Fiscal Policy and Environment: A Long-Run Multivariate Empirical Analysis of Ecological Footprint in Pakistan.

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FISCAL POLICY AND ENVIRONMENT: A LONG-RUN MULTIVARIATE EMPIRICAL ANALYSIS OF ECOLOGICAL FOOTPRINT IN PAKISTAN.

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Abstract

Despite differences in carbon emissions shares and differences in ecological footprint patterns of each nation, these differences are guaranteed to show similar features in long run, thus making it a global issue.

An increase in economic growth contributes to an increase in waste production with an impact on environmental degradation and climate change. An ecological footprint is a relatively comprehensive measure than previously used CO_2 emission as an environmental proxy as it includes comprehensive multi-facets environmental indicators because ecological footprint includes built-up land, CO_2 emission, cropland, fishing ground, grazing land, and forest products which has included all environmental dimensions. This research has focused to empirically investigate the long-run impact of fiscal policy on the ecological footprint in Pakistan keeping different socio-economic factors into consideration. Per annum, time-series data have been collected between 1976 and 2018. The Augmented Dickey-Fuller test has been employed to determine the unit root of the data. To investigate the long-run association between fiscal policy and ecological footprint, modern econometric techniques such as Johansen co-integration test, ARDL Bounds test, different diagnostic tests, and variance decomposition analysis are used. Johnson co-integration test depicts significant long-run co-integration between fiscal policy, ecological footprint, and its major socio-economic determinants in Pakistan. Conclusion of ARDL model shows that 1% increase in public development expenditures, total population, GDP, and energy consumption increase 0.19, 2.17, 1.16, and 2.17% ecological footprint respectively in Pakistan between 1976 and 2018 and vice versa. However, it is also derived that a 1% increase in public tax and non-tax revenue and public current expenditures (in health, education, and other social sectors) shrink 0.36 and 0.013% ecological footprint in the long-run in Pakistan. The stability, reliability, and credibility of the ARDL model are found correct based on different diagnostic tests. Variance decomposition analysis also depicts fiscal policy significantly cause ecological footprint in Pakistan.

Keywords: Ecological Footprint, Fiscal Policy, Socio-Economic Determinants, ARDL model, Variance Decomposition Analysis.

Introduction

Each country has its impact on the environment but anthropogenic emissions are no longer remain domestic but are being transferred through international trade which leads to environmental convergence. This shows that environmental degradation is being transferred between different income groups of the world which validate the existence of environmental convergence. Despite differences in carbon emissions shares and differences in ecological footprint patterns of each nation, these differences are guaranteed to show similar features in long run, thus making it a global issue. In other words, environmental degradation will spread to the equal or same level across the whole world under similar conditions nevertheless of different income groups. (Sarkodie, 2020).

An increase in economic growth contributes to an increase in waste production with an impact on environmental degradation and climate change. The ecological footprint is a relatively comprehensive measure than previously used CO_2 emission as an environmental proxy as it includes comprehensive multi-facets environmental indicators because ecological footprint includes built-up land, CO_2 emission, cropland, fishing ground, grazing land, and forest products (GFN 2020) which has included all environmental dimensions.

In the current era; ecological footprint is used as one of the important measures of sustainability; exhibits how much bio-capacity is required for human existence and how much is currently available. This measure is used to predict the human burden on the environment which is created every day. It is an important measure because it exhibits to understand the burden of environmental crises by human beings in the struggle to achieve economic sustainability and goals. It is important to consider that many fiscal instruments can be used to achieve environmental cum economic objectives, however, among all of them, taxes and public spending as fiscal policy are the most important fiscal instruments (Postula and Moroz; 2020).

Ranging from considering the impact of environmental degradation on living standards; researchers and governments have given special attention to analyzing the correlation between important socio-economic indicators and environmental sustainability. In this regard correlation between environment and economic growth has been explored by John and Pecchenino (1994); Grossman and Krueger (1995); Byrne (1997); Bertinelli et al., 2008, Bostan (2016), Bostan et al., 2010 and Burciu et al., 2010).

Similarly, Angelopoulos et al., 2013; Kuo et al., 2016; Vasilev (2019) and Pohoata et al., 2014 explored the correlation between taxation and environment; Barman and Gupta (2010); Adewuyi (2016); Xie and Wang (2018); Bostan (2015) have explored the relationship between the environmental condition and public or private expenditures.

While Baumol and Oates (1998), Oueslati (2002), Fischer and Heutel (2013), Lopez (2014) Bostan et al., 2016, Bostan et al., 2009 to encounter the process of environmental degradation tried to find out appropriate solutions and environmental policies in the best interest of environmental protection and economic stability. However, the present study considers ecological footprint as a comprehensive measure of environmental degradation.

Taxes, which is one of the vital components of fiscal policy can accelerate proficiency of energy use besides incentives drivers in public taxes which have a positive impact to improve the quality of the environment (Dongyan 2009; Liu et al., 2017 and Balcilar et al. 2016).

Socio-economic indicators taken in this proposed study are important inputs to investigate the nexus between environmental sustainability and economic objectives to be achieved. These socio-economic inputs are determinants of environmental performance and also indicators of economic growth and development. It is found that is long run while determining the nexus between socio-economic indicators and environmental inputs (drivers), ecological footprint, share in carbon emissions of nations and ecological performance may differ from its symmetry (equilibrium) but this deviation can be short-term with the trend of returning to equilibrium by applying useful and productive means and policies (Sarkodie, 2020).

Many studies have used CO_2 as an environmental degradation indicator, however, there are very limited research studies that have used ecological footprint as an indicator of environmental degradation (Baabou et al., 2017). In this regard to the best of my knowledge, the empirical impact of fiscal policy on ecological footprint as an environmental indicator concerning a developing country like Pakistan has not been explored yet to achieve the ways for sustainable economic development and other joint environmental-economic targets. To evaluate the environmental performance of Pakistan, the empirical methods to determine the impact of fiscal policy keeping important socio-economic indicators in the notice to achieve joint environment targets and economic growth, at least at its minimum level, is the first study to explore. Thus using to explore the impact of fiscal policy on ecological footprint rather than using carbon emissions as an environmental indicator is a more comprehensive approach to access environmental degradation.

