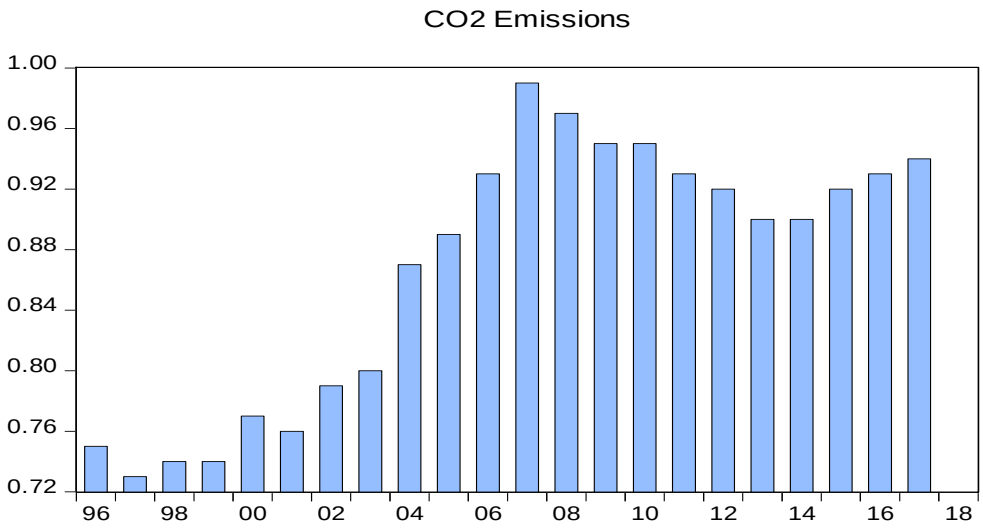


Figure 1. Per capita carbon emissions; source: Created by author.

Second: Pakistan is the 5th vulnerable nation to climate change which is frequently affected by the extreme climate events of 1552 from 1999 to 2018. Figure 2 shows the annual pattern of GHG releases (including carbon dioxide, nitrogen dioxide, and methane emissions) for 1990–2014. On *X*-axis there are years while on *Y*-axis there is CO_2 emission, Methane emission, and Nitrogen oxide.

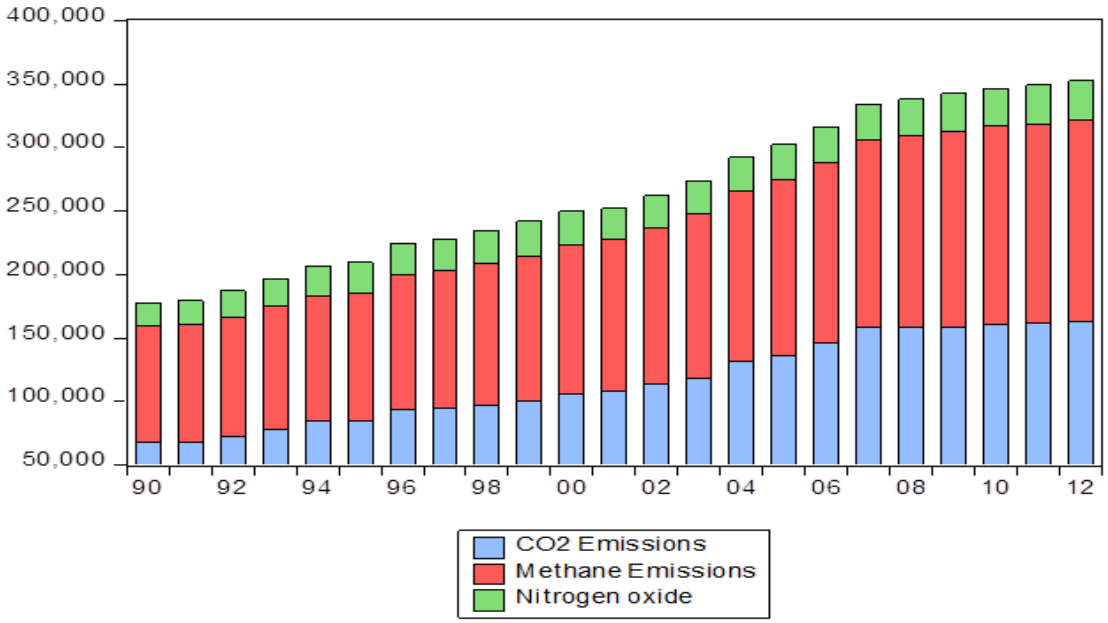


Figure 2. Greenhouse gas emissions; source: Author's calculations.

Extreme climate change events result in an economic loss of 2.8 billion dollars. the government of Pakistan is enthusiastic to overcome this issue through different adaptation approaches, environmental regulation policies, and reduction mechanisms of the emissions.

The contributions of the present study significantly enhance the existing literature of the environment. This study also provides an opportunity for future researchers to conduct a replica of this study in different emerging nations. This study also helps policymakers in making sound policies to tackle serious environmental problems in Pakistan.

The remaining paper is structured as follows: Section 2 explains the review of existing literature; hypotheses of the study are also highlighted in this section. Section 3 concerns data collection and econometric techniques. Section 4 elaborates on the empirical results of the study. Section 5 is about the conclusion, recommendation, policy implications, and the limitations of the study.

2. Literature Review

2.1. Financial Development and Environmental Sustainability

Many researchers have worked on the relationship between financial development and environmental quality and provide conflicting and contradictory results. Some studies showed a positive impact of financial development on environmental quality. For instance, Boutabba [2] investigated the association between income, financial development, trade, and environmental degradation by utilizing the data of India. the results of the study showed a negative relationship between these variables. Shahbaz and Hye [5] examined the empirical association between energy consumption, economic growth, financial development, trade openness, and CO_2 emissions. For this purpose, the study utilized the data of Indonesia from 1975 to 2011. the findings of the study revealed the positive relationship between trade openness, economic growth, energy consumption, and environmental degradation, as well as the negative relationship between trade openness, financial development, and environmental degradation. Shahbaz and Tiwari [18] examined the influence of coal consumption, economic growth, financial development, and trade openness on the environmental quality of South African economies for the period of 1965–2008, and revealed a positive relationship between trade openness, financial development, and environmental quality, while the negative relationship between coal consumption, economic growth, and environmental quality. Tamazian and Rao [6] utilized the data of BRICS economies and examined the empirical association between financial development and carbon

emissions. the study showed that financial development is an imperious factor for environmental sustainability. the findings of the study also validate the EKC in BRICS economies.

Other studies revealed the negative association between financial development and environmental quality. For example, Komal and Abbas [7] utilized the data of Pakistan from 1972 to 2012 and applied the Generalized Method of Moments (GMM) approach for examining the empirical results. the results of the study showed a positive relationship between financial development and carbon emissions. Gokmenoglu and Ozatac [8] explored the empirical relationship between industrial production, financial development, and carbon emissions. For this purpose, the study utilized the data of Turkey throughout 1960–2010 and applied a co-integration approach for examining the empirical results. the results of the study showed that financial development and industrial production positively contributes to carbon emissions. Charfeddine and Kahia [19]. Study utilized the data of the United Arab Emirates (UAE) from 1975 to 2011 ad found an inverted U shape relationship between this financial development and environmental quality. Ahmad and Khan [10] done valuable work in the financial development–environment nexus. the study for the first time investigated the asymmetric relationship between financial development and carbon emissions. For this purpose, the study utilized the data of China from 1980–2014 and applied the Non-Linear Auto Regressive Distributive Lag Model (NARDL) approach to seizure the asymmetry between financial development and carbon emissions. the results of the study showed that positive shock of financial development having more significant effects on carbon emissions as compared to a negative shock. Ganda [11] examined the influence of financial development on environmental degradation and environmental sustainability by utilizing the data of OECD nations throughout 2001–2012. Results of the study showed the negative contributions of financial development in environmental degradation, while positive contributions in environmental sustainability. the results of the study also showed the existence of Environment Kuznets Curve (EKC) in OECD economies.

After reviewing the above literature, it is concluded that the focus of most of the studies was on the relationship between financial development and environmental degradation, revealed conflicting or contradictory results. Moreover, as far as we know, few studies have explored the empirical contributions of financial development on environmental sustainability. Therefore, the present study contributes to the existing debate of financial development–environment nexus by investigating the empirical relationship between financial development and environmental sustainability and by investigating the asymmetric relationship between financial development and environmental degradation.

2.2. Trade Openness and Environmental Sustainability

The association between trade openness and the environment is extensively researched by different academic researchers. the results of the existing studies are of a mixed nature. For instance, some studies have found a positive association, while others revealed a negative association between these variables. Zamil and Furqan [13] examined the influence of trade openness on carbon emissions. In this regard, the study collected the data of Oman between 1972 and 2014. the study applied the Auto Regressive Distributive Lags (ARDL) technique for investigating the empirical results. the results of the study showed the positive effect of trade openness on carbon emissions. Frutos-Bencze, Bukkavesa [14] investigated the influence of foreign direct investment and trade openness on environmental quality. the study used CO_2, NO_X, and SO_2 as proxies of environmental quality. the findings of the study showed the negative influence of foreign direct investment and trade openness on SO_2, CO_2, and NO_X. the study, therefore, concluded that foreign direct investment and trade openness positively contributes to environmental quality. Honma [15] tested the empirical association between international trade and environmental efficiency. For this purpose, the study utilized the data from 98 countries from 1970 to 2008. the study used SO_2, NO, and CO_2 for measuring environmental efficiency. the results of the study revealed the positive relationship between international trade and environmental efficiency.

Udeagha and Ngepah [20] focused their work on South African economies and empirically investigated the affiliation between trade and environmental quality throughout 1960–2016. the results of the study indicated the positive relationship between trade and environmental quality in the short run, while a negative relationship between trade and environmental quality has been found in the long run. Abbas, Kousar [16] utilized the data of Pakistan for 1980–2012 and investigated the empirical association between trade openness and environmental degradation under the framework of the "pollution haven hypothesis" and showed a significant association between trade openness and environmental degradation. Results further confirmed the validation of the pollution haven hypothesis in the context of Pakistan. Solarin and Mulali [17] tested the influence of international trade and institutional quality on the environmental performance of Ghana and found the positive effects of institutional quality while negative effects of international trade on the environmental performance of Ghana. the study also confirmed the "pollution haven hypothesis". De-yong [21] tested the empirical linkage between trade and environmental quality by utilizing the data of emerging economies and results showed the negative relationship between trade and environmental quality. Sinha and Shahbaz [22] revealed similar findings on a panel of 150 economies. Khobai and Le Roux [12] also investigated the [16] empirical association between trade and environmental quality in the context of South African economies and showed the negative impact of trade on environmental quality.

Summarizing the above literature, it is concluded that several studies have explored the effects of trade openness on environmental quality. Despite the success of existing studies in certain aspects, it still suffers from the contradictory results. Moreover, to the extent of the author's best knowledge, the relationship between trade openness and environmental sustainability is not empirically investigated yet; more specifically in the context of developing nations like Pakistan. Therefore, the present study contributes to the existing debate of trade–environment nexus by investigating the empirical relationship between trade openness and environmental sustainability; and by investigating the asymmetric relationship between financial development and environmental degradation.

2.3. Institutional Quality and Environmental Sustainability

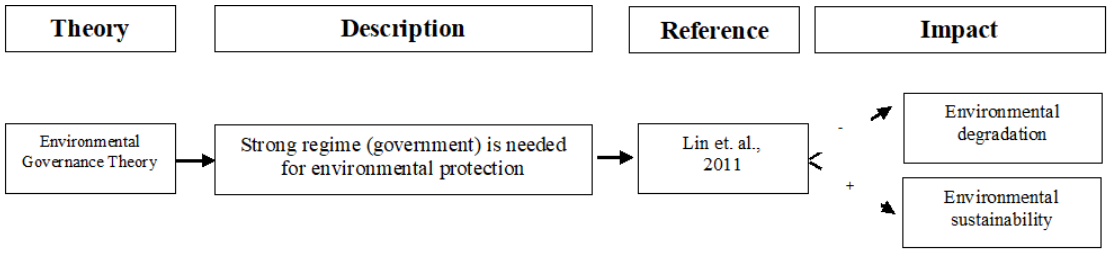
Ample studies have been found on the relationship between institutional quality and environmental quality. For example, Tamazian and Rao [6] investigated the influence of institutional quality on environmental performance. In this regard, the study collected the data of 24 transition economies for the period 1993–2004. the study applied the GMM technique and revealed the positive relationship between the proposed variables. Goel, Herrala [23] focused their work on MENA countries and showed that institutional quality positively contributes to environmental performance. the results of the study suggested that the higher the rate of corruption, the lower the quality of the environment. Cole [24] focused his work on the corruption–pollution nexus. the study collected the data of 94 nations from 1987–2000 and results showed the positive contributions of corruption in increasing environmental pollution. Lau and Choong [25] explored the relationship between institutional quality, economic growth, and carbon emissions in Malaysia for the period of 1980–2008. the findings of the study showed the positive relationship between economic growth and carbon emissions as well as a negative relationship between institutional quality and carbon emission. the results of the study suggested that controllers must ensure the effectiveness of institutions because curvaceous institutions reduce carbon emissions.

Zakaria and Bibi [26] investigated the empirical contributions of institutional quality in environmental performance in the context of South Asian Economies and showed that institutional quality positively contributes to environmental performance. Similarly, Ibrahim and Law [27] examined the influence of trade and institutional quality on CO_2 emissions. For this purpose, the study collected the data of 40 Sub Saharan African economies. the results of the study showed the negative influence of institutional quality and trade on CO_2 emissions. Summarizing the above literature, it is concluded that the focus of most of the studies was on the relationship between institutional quality and environmental performance. Moreover, to the extent of the author's best knowledge, the relationship between

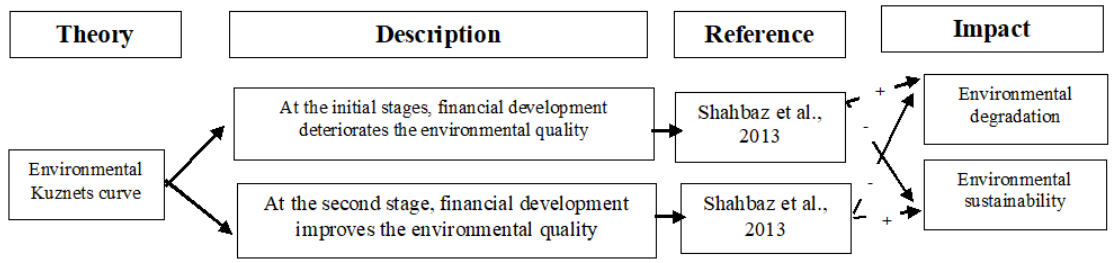
institutional quality and environmental sustainability is not empirically investigated yet, more specifically in the context of developing nations like Pakistan. Therefore, the present study contributes to the existing debate of the environment by empirically investigating the role of institutional quality on environmental sustainability.