The rest part of the study is divided into "Research Methodology" which elaborately explains the research models and methodology, "Results and Discussion" which explains the empirical results of this research study regarding previous research studies, and "Conclusion and Suggestions" which includes some policy implications

Research Methodology

Discretionary fiscal policy and built-in fiscal stabilizers play an important role to achieve desirable stability of macro-economic variables in different phases of economic fluctuations. To investigate the impact of fiscal policy, economic growth, and energy consumption on the ecological footprint in Pakistan, a time series data has been taken from 1976 to 2018. Total six exogenous variables are examined to explore their impact on ecological footprint, which are further explained in Table 1 below

Table 1: Description of variables.

Variables	Description
EFP	Ecological Footprint in million (gha)
TR	Consolidated Federal and provincial Government tax revenue and non-tax revenue (in millions of rupees).
CE	Consolidated federal and provincial government current expenditures (in millions of rupees).
DE	Consolidated federal and provincial government development expenditures (in millions of rupees).
TP	The total population in millions
GDP	Gross Domestic Product in millions (contact 2010 US dollars)
EU	Use of energy (oil in kg equivalent per capita)

Source: Author(s) calculations.

Both dependent and explanatory variables are converted into the natural log (Martinez- Zarzoso, 2011). Log-log model was selected for econometric analysis to determine the elasticity of explanatory variables coefficients. EViews 9 software is used to analyze the research process.

Figure 1 shows the complete research path of this research study to explain the step by step process.

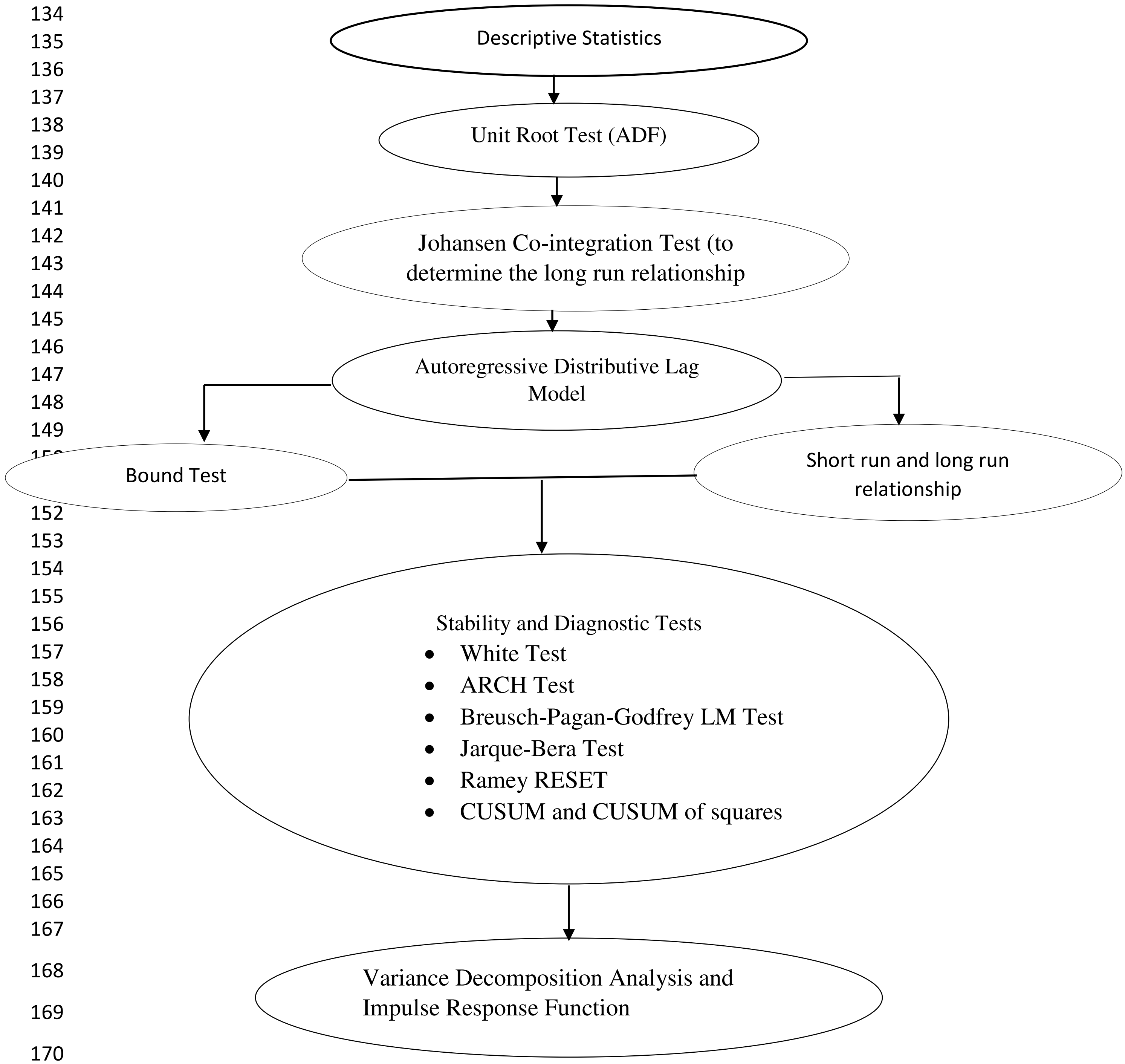

Fig. 1 Flowchart of research methodology.

The core objective of this research study is to explore the impact of fiscal policy and other important determinants such as economic growth and energy consumption on the ecological footprint in Pakistan.

Functionally,

Fiscal Policy = f(Total Public Revenue, Government Current Expenditures and Public Development Expenditures). (1)

Moreover, the following function is used to determine the associations between ecological footprint and its determinants in Pakistan.

$$EFP = f(Fiscal\ Policy, TP, GDP, EU) = f(TR, CE, DE, TP, GDP, EU) \quad (2)$$

Where EFP gives the value of ecological footprint, TR gives the value of total public revenue, CE presents the value of current public expenditures in Pakistan, DE represents development expenditure, TP represents total populations in millions between the period of 1976 and 2016, GDP represents economic growth throughout the selected era and EU is a notion used for use of energy in Pakistan. It is important to note that oil used in KG equivalent per capita is used as a proxy for total energy use in Pakistan.

Log-log model (double log model) is selected for the analysis of this association as it is used to determine the elasticity of coefficients of explanatory variables. In other words, all the data of both dependent and independent variables are converted to a natural logarithm. Mathematically, the following double log model is used to determine the impact of fiscal policy, economic growth, and energy use in Pakistan.

$$logEFP_t = \beta_0 + \beta_1 logTR_t + \beta_2 logCE_t + \beta_3 logDE_t + \beta_4 logTP_t + \beta_5 logGDP_t + \beta_6 logEU_t + e_t \quad (3)$$

Where, *B* shows parameters and *e* shows residual term at time *t*.

First of all, it is crucial to investigate the problem of the unit root as most of the time-series data are non-stationary. Applying standard OLS regression on non-stationary time series data leads to spurious results. Granger (1969) and Granger and Newbold (1974) called this regression spurious regression. AR (1) autoregressive of order one model is used to determine the condition of stationarity which is given below:

$$k_t = \theta\ k_{t-1} + \in_t \quad (4)$$

The time-series behavior of k_t depends on its previous value (k_{t-1}) is an axiom of the AR (1) model. There can be three possible instances of this model given below:

If $|\theta| < 1$; the series is stationary.

If $|\theta| > 1$; the series is explodes.

If $|\theta| = 1$; the series is non-stationary.

This study applies the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1981) to check the stationarity in this time series data which is an extension of the simple Dickey-Fuller test of a unit root. This test includes the optimal lag length of EFP (dependent Variable) used to eliminate the problem of autocorrelation where Akaike Information Criteria (AIC) is used to determine the optimal lag length. Mathematically the following two equations of the ADF test are utilized in this research paper out of its three equations to deal with the problem of a unit root.

$$\Delta k_t = \beta_0 + \theta\ k_{t-1} + \sum_{i=1}^{n} \partial_i \Delta k_{t-1} + \in_t \quad (5)$$

$$\Delta k_t = \beta_0 + \beta_1 t + \theta\ k_{t-1} + \sum_{i=1}^{n} \partial_i \Delta k_{t-1} + \in_t \quad (6)$$

Intercept term is denoted by β_0 while θ represents the coefficient of trend variables. On the other hand $\in_t$ is used for the error term at time *t* in the model. For the ADF test, it is hypothesized at the null hypothesis that the data has the problem of the unit root while the alternative hypothesis assumes that the data has not the problem of a unit root.

The second step, after determining the stationarity of data, is to explore the long run possible correlation between ecological footprint and all explanatory variables of this research in Pakistan. Two methods are used to specify the total number of co-integrating vectors or co-integration relationships proposed by Johansen (1988) and Johansen and Juselius (1990). Both of them involve matrix II estimations. The first method is based on Eigen Values with a null hypothesis of co-integration presence in the data up to n co-integration relationships. Otherwise;

the alternative hypothesis for maximum Eigenvalues is about the presence of co-integration but these relationships are more than n (n+1).

Mathematically,

$$T_{max} \text{ (n+1) } = -S\, ln(1-\partial_{n+1}) \quad (7)$$

The second technique is based on trace statistic used to determine either the number of co-integrating vectors is equal to n or less than n and vice versa.

Mathematically trace statistic can be presented as follows:

$$T_{trace} \text{ (n) } = -S \sum_{j=n+1}^{r} ln\,(1-\partial_{n+1}) \quad (8)$$

In both of the above equations, the sample size is denoted by the S sign while ∂ shows i_{th} order projected value while n manifests a total number of co-integration vectors.

As this is the base objective of the research study to explore both the short-run and long-run impact of fiscal policy, use of energy, and economic growth on the ecological footprint in Pakistan, therefore ARDL is the prime adopted econometric model to fulfill this objective. The research study also employs the F bound test (Pesaran et al. 2001) to determine the overall co-integration in the model. It is important to note that that either all the variables in the model are integrated at 1st difference and vice versa or all of them are mutually co-integrated, ARDL bound test is the best technique to explore the short-run and long-run impact of explanatory variables on the dependent variable in time series data (Janjua et al. 2014).

Mathematically,

$$\Delta logEFP_t = \alpha_0 + \sum_{k=1}^{m} \alpha_{1i}\, \Delta logTR_{t-k} + \sum_{k=0}^{m} \alpha_{2j} \Delta logCE_{t-k} + \sum_{k=0}^{m} \alpha_{3k}\, \Delta logDE_{t-k} + \sum_{k=0}^{m} \alpha_{4l}\, \Delta logTP_{t-k} + \sum_{k=0}^{m} \alpha_{5m}\, \Delta logGDP_{t-k} + \sum_{k=0}^{m} \alpha_{6n}\, \Delta logEU_{t-k} + \beta_1 logTR_{t-1} + \beta_2 logCE_{t-1} + \beta_3 logDE_{t-1} + \beta_4 logTP_{t-1} + \beta_5 logGDP_{t-1} + \beta_6 logEU_{t-1} + e_t \quad (9)$$

Equation no 8 shows both long-run and short-run effects with α_i and β_i as short-run and long-run parameters respectively while Δ shows the differences for stationarity. On the other hand e_t represents residual term with mean is equal to zero and constant variance. Analytically these short-run and long-run coefficients can be calculated separately in the following mathematical forms (equation no 9 and equation no 10) after determining long-run relationships among variables (Pesaran et al 2001).

$$\Delta logEFP_t = \lambda_0 + \sum_{i=1}^{m} \lambda_{1i}\, \Delta logTR_{t-k} + \sum_{i=0}^{m_1} \lambda_{2j} \Delta logCE_{t-k} + \sum_{i=0}^{m_2} \lambda_{3k}\, \Delta logDE_{t-k} + \sum_{i=0}^{m_3} \lambda_{4l}\, \Delta logTP_{t-k} + \sum_{i=0}^{m_4} \lambda_{5m}\, \Delta logGDP_{t-k} + \sum_{i=0}^{m_5} \lambda_{6n}\, \Delta logEU_{t-k} + e_t \quad (10)$$

$$logEFP_t = \gamma_0 + \sum_{i=1}^{m} \gamma_{1i}\, logTR_{t-k} + \sum_{i=0}^{m_1} \gamma_{2j}\, logCE_{t-k} + \sum_{i=0}^{m_2} \gamma_{3k}\, logDE_{t-k} + \sum_{i=0}^{m_3} \gamma_{4l}\, logTP_{t-k} + \sum_{i=0}^{m_4} \gamma_{5m}\, logGDP_{t-k} + \sum_{i=0}^{m_5} \gamma_{6n}\, logEU_{t-k} + e_t \quad (11)$$

It is right important to note that the choice of lag order is receptive to select the optimal lag length for the ARDL model. There are different selection measures used to determine the most suitable lag length. In this study, AIC as a standard measure is used to determine the optimal lag length of the model.