2.4. Conceptual/Theoretical Justification of the Study

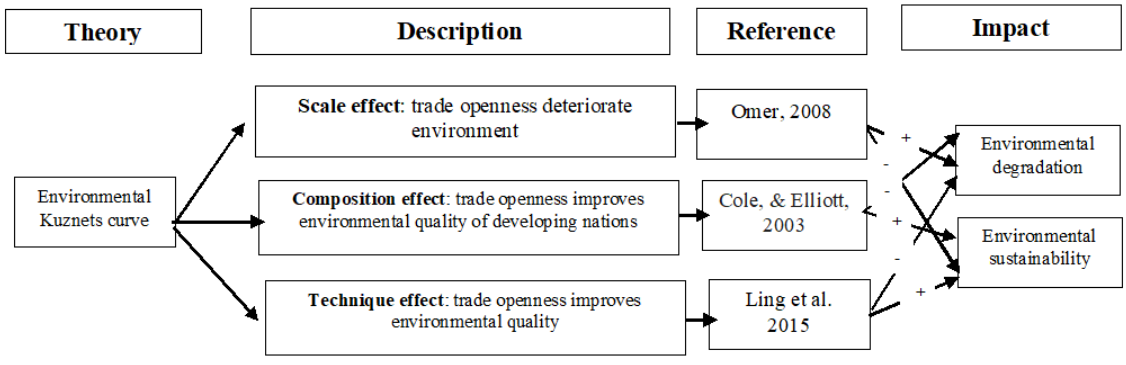
This section highlights the theoretical reasons for expecting the linkage between financial development, institutional quality, trade openness, environmental degradation, and environmental sustainability. the theoretical model of the study is shown in Figure 3, which is proposed by two theoretical perspectives that are environmental governance theory and environmental Kuznets curve (EKC) by Grossman and Krueger 1991.



A: Institutional Quality, Environmental Degradation, and Environmental Sustainability



B: Financial development, Environmental Degradation, and Environmental Sustainability



C: Trade Openness, Environmental Degradation, and Environmental Sustainability

Figure 3. Theories behind the theoretical model of the study, created by author.

The relationship between Institutional quality, environmental degradation, and environmental sustainability is justified with the help of environmental governance theory and are shown in Figure 3A. the theory indicates that we need a strong regime for protecting the environment. the advocates of environmental governance theory portray a direct association between institutional quality and environmental sustainability. the theory concluded that governance of a country is one

of the fundamental factors for guaranteeing efficient environmental management as it organized activists for protecting the environment, which improves the environmental quality that ultimately leads towards sustainability [28]. Thus, the theory of environmental governance provides the theoretical links to expecting a significant relationship institutional quality, environmental degradation, and environmental sustainability.

The relationship between financial development, environmental degradation, and environmental sustainability is justified with the help of the inverted U shape of EKC that was proposed by Grossman and Krueger in 1991 [29] and is shown in Figure 3B. EKC specified that at the initial stages of financial development, there is the increase in the volume of industrial activities, which in turn increase the level of carbon emissions and degrade the environmental quality because, at the initial stage of financial development, economic growth is prioritized over the clean environment; whereas, at the second stage, financial development improves the environmental quality because, at this stage, sustainable environment is prioritizing on economic growth. Thus, the inverted U shape of EKC provides the theoretical lenses to justify the relationship between financial development, environmental degradation, and environmental sustainability [30]. For instance, EKC portrays positive or negative linkage between financial developments and environmental degradation (environmental sustainability) at the initial stages of financial development, while at the second stage, there exists a negative or positive linkage between financial development and environmental degradation.

The relationship between trade openness, environmental quality, and environmental sustainability is justified with the help of the scale, composition, and techniques effect of EKC that was proposed by Grossman and Krueger in 1995 and are shown in Figure 3B. EKC proposed that trade is one of the most essential factors that help the developing economies to reduce carbon emissions through the combination of "scale, composition and technique effect" [31].

The scale effect indicates the trade increases the production of goods and services that ultimately increases the consumption of energy. Increased consumption of energy deteriorates the environment by increasing GHG emissions [32]. Therefore, the scale effect suggests that there is a positive or negative relationship between trade-openness and environmental degradation (environmental sustainability). the composition effect indicates that if the demand for labor-intensive production is increased from the trade then the trade will positively contribute to environmental quality because the labor-intensive production does not contribute positively to environmental degradation [33]. the composition effect is applicable in developing nations because most of the production in developing nations is labor intensive. Therefore, the composition effect concludes the positive or negative relationship between trade openness and environmental sustainability (environmental degradation). Finally, the technique effect also indicated that positive (negative) relationship between trade openness and environmental sustainability (environmental degradation). This effect concluded that trade openness promotes environmentally friendly and energy proficient technologies that have less significant contributions to carbon emissions [34]. However, the present study proposed that the above-mentioned theories could be useful lenses through which the underlying mechanism among modeled variables has been tested.

2.5. Conceptual Model of the Study

The conceptual model of the study is shown in Figure 4. the conceptual model of the study is developed based on the empirical and theoretical review of the existing literature. the conceptual model shows that the study will investigate the relationship between financial development, institutional quality, trade openness, environmental degradation, and environmental sustainability.

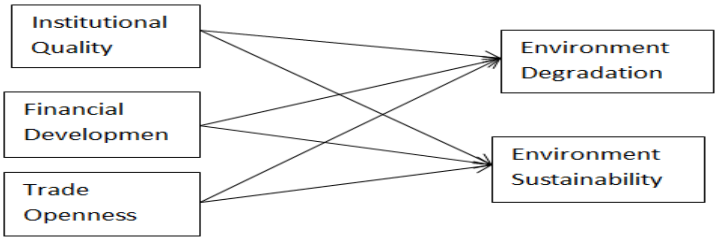


Figure 4. Conceptual model of the study, created by author.

3. Methodology and Data

3.1. Hypothesis Specification, Data, and Methodology

3.1.1. Hypothesis

This study aims to first explore the symmetric and asymmetric relationship of financial development, institutional quality, and environmental degradation, and second, the symmetric and asymmetric relationship of financial development, institutional quality, and environmental sustainability. Therefore, the proposed hypotheses are as follows:

H1: *There is an asymmetric relationship between financial development and environment degradation.*

H2: *There is symmetric relationship between institutional quality and environment degradation.*

H3: *There is symmetric relationship between trade openness and environment degradation.*

H4: *There is asymmetric relationship between financial development and environment degradation.*

H5: *There is asymmetric relationship between institutional quality and environment degradation.*

H6: *There is symmetric relationship between financial development and environment sustainability.*

H7: *There is symmetric relationship between institutional quality and environment sustainability.*

H8: *There is symmetric relationship between trade openness and environment sustainability.*

H9: *There is asymmetric relationship between financial development and environment sustainability.*

H10: *There is asymmetric relationship between institutional quality and environment sustainability.*

This study explores the asymmetric association of financial development, institutional quality with environmental degradation, and environmental sustainability for Pakistan. This study utilized the data over the period 1996 to 2018 for two reasons. First, the data of institutional quality is available only from 1996–2018 and the second is the environmental issues in Pakistan are getting worse during this period due to economic expansion and population growth [27]. the data of all variables are taken from the World Bank. the dependent variables are environmental degradation and environmental sustainability while financial development, institutional quality, and trade openness are taken as explanatory variables. the description of the variables is presented in Table 1.

3.1.2. Empirical Model

Simple Regression Model in linear form

$$ED = \beta_0 + \beta_1 T + \beta_2 FD + \beta_3 IQ + \beta_4 TO + \varepsilon, \quad (1)$$

$$ES = \beta_0 + \beta_1 T + \beta_2 FD + \beta_3 IQ + \beta_4 TO + \varepsilon, \quad (2)$$

where ED_t (environment degradation) and ES_t (environment sustainability) are endogenous variables while FD (financial development), IQ (institutional quality), and TO (trade openness) are exogenous variables and ε is the error term.