Additionally, six different stability and diagnostic tests are used to determine either the coefficients of the selected ARDL model are reliable, stable, and predictable or not.

The white test included in diagnostic tests is used to determine the problem of heteroscedasticity in the data (White, 1980). To check the residuals autocorrelation and serial correlation ARCH i.e.

Autoregressive Conditional Heteroscedasticity (Engle, 1982) and Breusche – Pagan – Godfrey LM test (Breusch, 1978; Godfrey, 1978) are used respectively. Similarly, Jarque – Bera test (Jarque and Bera, 1987) and the Ramsey RESET test (Ramsey, 1969) are employed to check the normal distribution of the residual terms and specification of the model i.e. appropriate selection of the model are used respectively. In addition to them, CUSUM (cumulative sum of residuals) and CUSUMQ (cumulative sum of the square of residuals) are used to check the stability of ARDL parameters (Brown et al. 1975).

Lastly, this research methodology uses variance decomposition analysis and impulse response functions that are generated from the Cholesky technique. The variations in any independent variable into the component fluctuations or shocks within the vector autoregressive is split by variance decomposition. In another word, these techniques determine the forecast of error variance of each of the variables; which can be clarified by exogenous shocks to the dependent variable.

Empirical Results and Description

Time-series data is utilized to determine the impact of fiscal policies, economic growth, and energy consumption for the period of 1976 to 2018 in Pakistan. The data is collected from different resources such as data of World Bank, Pakistan Bureau of Statistics, 50 Years of Yearly Statistic Book of Pakistan since 1976, and Global Footprint Network. It is evident from Table 2, which interprets the description of all variables included in this research model, that descriptive statistics are vital to understanding the overall features of the data. It also helps in comprehending the basic features and trends of the ecological footprint and all other explanatory variables of the model. The mean value of the dependent variable is 104.08 in million (gha) ranging from 43.62 in million (gha) to 169.87 in million (gha) with a standard deviation of 39.65 used to measure dispersion in the data. Similarly, average values of consolidated Federal and Provincial Government tax and non-tax revenue (in millions of rupees), aggregate Federal and Provincial Government current expenditures (in millions of rupees), public development expenditures (in millions of rupees), the total population in millions, Gross Domestic Product at constant 2010 US $ and use of energy (oil in kg) are 782715.7, 961703.1, 215403.5, 134.58, 118183.7 and 420.69 with standard deviation (a measure of dispersion) 39.65, 889756.9, 889756.9, 1160676, 246985.3, 44.10, 63897.42 and 66.24 respectively.

Table2: Descriptive statistics.

Variables	EFP	TR	CE	DE	TP	GDP	EU
Mean	104.0854	782715.7	961703.1	215403.5	134.58	118183.7	420.69
Median	104.0348	368260.0	423866.0	90106.00	131.06	105342.8	440.25
Max.	169.8562	2694300.0	3605100.	775600.0	216.57	256728.8	527.43
Min.	43.62359	19264.00	19963.00	12366.00	68.83	33583.02	299.10
S.D.	39.65019	889756.9	1160676.	246985.3	44.10	63897.42	66.24

Source: Author(s) calculations.

Additionally, Figure 2 represents the periodic trends of ecological footprint and all explanatory variables of the model in Pakistan. It is determined that current expenditures, public development expenditures, and public revenue has upward fluctuation trends while total population and GDP have been increased over a selected period. It is also shown that the use of energy and ecological footprint has overall increasing trends with the same patterns approximately.

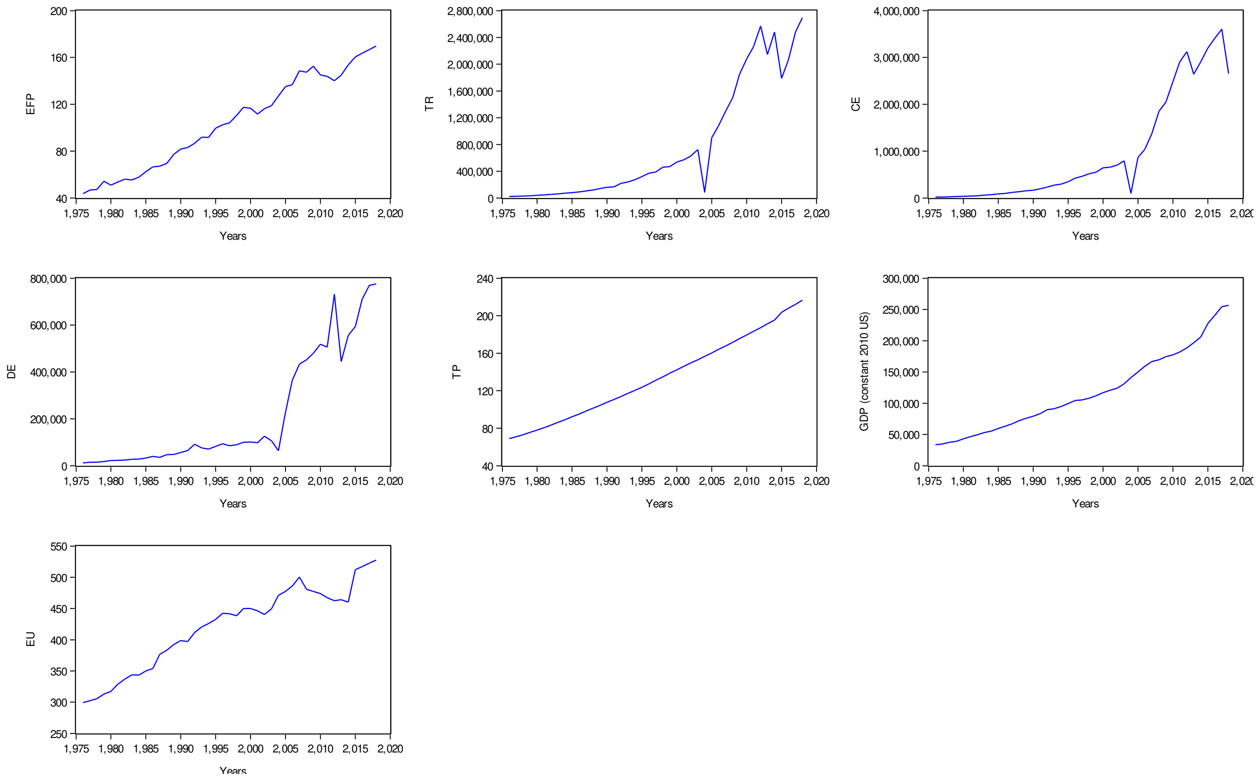

Figure 2: Periodic trends of ecological footprint and explanatory variables in Pakistan.

The first step towards the econometric analysis of this research study is to analyze the data for stationarity. The problem of unit root usually arises due to the presence of time trends in time series data. Employing regression analysis with unit root trends in the data gives the results of spurious regression and parameter estimation in such situations determines misleading and unpredictable results (Granger and Newbold, 1974). Therefore; at first instance, the data is analyzed to determine the stationarity of the data by retaining the Augmented Dickey-Fuller test at constant trend (Dickey and Fuller, 1981) shown in Table 3.

Table 3: Results of ADF test (constant).

Variables	Test equation	*t* stat.	*P*-value	Lags	Conclusion
LogEFP		-1.79	0.38	(1)	
ΔLogEFP	Constant	-4.33*	< 0.05	(1)	I(1)
LogTR		-1.02	0.74	(1)	
ΔLogTR	Constant	-6.84*	< 0.05	(1)	I(1)
LogCE		-1.03	0.73	(1)	
ΔLogCE	Constant	-6.40*	< 0.05	(1)	I(1)
LogDE		-0.51	0.88	(1)	
ΔLogDE	Constant	-5.58*	< 0.05	(1)	I(1)
LogTP		-4.84	0.75	(1)	
ΔLogTP	Constant	-3.84	< 0.05	(1)	I(1)
LogGDP		-2.94	0.20	(1)	
ΔLogGDP	Constant	-4.84	< 0.05	(1)	I(1)
LogEU		-2.57	0.109	(1)	
ΔLogEU	Constant	-3.094*	< 0.05	(1)	I(1)

*5% level of significance. Source: Author(s) calculations.

These results show that each one of the series has the problem of unit root at level but become stationarity at the first difference at 5% level of significance. In other words, all the variables in this research study for a period of 1976 to 2018 have the first order of integration I (1) series at 0.05 level.

According to Engle and Granger (1987) when all the series of data is integrated at the same order of integration, then Johansen co-integration test (1988, 1991) is an appropriate tool to determine the variable movement of data in the long run. Keeping the results of the stationarity test in mind, Johansen co-integration test is a good selected test at the next step to determine the long-run relationship between dependent and independent variables of this research model.

Table 4: Outcome of Johanson Co-integration

H_0	H_1	Eigen Value	Trace Value	C.V 5%	P Values**	Co-integrating Equations
$H_0: j = 0$	$H_1: j = 1$	0.74	175.00	125.61	0.00	None *
$H_0: j \leq 1$	$H_1: j = 2$	0.654	125.06	95.75	0.00	At most 1 *
$H_0: j \leq 2$	$H_1: j = 3$	0.58	85.76	69.82	0.00	At most 2 *
$H_0: j \leq 3$	$H_1: j = 4$	0.45	53.24	47.86	0.01	At most 3 *

$\boldsymbol{H_0: j \leq 4}$	$H_1: j = 5$	0.36	31.28	29.80	0.03	At most 4 *
$\boldsymbol{H_0: j \leq 5}$	$H_1: j = 6$	0.26	14.93	15.49	0.06	At most 5
$\boldsymbol{H_0: j \leq 6}$	$H_1: j = 7$	0.10	3.96	3.84	0.04	At most 6 *
Max- Eigen Statistic						
$\boldsymbol{H_0: j = 0}$	$H_1: j = 1$	0.74	49.94	46.23	0.01	None *
$\boldsymbol{H_0: j \leq 1}$	$H_1: j = 2$	0.65	39.30	40.08	0.06	At most 1 *
$\boldsymbol{H_0: j \leq 2}$	$H_1: j = 3$	0.58	32.53	33.89	0.072	At most 2 *
$\boldsymbol{H_0: j \leq 3}$	$H_1: j = 4$	0.45	21.96	27.58	0.22	At most 3 *
$\boldsymbol{H_0: j \leq 4}$	$H_1: j = 5$	0.36	16.35	21.13	0.21	At most 4 *
$\boldsymbol{H_0: j \leq 5}$	$H_1: j = 6$	0.26	10.97	14.26	0.16	At most 5
$\boldsymbol{H_0: j \leq 6}$	$H_1: j = 7$	0.10	3.96	3.84	0.05	At most 6 *

C.V presents critical values. Statistical significance: * 5% level of significance

Table 4 reveals the outcomes of the Johansen co-integration test with seven co-integrated vectors at a 5% level of significance along with trace and max Eigenvalue. In both Trace and Max-Eigen value statistics null hypotheses ofH_0: j =0, H_0:j ≤ 1, H_0:j ≤ 2, H_0:j ≤ 3, H_0:j ≤ 4, H_0:j ≤ 5, H_0:j ≤ 6 are tested against alternative hypotheses of H_1: j=0, H_1: j=1, H_1: j=2, H_1: j=3, H_1: j=4, H_1: j=5, H_1: j=6, H_1: j=7.

Results show that in the case of the Trace test there are six co-integration vectors at 0.05 level which determine the rejection of their null hypotheses against alternative hypotheses. On the other hand, the Max-Eigenvalue tool determines one co-integration vector at a 5% level of significance. It is important to note when there is controversy in deciding the number of co-integration vectors between Trace Test and Max- Eigenvalue in the model, the most appropriate test is the Trace test to decide the appropriateness of co-integration vectors (Johansen and Juselius, 1990).

It is concluded that both exogenous and endogenous variables are jointly co-integrated to each other; determining the long-run relationship between a dependent variable that is ecological footprint and fiscal policy besides energy consumption.

The research satisfies the condition to use ARDL Bound test developed by Pesaran et al. (2001) and that is all the variables in the selected model are stationary at first difference. F Bound test is used to explore the overall co-integration of the model contrary to giving a picture about co-integration of individual variables.

Table 5: Results of ARDL F-Bound test.