Table 1. Description of variables.

Variable	Notation	Measurement	Data Source	References
Dependent Variable (s)				
Environmental Sustainability	ES	"National adjusted net savings (excluding particular emission damage)"	WDI	Ganda (2019) [11]
Environmental Degradation	ED	"Per capita CO_2 Emissions"	WDI	Ozturk & Acaravci (2010) [35]
Independent Variable (s)				
Institutional Quality	IQ	"To measure institutional quality, the study will construct an index based on six variables that are government effectiveness, political stability, voice and accountability, control of corruption, and regulatory quality. the overall index will be calculated by using principal component analysis"	WDI	Fukumi & Nishijima (2010) [31]
Financial Development	FD	"To measure financial development, the study will construct an index based on 3 variables, including liquid liabilities (% of GDP); Money supply (% of GDP), and domestic private credit to the banking sector (% of GDP). the overall index will be calculated by using principal component analysis"	WDI	Batuo et al. (2018) [36]
Trade openness	TO	"Exports + imports (% of GDP)"	WDI	Le et al. (2016) [32]

3.1.3. Model Specification ARDL

To explore the symmetric relationship among the modeled variable, this study utilized the standard method of ARDL

$$\Delta ED_t = \alpha_0 + \beta_1 ED_{t-1} + \beta_2 FD_{t-1} + \beta_3 IQ_{t-1} + \beta_4 TO_{t-1} + \alpha_1 ED_{t-i} + \alpha_2 FD_{t-i} + \alpha_3 IQ_{t-i} + \alpha_4 TO_{t-i} + \varepsilon_t, \quad (3)$$

$$\Delta ES_t = \alpha_0 + \beta_1 ES_{t-1} + \beta_2 FD_{t-1} + \beta_3 IQ_{t-1} + \beta_4 TO_{t-1} + \alpha_1 ED_{t-i} + \alpha_2 ES_{t-i} + \alpha_3 IQ_{t-i} + \alpha_4 TO_{t-i} + \varepsilon_t \quad (4)$$

In Equations (3) and (4) α_1 , α_2 , α_3 , and α_4 represents the long-run relationship while β_1 , β_2 , β_3 , and β_4 represents short-run dynamics. In the next step, the study follows the Error correction model (ECM) to estimate the short dynamics and ECM can be expressed in the following form:

$$\Delta ED_t = y_0 + \alpha_1 \sum_{i=1}^{n} ED_{t-i} + \alpha_2 \sum_{i=0}^{n} FD_{t-i} + \alpha_3 \sum_{i=0}^{n} IQ_{t-i} + \alpha_4 \sum_{i=0}^{n} TO_{t-i} + \eta\, ECT_{t-i} + \varepsilon_t \quad (5)$$

$$\Delta ES_t = y_0 + \alpha_1 \sum_{i=1}^{n} ES_{t-i} + \alpha_2 \sum_{i=0}^{n} FD_{t-i} + \alpha_3 \sum_{i=0}^{n} IQ_{t-i} + \alpha_4 \sum_{i=0}^{n} TO_{t-i} + \eta\, ECT_{t-i} + \varepsilon_t \quad (6)$$

In Equations (5) and (6), ECT_{t-i} are the error correction term and η shows the speed of adjustment; for a stable model, the study expects the negative sign with ECM and the value of η is less than one.

3.1.4. Non-Linear Auto Regressive Distributive Lag Model (NARDL)

Though we can investigate short-run and long-run relationships among modeled variables with the help of ECM, ARDL, and Granger causality methods, these methods are unable to capture the nonlinear relationship among the variables of the interest. Therefore, to investigate the asymmetric or nonlinear behavior of the variables, Shin and Yu [33] has developed NARDL by extending the bound test approach. Many researchers have utilized the NARDL approach to investigate the nonlinear behavior of the variables of their interest [37]. Keeping in view the nonlinear behavior of the variables of interest, Equations (1) and (2) are modified as follows:

$$ED_t = \beta_0 + \beta_1{}^{+}FD_t^{+} + \beta_2{}^{-}FD_t^{-} + \beta_3{}^{+}IQ_t^{+} + \beta_4{}^{-}IQ_t^{-} + \beta_5 TO + \varepsilon_t \quad (7)$$

$$ES_t = \beta_0 + \beta_1{}^{+}FD_t^{+} + \beta_2{}^{-}FD_t^{-} + \beta_3{}^{+}IQ_t^{+} + \beta_4{}^{-}IQ_t^{-} + \beta_5 TO + \varepsilon_t \quad (8)$$

Equations (7) and (8), *FD* and *IQ* are divided into the positive and negative group; whereas the β_0 , $\beta_1{}^{+}$, $\beta_2{}^{-}$, $\beta_3{}^{+}$, $\beta_4{}^{-}$, and, β_5 are parameters while FD_t^{+}, FD_t^{-}, , IQ_t^{+}, IQ_t^{-}, are the long-run vector of unknown parameters and ε_t is the error term. Moreover, the partial sum of positive and negative variations in *FD* and *IQ* are written below.

$$\begin{aligned} FD_t^{+} &= \sum_{j=1}^{t}\Delta FD_j^{+} = \sum_{j=1}^{t} Max\,(\Delta FD_j,\ 0) \\ FD_t^{-} &= \sum_{j=1}^{t}\Delta FD_j^{-} = \sum_{j=1}^{t} Mini\,(\Delta FD_j,\ 0) \\ IQ_t^{+} &= \sum_{j=1}^{t} IQ_j^{+} = \sum_{j=1}^{t} Max\,(\Delta IQ_j,\ 0) \\ IQ_t^{-} &= \sum_{j=1}^{t}\Delta IQ_j^{-} = \sum_{j=1}^{t} Mini\,(\Delta IQ_j,\ 0) \end{aligned}$$

The above-mentioned equations are based on positive and negative decomposition to examining the asymmetric impact of *FD* and *IQ* on *ED* and *ES*. the NARDL equation based on Shin and Yu [30] methodology is written as:

$$\begin{aligned} \Delta ED_t = {} & \delta_0 + \delta_1 ED_{t-1} + \delta_2{}^{+}FD_{t-1}^{+} + \delta_3{}^{-}FD_{t-1}^{-} + \delta_4{}^{+}IQ_{t-1}^{+} + \delta_5{}^{-}IQ_{t-1}^{-} + \\ & \delta_6 \text{ TO} + \sum_{i=1}^{p} c_i\,\Delta ED_{t-i} + \sum_{j=0}^{a}(\omega_j{}^{+}\Delta FD_{t-j}^{+} + \omega_j{}^{-}\Delta FD_{jt-j}^{-}) + \\ & \sum_{j=0}^{h}(\alpha_j{}^{+}\Delta IQ_{t-j}^{+} + \alpha_j{}^{-}\Delta IQ_{t-j}^{-}) + \varepsilon_t \end{aligned} \quad (9)$$

$$\begin{aligned} \Delta ES_t = {} & \delta_0 + \delta_1 ES_{t-1} + \delta_2{}^{+}FD_{t-1}^{+} + \delta_3{}^{-}FD_{t-1}^{-} + \delta_4{}^{+}IQ_{t-1}^{+} + \delta_5{}^{-}IQ_{t-1}^{-} + \\ & \delta_6 \text{ TO} + \sum_{i=1}^{p} c_i\,\Delta ES_{t-i} + \sum_{i=0}^{a}(\omega_i{}^{+}\Delta FD_{t-i}^{+} + \omega_i{}^{-}\Delta FD_{t-i}^{-}) + \\ & \sum_{i=0}^{h}(\alpha_i{}^{+}\Delta IQ_{t-i}^{+} + \alpha_i{}^{-}\Delta IQ_{t-i}^{-}) + \varepsilon_t \end{aligned} \quad (10)$$

where *a*, *p*, and *h* are lag orders while the short-run impact of the increase in *FD* on *ED* is estimated with $\sum_{j=0}^{a}\omega_j{}^{+}$ and the impact of the decrease in *FD* on *ED* is estimated with $\sum_{j=0}^{a}\omega_j{}^{-}$. Similarly, the short-run impact of increase and decrease in *IQ* on *ED* is estimated with $\sum_{j=0}^{h}\alpha_j{}^{+}$ and $\sum_{j=0}^{h}\alpha_j{}^{-}$. Moreover, the short-run impact of the increase in *FD* on *ES* is estimated with $\sum_{i=0}^{a}\omega_i{}^{+}$ and the impact of the decrease in *FD* on *ED* is estimated with $\sum_{i=0}^{a}\omega_i{}^{-}$. Similarly, the short-run impact of increase and decrease in *IQ* on *ES* is estimated with $\sum_{i=0}^{h}\alpha_i{}^{+}$ and $\sum_{i=0}^{h}\alpha_i{}^{-}$.

The error correction model of Equations (9) and (10) are portrayed as:

$$\begin{aligned} \Delta ED_t = {} & \delta_0 + \sum_{i=1}^{p} P_i\,\Delta ED_{t-i} + \sum_{j=0}^{a}(\omega_j{}^{+}\Delta FD_{t-j}^{+} + \omega_j{}^{-}\Delta FD_{jt-j}^{-}) + \\ & \sum_{j=0}^{h}(\alpha_j{}^{+}\Delta IQ_{t-j}^{+} + \alpha_j{}^{-}\Delta IQ_{t-j}^{-}) + \Psi\, ECT_{t-1} + \varepsilon_t{}^{-} \end{aligned} \quad (11)$$

$$\begin{aligned} \Delta ES_t = {} & \delta_0 + \sum_{i=1}^{p} P_i\,\Delta ES_{t-i} + \sum_{j=0}^{a}(\omega_j{}^{+}\Delta FD_{t-j}^{+} + \omega_j{}^{-}\Delta FD_{jt-j}^{-}) + \\ & \sum_{j=0}^{h}(\alpha_j{}^{+}\Delta IQ_{t-j}^{+} + \alpha_j{}^{-}\Delta IQ_{t-j}^{-}) + \Psi\, ECT_{t-1} + \varepsilon_t \end{aligned} \quad (12)$$

Equations (11) and (12), $\omega_j{}^{+}$, $\omega_j{}^{-}$, $\alpha_j{}^{+}$, $\alpha_j{}^{-}$ represent asymmetric short-run dynamics while Ψ is an error correction term that indicates the speed of adjustment.

Moreover, the "asymmetric cumulative multiplier effect" of one % change in FD^{+}_{t-i}, FD^{-}_{t-i}, is formulated as:

$$K^{+}_{b} = \sum^{b}_{j=0} \frac{\Delta ED_{t+j}}{\Delta FD^{+}_{t-1}}, K^{-}_{b} = \sum^{b}_{j=0} \frac{\Delta ED_{t+j}}{\Delta FD^{-}_{t-1}}$$
$$K^{+}_{b} = \sum^{b}_{j=0} \frac{\Delta ES_{t+j}}{\Delta FD^{+}_{t-1}}, K^{-}_{b} = \sum^{b}_{j=0} \frac{\Delta ES_{t+j}}{\Delta FD^{-}_{t-1}}$$

Similarly, the "asymmetric cumulative multiplier effect" of one % change in IQ^{+}_{t-1}, IQ^{-}_{t-1}, is formulated as:

$$K^{+}_{b} = \sum^{b}_{j=0} \frac{\Delta ED_{t+j}}{\Delta IQ^{+}_{t-1}}, K^{-}_{b} = \sum^{b}_{j=0} \frac{\Delta ED_{t+j}}{\Delta IQ^{-}_{t-1}}$$
$$K^{+}_{b} = \sum^{b}_{j=0} \frac{\Delta ES_{t+j}}{\Delta IQ^{+}_{t-1}}, K^{-}_{b} = \sum^{b}_{j=0} \frac{\Delta ES_{t+j}}{\Delta IQ^{-}_{t-1}}$$

It should be observed that as $b \to \infty$ then K^{+}_{b} will approach to β^{+} and K^{-}_{b} will approach to β^{-}.

4. Empirical Analysis and Discussion

Before the empirical investigation, this study employed a unit root test to check the stationarity of data. the stationary data ensure reliable estimates and eliminate the possibility of spurious estimates. Moreover, one major precondition for employing the ARDL bounds testing approach is that series should be stationary at the level or first difference and none of the series should be stationary at 1(2). This study applied ADF and PP tests by including both intercept and trend components of the series and results are reported in Table 2. As Perron [34] stated, in the presence of structural break, the result of ADF unit root can be misleading; thus, to confirm the integration order in the presence of structural, this study also applied Zivot and Andrews [37] unit root test to check the integration order of the series in the presence of structural breaks and results are reported in 3. the ADF and PP test are extensively used in the applied literature in case of small sample size with the null hypothesis of non-stationary. For instance, Salahuddin and Gow [38] applied ADF and PP unit root test to investigate the stationarity of the financial development, trade openness, economic growth, and internet usage in case of South Africa for the period of 1991 to 2013. Similarly, Erdoğdu and Çiçek [39] also applied ADF and PP unit root test for the case of Turkey to check the stationarity of modeled variable from 1994 to 2014. However, Perrone and Hornberger [40] argued that ADF provides misleading results in the presence of structural break; thus, to confirm the integration order in the presence of structural break, and to test the robustness of ADF and PP unit root test, the study also applied Zivot and Andrews [37] unit root test to check the integration order of the series in the presence of structural breaks and results are reported in Table 3. Results indicates that *FD* and *IQ* are stationary at first difference while *ED*, *ES* and *TO* are stationary at level. This test is also applied by Salahuddin and Khan [41] to test the robustness of the modeled variable's stationarity and order of integration from 1991 to 2013 in South Africa.

Table 2. Unit root test: Augmented Dicky Fuller and Phillips Perron.

Variables	ADF		PP	
	I (0)	I (1)	I (0)	I (1)
IQ	−1.499561	−3.418185 *	−1.526926	−3.412630 *
FD	−0.010631	−4.323359 *	−0.212541	−4.323359 *
TO	−2.222722	−5.068862 *	−2.310778	−5.068862 *
ED	−1.088568	−3.562594 *	−1.148435	−3.602603 *
ES	−1.098678	−3.702963 *	−1.098678	−3.661068 *

* Indicate significance at less than 1%.

Table 3. Unit root test: Zivot and Andrews.

Variables	*t*-Statistics	Year of Break
ED	−4.741431 *	2004
ES	−4.644488 *	2006
D(*FD*)	−2.457307 *	2008
D(*IQ*)	−3.46234 *	2006
TO	−4.205241 *	2004

* Indicate significance at less than 1%, Source: Created by Author.