	F-Bound Test	
F-statistic	*6.66	
K	6	
Significance level	**L_0 (lower bound critical value)**	**L_1 (upper bound critical value)**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

*1% level of significance. Source: Author(s) calculations.

As shown in Table 5, 6.66 (F statistic) is greater than the upper critical bound at 0.05 level of significance, suggesting the presence of long-run co-integration between explanatory variables and ecological footprint in Pakistan.

After determining the overall long-run relationship between the dependent variable and explanatory variables; the analysis is advanced to find out short-run and long-run elasticities by the ARDL model shown in Table 6. More elaborately the result ARDL model also determines the positive or negative relationship between the dependent and explanatory variables in both the short-run and long run. Additionally, it also determines the significance of all explanatory variables to decide either each of them is determinant of ecological footprint in the short and long period.

Table6: Results of ARDL model.

Variables	Short-run elasticity	Std. error	t-statistic	prob.
$\Delta \boldsymbol{logEFP_{t-1}}$	0.89	0.26	3.40	0.006
$\Delta \boldsymbol{logTR_t}$	-0.05	0.12	-0.46	0.65
$\Delta \boldsymbol{logCE_t}$	0.089	0.07	1.27	0.22
$\Delta \boldsymbol{logDE_t}$	0.0079	0.05	0.15	0.88
$\Delta \boldsymbol{logTP_t}$	10.73	7.93	1.35	0.20
$\Delta \boldsymbol{logGDP_t}$	0.28	0.50	0.56	0.59
$\Delta \boldsymbol{logEU_t}$	0.79	0.50	1.56	0.14
ECT_{t-1}	-1.95	0.39	-5.05	≤ 0.05
	Long run elasticity			
$\boldsymbol{logTR_t}$	-0.36	0.18	-2.00	0.07
$\boldsymbol{logCE_t}$	-0.013	0.05	-0.26	0.79
$\boldsymbol{logDE_t}$	0.19	0.04	4.58	≤ 0.05
$\boldsymbol{logTP_t}$	2.17	0.32	6.86	≤ 0.05
$\boldsymbol{logGDP_t}$	1.16	0.18	6.32	≤ 0.05
$\boldsymbol{logEU_t}$	2.17	0.22	9.71	≤ 0.05
Constant	-2.59	0.48	-5.39	≤ 0.05

*5% level of significance. Source: Author(s) calculations.

Table 6 shows the negative association of consolidated tax and non-tax public revenue to the ecological footprint in Pakistan. In other words, a 1% increase in public revenue reduces 0.05% ecological footprint in Pakistan.

Contrary, an increase in public expenditures, total population, and energy consumption lead to an increase in ecological footprint in the selected period in Pakistan in the short run. Moreover, in the short run, a 1% increase in public current expenditures, public development expenditures, total population, and energy consumption lead to a 0.089%, 0.0079%, 10.73%, and 0.79% increase in ecological footprint in Pakistan.

Similarly, in the short-run there is a positive and significant relationship of economic growth is noted with an ecological footprint in Pakistan. It is interesting to note that a 1% increase in GDP in Pakistan leads to a 0.28% increase in ecological footprint.

On the other hand, a long-run negative association is observed between total public revenue and ecological footprint and current public expenditures and ecological footprint in Pakistan likewise in the short run. It is depicted from the results that a 1% increase in both these variables leads to a 0.36% and 0.013% decrease in ecological footprint in long run. Similar to these results taxes are interpreted as one of the important built-in stabilizers and instruments of fiscal policy that escalate energy efficiency along with a positive but significant influence on the quality of the environment (Dongyan 2009; Liu et al., 2017 and Balcilar et al., 2016).

It is important to note that all the explanatory variables in the short-run are insignificant, determining that all selected independent variables are not the major determinants of ecological footprint at a 5% level of significance in Pakistan between 1976 and 2018.

Alternatively, in the long-run total public revenue and public current expenditures are insignificant at a 0.05 significance level depicting these two variables are not the major cause of ecological footprint. However, both of these variables are negatively associated with an ecological footprint in Pakistan in long run. It is important to note that a 1% increase in current public expenditures and public revenue causes a 0.013% and 0.36% reduction in ecological footprint in Pakistan respectively in long run. Concerning the results of this paper, it is quoted that taxes, which is one of the vital components of fiscal policy can accelerate proficiency of energy use besides incentives drivers in public taxes which have a positive impact to improve the quality of the environment (Dongyan 2009; Liu et al., 2017 and Balcilar et al., 2016). As is shown in table 6 that there is a negative relationship between current public expenditures and ecological footprint in long run. The same results have been explored by noting that shares of public expenditures in sectors of education and health (a portion of current public expenditures) accelerate the level of present and prospective future income, lead to improving environmental quality which is a major income effect in the environmental arena. Besides, public consumption may lead to stabilizing institutions which is also a cause of environmental quality enhancement. Therefore, it is concluded that government expenditures are a significant but positive determinant of environmental quality (Lopez et al., 2011). In support of these conclusions, it is cited that government expenditures both in direct and indirect spheres minimize sulfur emissions besides the inconclusive results are noted for both direct and indirect shares of public expenditures in case of CO_2 emission (Halkos and Paizanos, 2013). Adewuyi (2016) noted negative but direct and indirect relationship among public expenditures and CO_2 emissions. Additionally, Katircioglu and Katircioglu (2018) noted the same negative but significant relationship between public spending and carbon emission in long run in the case of Turkey.