The results of ADF and PP indicate that all variables are integrated at order first [I (1)] while the results of Zivot and Andrews unit root test indicate that *FD* and *FS* are stationary at first difference while *ED*, *ES*, and *TO* are stationary at level. Conclusively, ADF, PP and Zivot and Andrews unit root test confirm that no series is integrated at [I (2)] in the model. In the next step, the study applies the ARDL bound test to investigate the long-run co-integration among the modeled series. This technique is superior to other co-integrating techniques in the following ways. First, where other co-integration techniques require the same order of integration, the ARDL bound co-integration technique is applicable to the series of having the mix order of integration i.e., I (0), I (1) and I (0)/I (1) [29]. Second, this technique provides reliable results in the case of small sample size [42]. Third, this technique provides unbiased results by adjusting the problem of endogeneity that arises from the estimation of regresses [28]. Numerous studies have used this co-integration technique to test the long-run relationship among the variables in the case of a small sample size. For instance, Salahuddin and Gow [38] applied ARDL bound co-integration to test the long-run association among modeled variables in South Africa for the period of 1994–2014, while Erdoğdu and Çiçek [39] applied it by utilizing the sample of turkey for the period of 1994–2014 to test the co-integration among their hypothesized variables.

Results of co-integration are reported in Table 4 and results indicate that in both models, the long-run co-integration exists among the variables because the value of F statistics is greater than the lower bound and upper bound, so we reject the null hypothesis of no co-integration among the modeled series; thus, we can proceed with ARDL and NARDL to investigate the symmetric and asymmetric relationship among variables.

Table 4. Bound Test.

Test Statistic	Model 1		Model 2	
	Value	k	Value	k
F. Statistics	26.25711	3	5.483794	5
	8.536390	3	9.938447	5
Critical Value Bounds				
	Lower bound	**Upper Bound**	**Lower bound**	**Upper Bound**
10%	2.72	3.77	2.26	3.35
5%	3.23	4.35	2.62	3.79
2.5%	3.69	4.89	2.96	4.18
1%	4.29	5.61	3.41	4.68

Source: Created by author.

After confirmation of long-run co-integration, this study applied the ARDL model to estimate the short-run and long-run coefficients, and the results are reported in Tables 5 and 6 represents the long-run estimates. the results of Model 1 indicate that *IQ* negatively and significantly affects the environment degradation and environmental sustainability in the long run ($\beta = -0.308525$, $t = -2.14796$; $\beta = 53.463064$, $t = -3.521380$). Results indicate that one unit increase in *IQ* will

lower the 0.308525 unit decrease in environmental degradation and 53.463064 unit increase in environmental sustainability.

Table 5. Short-run estimates of Auto Regressive Distributive Lags (ARDL).

Variable	Model 1(1, 0, 0, 0) DV = *ED*			Model 2 (1, 2, 0, 1) DV = *ES*		
	β	S.E	*t*-Statistic	*β*	S.E	*t*-Statistic
D (*IQ*)	−0.126978	0.096853	−1.311044	−1.324428	9.587217	−0.138145
D (*IQ* (−1))				32.737021 *	9.588269	3.414278
D (*FD*)	0.007529 *	0.002391	3.148906	2.025239 *	0.443035	4.571287
D(*TO*)	−0.001222	0.001904	−0.641743	−0.075875	0.248866	−0.304883
ECM	−0.411565 *	0.145497	−2.828689	−0.897076 *	0.192725	−4.654691

* Indicate significance at less than 1%, Source: Created by Author.

Table 6. Long-run estimate of ARDL.

	Model 1			Model 2		
Variable	Coefficient	Std. Error	*t*-Statistic	Coefficient	Std. Error	*t*-Statistic
IQ	−0.308525 *	0.143636	−2.14796	53.463064 *	15.182418	3.521380
FD	0.018294 *	0.004196	4.35973	−2.257602 *	0.435656	−5.182079
TO	−0.02969 *	0.004111	−7.22208	0.638411 *	0.176480	3.617477
C	0.002816	0.179732	0.01566	−69.130437	30.934520	−2.234734

* Indicate significance at less than 1%, Source: Created by Author.

The findings of this study are consistent with Lau and Choong [25] and Ozturk and Al-Mulali [35] who documented the negative relationship between *IQ* and *ED* in Malaysia and MENA countries, respectively. the findings revealed that the quality of institutions effectively reduces the emission of carbon dioxide and improves the quality of the environment. Similarly, the results are consistent with Mavragani and Nikolaou [43] who found a positive relationship between *IQ* and environment sustainability. Therefore, good governance or *IQ* plays a critical role in environmental quality and suitability; as Tamazian and Rao [6] emphasized, the countries with high institutional qualities are in a better position to develop the trade openness mechanism to protect the quality of their environment.

Moreover, *FD* has a positive and significant association with *ED* (β = 0.018294, t = 4.35973), it implies that one unit increase in *FD* will cause a 0.018294 unit increase in *ED*. Results are consistent with Ahmad and Khan [10] and Majeed and Samreen [44]. the finding emphasized that in Pakistan, the banking sector does not care about environmentally friendly investment and does not guide the investors or impose any restriction on the usage of credit on environmentally friendly technologies.

Moreover, in Model 2, results indicate that *FD* has a negative and significant association with environmental sustainability in the long run (β = −2.257602, t = −5.182079). Results imply that the effect of *FD* is stronger on environmental sustainability than environmental degradation. Furthermore, TO has a significant and negative association with *ED* (β = −0.02969, t = −7.22208) and a positive and significant association with *ES* (β = 0.638411, t = 3.617477) in the long run. Results imply that as TO increases one unit, it will cause *ED* to decrease by 0.02969 units and cause *ES* to increase by 0.638411 units. Results are consistent with previous studies [45]. Trade openness improves the quality of the environment through technique effect; technique effect means trade openness allows the investors to import environmentally friendly technologies from developed nations, which causes reductions in carbon emission and improve the quality of the environment.

Moving toward Table 5, which represents the short-run association, the short-run coefficient of models 1 and 2 indicates that the error correction mechanism exists. Further, the convergence of variables to equilibrium is speedy since the ECT is negative and significant at 1% level of significance. However, the speed of convergence is larger in Model 2 (β = −0.411565) as compared to Model one (β = −0.411565).

Estimates of Non-Linear Auto Regressive Distributed Lag (NARDL)

The results of NARDL bound test in Table 4 indicate that long-run co-integration exist among the variable; thus, to explore the asymmetric relationship of *FD*, *IQ*, and *TO* with *ED* and *ES*, this study applied NARDL, and short-run and long-run estimates are reported in Tables 7 and 8.

Table 7. Short-run estimates of NARDL.

	Model 1 (1, 1, 0, 1, 0, 0) DV: *ED*			**Model 2 (1, 0, 0, 0, 0, 0) DV: *ES***		
Variable	***β***	**S.E**	***t*-Statistic**	***β***	**S.E**	***t*-Statistic**
D(*IQ*+)	−0.406090 *	0.201064	−2.0197	1.683484 *	0.618599	2.72144
D(*IQ*-)	−0.096614	0.128870	−0.7497	1.124892 *	0.543223	2.07077
D(*FD*+)	−0.01412 *	0.005228	−2.7008	5.182998 *	1.240799	4.17714
D(*FD*-)	0.04637 *	0.002688	17.2507	−6.274767 *	1.353847	−4.63476
D(*TO*)	0.09099 *	0.02694	3.3775	−0.032170	0.272118	−0.11822
ECM	−0.210394	0.103389	−2.0349	−0.158403	0.031748	−4.9893

* Indicate significance at less than 1%, Source: Created by author.

Table 8. Long-run coefficient of NARDL.

IV	**Model 1 (1, 1, 0, 1, 0, 0) DV: *ED***			**Model 2 (1, 0, 0, 0, 0, 0) DV: *ES***		
	β	**S.E**	***t*-Statistic**	***β***	**S.E**	***t*-Statistic**
IQ+	−3.875723 *	1.574625	−2.46136	1.453280 *	0.635865	2.28551
IQ-	−0.459204 *	0.057875	−7.93441	0.097107	0.282559	0.34366
FD+	−0.192986 **	0.097802	−1.973231	4.474262 *	1.487417	3.00807
FD-	0.122039 *	0.014466	8.43626	5.416740 *	1.746447	3.10157
TO	0.143246	0.037562	3.813588	−0.027771	0.234810	−0.11827
C	0.175503	0.587932	0.298510	40.805676	8.216352	4.966398

* Indicate significance at less than 1%, while ** indicates significance at less than 5%, Source: Created by author.

Table 8 represents the long-run estimates of NARDL. the result of Model 1 indicates that there is an asymmetric long-run relationship between *IQ* and *ED*. Due to the fact that a positive or negative shock to *IQ* will bring a significant impact on *ED*, a positive shock to *IQ* will cause a reduction in *ED* and a negative shock to *IQ* will cause an increase in *ED* [6]. However, the size of the impact of a positive shock to *IQ* on *ED* is greater (β = −3.875723 *) than the impact of a negative shock to *IQ* on *ED* (β = −0.459204 *). It implies that as *IQ* improves, rules and regulations related to the environment will be enforced more effectively, so the emission of carbon dioxide will decrease and vice versa. Moreover, improved *IQ* will restrict production companies to use environmentally friendly technology and green practices in the production process.

Moreover, results also indicate that positive and negative shock to *FD* will also significantly affect *ED*; the positive shock to *FD* will cause a decrease in *ED* (β = −0.192986 **) and negative shock to *FD* will also decrease *ED* (β = 0.122039 *). It implies that as *FD* increases, investors have more opportunities to get a loan and can import high-cost environmentally friendly technologies. Moreover, increased *FD* will provide opportunities to investors to operate at a large scale that increases the profit, and they will employ more sophisticated technologies in the production process. A contrary decrease in *FD* will cause *ED* to lower because a decrease in *FD* decreases the availability of credit to investors and shrinks investment opportunities [44]. As a result, the production scale will decrease and lower the carbon emission that ultimately causes *ED* to decrease.

The results of Model 2 indicate that there is a significant asymmetric long-run relationship between *IQ* and *ES*. However, a positive shock to *IQ* will increase *ES* (β = 1.453280 *) while a negative shock to *IQ* has an insignificant association with *ES* (β = 0.097107). Similarly, results confirm the asymmetric long-run relationship between *FD* and *ES*; a positive shock to *FD* will increase *ES*, and the negative

shock causes a decrease in *ES* [43]. However, the size of the impact of the negative shock on *ES* is greater (β = 5.416740 *) than the impact of the positive shock on *ES* (β = 4.474262 *).

Table 7 indicates short-run estimates of NARDL; the results show that a positive shock to *IQ* will significantly decrease *ED* while a negative shock will have no significant impact on *ED*. Similarly, the positive and negative shock to *FD* has a significant impact on *ED* in the short-run; a positive shock to *FD* will decrease *ED* (β = −0.01412 *) and a negative shock to *FD* will also decrease *ED* (β = 0.04637 *). However, short-run and long-run estimates indicate that the size of the impact is very small in the short-run as compared to long-run. Moreover, the error correction term is negative and significant, which confirms that the model is stable and if any shock will disturb the equilibrium growth path, the model will converge with 21.03% speed of adjustment in one year. Similarly, the short-run estimates of model 2 indicate that positive and negative shock to *IQ* has a significant contribution to environmental sustainability. However, results suggest that positive shock to *IQ* will enhance *ES* while a negative shock to *IQ* will decrease *ES* in the short-run period. Moreover, the short-run results of NARDL indicate that positive shock to *FD* will increase *ES* and negative shock to *FD* will also increase *ES*. the ECM term indicates that the model is stable and if any disturbance occurs, the model will converge with 15.8% speed of adjustment in one year. Moreover, his study employed several diagnostic tests, and results are reported in Table 9. the results of the LM test (p = 0.1062, p = 0.7066, p = 0.3217, p = 0.6336) and Brush pagan test (p = 0.8921, p = 0.2154, p = 0.3701, p = 0.9498) indicate that both models are free from serial correlation and hetroscadasticity. Additionally, the value of Jarqa Bera (p = 0.1586, p = 0.1040, p = 0.2850), p = 0.9271) indicates that residuals are normally distributed, and the value of Ramsey reset test (p = 0.1586, p = 0.1040, p = 0.2850, p = 0.9271) states that models are correctly specified.

Table 9. Diagnostic test.

Tests Specification	ARDL		NARDL		Decision
	Model 1	Model 2	Model 1	Model 2	
LM Test	2.829349 (0.1062)	4.729477 (0.0706)	1.259593 (0.3217)	0.475793 (0.6336)	No serial correlation exists
Brush Pagan	1.380220 (0.8921)	2.35054 (0.2154)	1.166538 (0.3701)	0.170182 (0.9498)	No hetroscadasticity exists
Adjusted R2	0.903815	0.829483	0.951113	0.823486	the value of adjusted R. Square is above 0.80
F-statistic	16.26944 (0.003508)	12.35054 (0.001150)	67.14820 (0.0000)	16.86190 (0.000046)	Models are a good fit
Ramsey Reset Test	2.287644 (0.1586)	1.772541 (0.1040)	1.233333 (0.2850)	0.103374 (0.9271)	Models are correctly specified
Jarqa Bera Test	1.060869 (0.588349)	0.683017 (0.710697)	0.810324 (0.666869)	1.045609 (0.592856)	Residuals in all models are normally distributed

Source: Created by author.

To present the plotting of non-linearity, the dynamic multiplier graph is presented in Figures 5 and 6 for models 1 and 2. the dynamic multiplier graph in Figures 5 and 6 measures the asymmetric adjustment in *ED* and *ES* in the long run because of negative and positive shocks in *FD* and *IQ*. the asymmetric adjustment is evident from positive and negative change curves at a particular period. Moreover, in Figures 5 and 6, *FD* is financial development and *IQ* is institutional quality. Years are plotted on the horizontal axis and the magnitude shocks (positive and negative) on the vertical axis. Figure 5 indicates positive shock to *FD* and *IQ* has a stronger impact on *ED*. Similarly, Figure 6 indicates that positive and negative shock to *FD* both have a stronger impact on *ES* while a positive and negative shock to *IQ* has a smaller impact on *ES*.

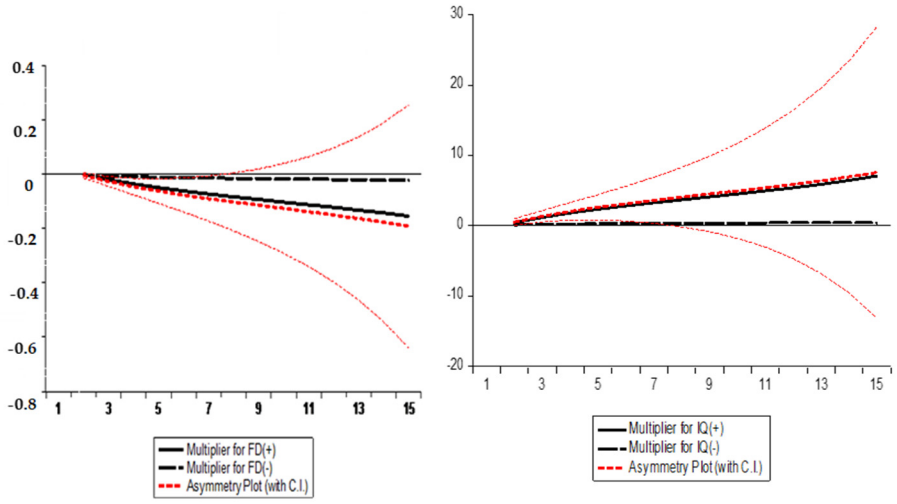


Figure 5. Dynamic multiplier graph for model 1, created by author.