In long run, development expenditures, energy consumption, GDP, and the total population of Pakistan have positive dominancy and are major determinants of the ecological footprint from 1976 to 2018. McAusland (2008) agreed to these results by exploring that there are different procedures involved as fiscal policy determinants that may negatively influence environmental standards. Fiscal expenditures negatively affect the quality and standards of the environment by differentiating the real causes of environmental degradation in form of either consumption or production produced. Similarly, in the context of China, Yuelan et al. (2019) empirically explored the positive and significant relationship between environmental degradation and fiscal policy tools (particularly expansionary fiscal policy tools). A positive and significant impact of public expenditure in both consumption CO_2 emission and production CO_2 has been explored (Muhafidin, 2020). 1% increase in development expenditures, energy consumption, GDP, and the total population in long run becomes the major cause of 0.19%, 2.17%, 1.16%, and 2.17% increase in ecological footprint in Pakistan in long run. Similarly, Muhafidin (2019) explored the positive relationship between population and environmental degradation in Indonesia. According to him because of the expansion in population, there is an increase in consumption patterns as well, which may cause an increase in the use of energy, leads to intensifying greenhouse gas emitters. Regarding the relationship between energy consumption and the ecological footprint of this research study, the same results are explored by noting an increase in the use of different sources of energy like oil and natural gas plays an essential role as a key determinant of air pollution (Kristom, 2003). Similarly, Alper and Oguz (2016) have also investigated the positive relationship between environmental degradation and the use of energy sources and industrialization. It is explored that practically a strong positive relationship is expected between energy consumption and economic growth. An increase in the use of energy leads to accelerate pace of economic growth which is a major cause of environmental degradation (Alvarado and Toledo, 2016). Energy consumption is one of the important determinants of environmental pollution in the context of the Environmental Kuznets Curve. In most the studies noticeable harmful impact of energy consumption on environmental pollution is found (Haq et al., 2019; Gamage et al., 2017; Jalil et al., 2009; Shahbaz et al., 2014; Hossain, 2012; Ozturk and Mulali, 2015). Similarly, economic activity is considered as an important determinant of environmental quality degradation which leads to an increase in income level at expenses of natural resources exploitation, thus cause environmental pollution. (Guo et al., 2019). In the environmental economics literature, the relationship or association between economic growth and environmental degradation is studied as an important sphere of the Environmental Kuznets Curve i.e. (Narayan and Narayan, 2010; Apergis and Payne, 2010; Fodha and Zaghdoud, 2010).

It is also revealed that all the variables are less elastic except total population in short-run interpret that elasticity's values are less than 1 while other factors are remaining constant. On the other hand; the case is different in the long run where public revenue, public current expenditures, and development expenditures are inelastic while total population, economic growth, and energy consumption are more elastic in Pakistan for selected period with the condition of other determinant held constant.

To check the stability of the ARDL model in long run, ECT is introduced as co-integration Eq (-1) which is significant at a 5% level with a negative sign. This turn-out explains that the ARDL model dynamically stable in long run. This result show that 195% more imbalance appropriateness would bring ARDL long-run stability.

Fiscal instruments are significant determinants in the USA (Halkos and Paizanos ; 2016) while Yeulan et al. (2019) explored the same conclusion for China which is to some extend is exact to the existing results of this research paper. Similarly, many studies have explored the symmetric impact of fiscal policies on environmental quality (Lepoz et al., 2011; Katircioglu and Katircioglu 2018; Chan 2020; Halkos and Paizanos 2016 and Yuelan et al., 2019)

Above all, the best 20 ARDL models are given in Table 7. There are five different types of model selection criteria which are log-likelihood, SBC, HQ, AIC, and adjusted R^2.

Table 7: ARDL model specification

Model	Log L	AIC*	BIC	HQ	Adj. R^2	Specification
1	134.70	-6.09	-4.99	-5.71	0.99	ARDL(1, 0, 0, 0, 0, 0, 0)
2	133.58	-6.08	-5.03	-5.72	0.99	ARDL(3, 3, 3, 3, 0, 2, 3)
3	132.99	-6.05	-4.99	-5.69	0.99	ARDL(2, 3, 3, 3, 1, 2, 3)
4	134.73	-6.04	-4.90	-5.64	0.99	ARDL(3, 3, 3, 3, 1, 3, 3)
5	134.72	-6.04	-4.90	-5.64	0.99	ARDL(3, 3, 3, 3, 2, 2, 3)
6	133.69	-6.04	-4.94	-5.65	0.99	ARDL(3, 3, 3, 3, 0, 3, 3)
7	132.47	-6.03	-4.97	-5.66	0.99	ARDL(2, 3, 3, 2, 1, 3, 3)
8	133.46	-6.03	-4.93	-5.64	0.99	ARDL(2, 3, 3, 3, 1, 3, 3)
9	135.31	-6.02	-4.83	-5.60	0.99	ARDL(3, 3, 3, 3, 3, 2, 3)
10	132.99	-5.99	-4.90	-5.62	0.99	ARDL(2, 3, 3, 3, 2, 2, 3)
11	131.91	-5.60	-4.94	-5.63	0.99	ARDL(3, 3, 3, 2, 1, 2, 3)
12	133.85	-5.99	-4.85	-5.60	0.99	ARDL(2, 3, 3, 3, 3, 2, 3)
13	132.76	-5.98	-4.89	-5.60	0.99	ARDL(3, 3, 3, 2, 1, 3, 3)
14	134.74	-5.98	-4.80	-5.58	0.99	ARDL(3, 3, 3, 3, 2, 3, 3)
15	130.69	-5.98	-4.97	-5.63	0.99	ARDL(3, 3, 3, 2, 0, 2, 3)
16	130.61	-5.98	-4.97	-5.63	0.99	ARDL(2, 3, 3, 2, 1, 2, 3)
17	133.49	-5.97	-4.83	-5.57	0.99	ARDL(2, 3, 3, 3, 2, 3, 3)
18	132.47	-5.97	-4.87	-5.58	0.99	ARDL(2, 3, 3, 2, 2, 3, 3)
19	135.34	-5.96	-4.73	-5.53	0.99	ARDL(3, 3, 3, 3, 3, 3, 3)
20	131.32	-5.96	-4.91	-5.59	0.99	ARDL(3, 3, 3, 2, 0, 3, 3)

Source: Author(s) calculations.

However, in this study, AIC criteria is used to select the best fitted Autoregressive Distributive Lag model. Given in Table 7 the best fitted model is ARDL (1, 0, 0, 0, 0, 0, 0) selected on the basis of smallest AIC value (-6.09).

To confirm the credibility and correctness of the ARDL model; different diagnostic tests are employed and the results are given in Table 8.

Table8: Results of diagnostic tests.

Test type	**Statistic**	**Value**	**d.f**	**Prob.**
White test	χ^2statistic	26.78	*df* (24)	0.31
ARCH test	χ^2-tatistic	2.29	*df* (1)	0.13
Breusch–Pagan-Godfrey LM test	χ^2-tatistic	27.35	*df* (13)	0.29
Jarque–Bera test	F-statistic	0.96	-	0.61
Ramsey RESET test	F-statistic	0.006	*df* (1,10)	0.94

Source: Author(s) calculations.