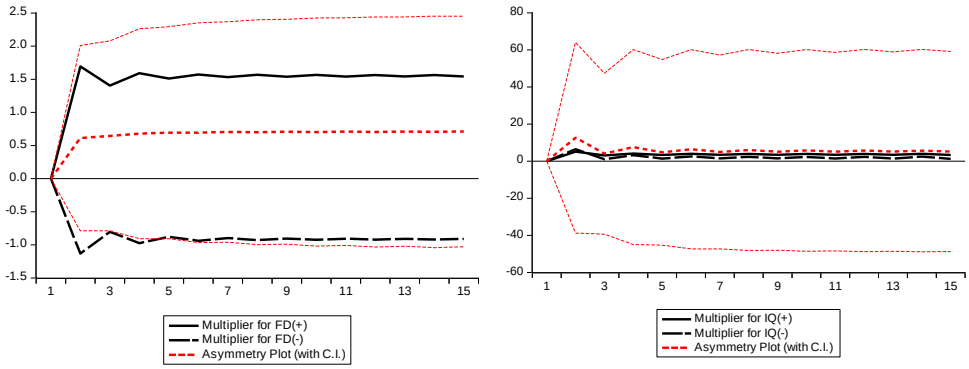


Figure 6. Dynamic multiplier graph for model 2, created by author.

Figures 7 and 8 plot the cumulative sum (CUSUM) and CUSUM of the squares at the 5% level of significance and the figure indicates that parameters and variance are stable in both models.

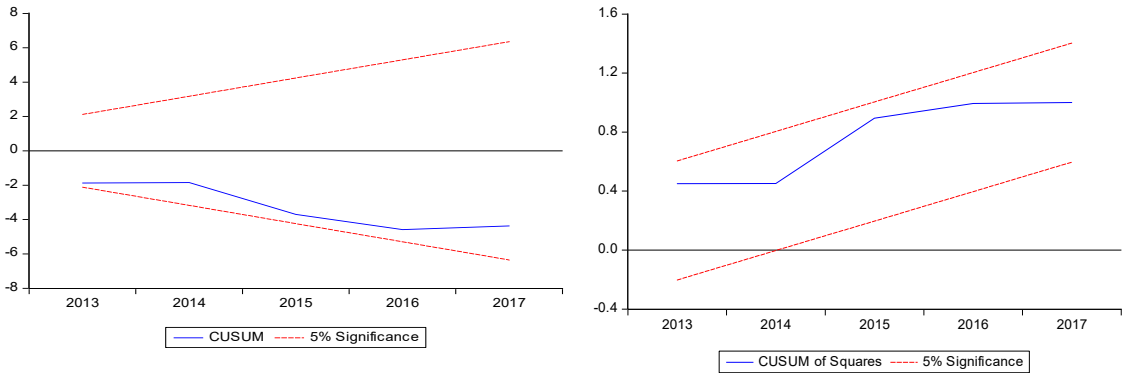


Figure 7. Parameters stability test for model 1, created by author.

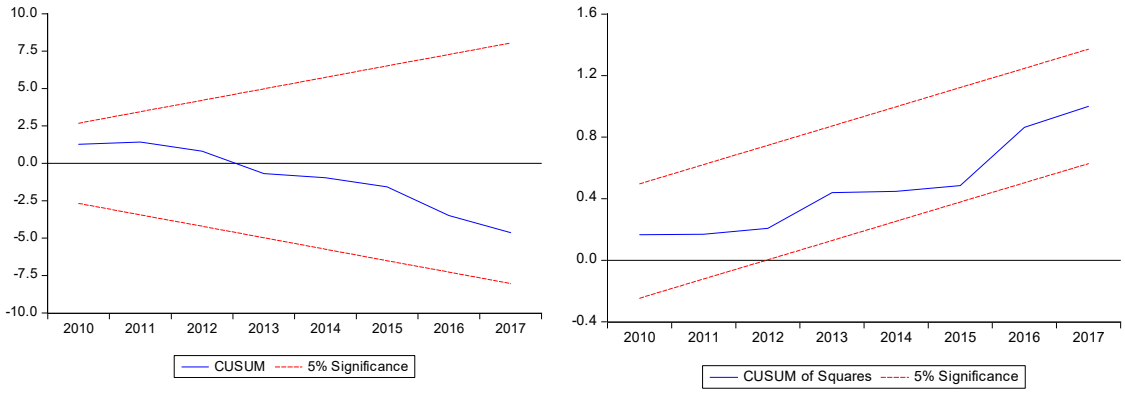


Figure 8. Parameters stability test for model 2, created by author.

5. Conclusions

This study aimed to estimate two models. Model 1 examined the symmetric and asymmetric relationship between quality of the institution, financial development, and trade openness with environmental degradation, and model 2 examined the symmetric and asymmetric relationship between institutional quality, financial development, and trade openness with environment sustainability for Pakistan for 1996–2018. Based on the above empirical investigation of model 1, this study found a significant long-run symmetric and asymmetric association of *IQ* with *ED*. the rise in *IQ* has a greater impact on *ED* as compared to a fall in *IQ*, and the dynamic multiplier analysis demonstrates that a positive shock to *IQ* has a stronger impact on *ED* as compared to a negative shock. Moreover, this study found a significant symmetric and asymmetric impact of *FD* on *ED*; an increase in *FD* will decrease environmental degradation while a decrease in *FD* will decrease environmental degradation. the dynamic multiplier analysis validates that positive shock to *FD* has a greater impact on *ED*.

Similarly, the empirical investigation of model 2 revealed a significant long-run symmetric and asymmetric association of *IQ* with *ES*. However, *IQ*- has an insignificant association with *ES*, and the dynamic multiplier shows that positive and negative shock to *IQ* strongly affects *ES*. Additionally, the study found that *FD* also has a symmetric and asymmetric relationship with *ES*; the effect of falls in *FD* on *ES* is greater than the rise in *FD*. This study also found the significant long-run symmetric association of *TO* with *ED* and *ES*.

Policy Recommendations

Based on these findings, this study recommends several policies. First, as a rise in *IQ* negatively affects CO_2 emissions, the policymakers may focus on the quality of institutions while formulating environment protection policies. the quality of institution will strengthen the institutions and allow them to work effectively; so effective functioning of institutions in Pakistan will deliver proper laws, regulations, and property rights as well as ways to combat corruption, which if systematically followed, will reduce carbon dioxide emissions, and improve the quality of the environment in Pakistan.

Second, the results suggest that the rise and fall in *FD* cause reduce CO_2 emission and improve environmental sustainability; thus, financial institutions play a significant role to improve the increase in the financing facilities for clean and carbon-free projects. Since environmentally friendly technologies usually need a huge investment and due to lack of guarantees and mortgage, banks become unable to provide loan for carbon-free projects, the state bank of Pakistan should provide loans on an easy term and conditions to the commercial banks that are providing loans for low-carbon technologies and products. Third, as the results show that trade openness has a significant relationship with environmental degradation and environment suitability, this study suggests that Pakistan should introduce more trade liberalization policies and open the border for trade and technology transfer to get the advantage of carbon-free technologies and products. This study suggests that future studies can employ the same methodology for other developing countries by introducing more

significant determinants of carbon emissions such as energy consumption, foreign direct investment, and population. Moreover, this study utilized money supply in the financial index, which is mainly related to macroeconomic conditions, so future studies should develop an alternative index that does not include money supply. Furthermore, this study suggests that future studies should utilized quarterly data to control sample size bias.

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