ARCH and LM tests suggest that there is no evidence of heteroscedasticity and serial correlation in the model. Similarly, the Ramsey RESET test (Ramsey 1969) elaborates that the ARDL model is the best-selected model for the selected research problem. Jarque Bera's (1987) test shows that the ARDL model is normally distributed. The results are based on the probability values of the respective tests as all the probability values of diagnostic are more than 0.05.

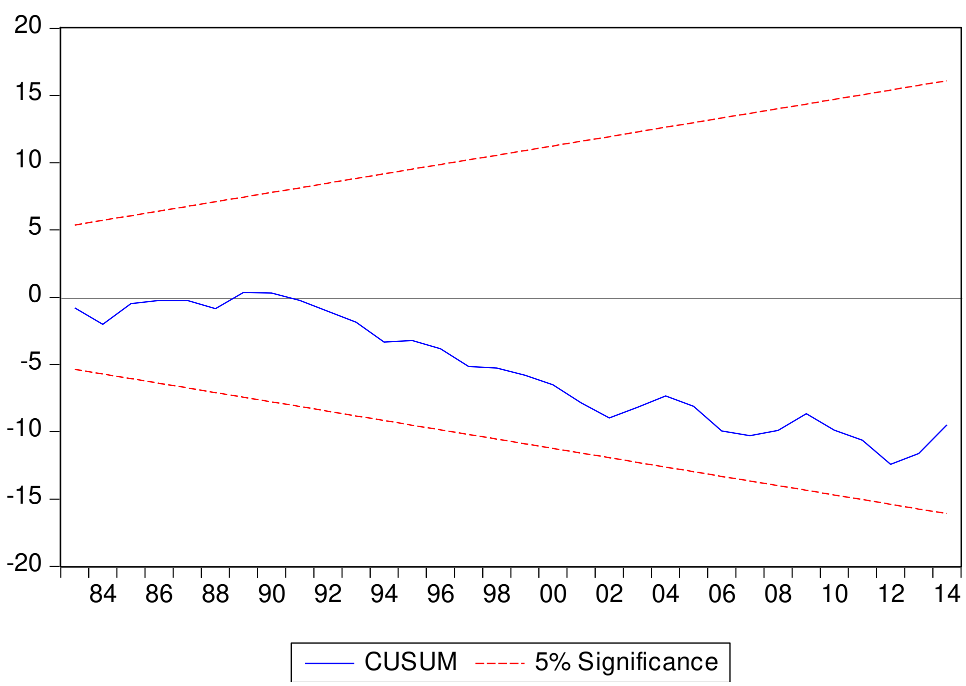

Fig 3: Results of CUSUM test.

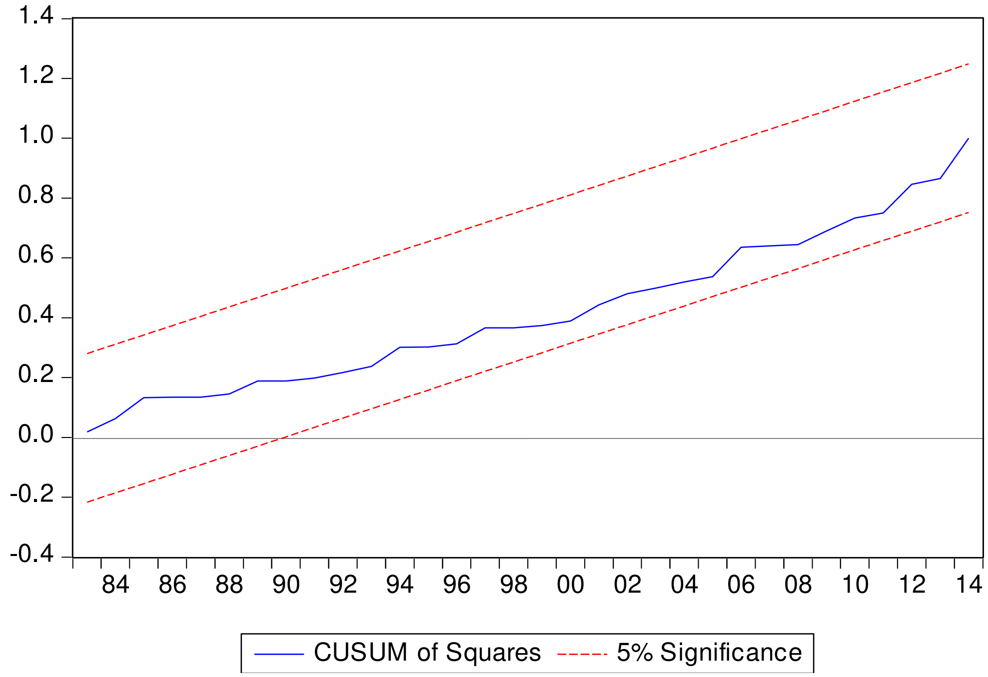

Fig 4: Results CUSUMSQ tests.

Figure 3 and Figure 4 show that CUSUM and CUSUMSQ tests are stable because their respective lines are within the boundaries at a 5% level of significance. These findings indicate that the ARDL model is stable and reliable in the current condition.

Table 9 shows the results of Variance and Decomposition Analysis of all explanatory variables of the model in combination with ecological footprint for the total horizon of periods.

Table 9: Results of Variance Decomposition Analysis

Periods	SE	EFP	TR	CE	DE	TP	GDP	EU
1	0.015	100.0	0.00	0.0	0.00	0.00	0.00	0.00
2	0.018	78.72	4.57	2.97	0.27	0.95	12.51	0.005
3	0.019	67.10	3.93	2.82	0.38	1.38	13.63	10.75
4	0.02	58.74	3.49	5.90	3.25	2.46	15.51	10.64
5	0.023	49.80	3.59	6.41	10.93	3.56	16.62	9.09
6	0.025	43.65	3.22	6.15	17.08	4.11	17.83	7.96
7	0.026	40.74	3.65	5.61	21.03	4.03	17.44	7.49
8	0.026	39.19	4.24	5.35	23.43	3.81	16.79	7.18
9	0.027	38.09	4.57	5.28	24.74	3.81	16.55	6.95
10	0.027	37.45	4.87	5.22	24.98	4.08	16.56	6.83

Source: Author's computation

The results of this test show that fluctuations in ecological footprint are triggered by shocks of its own as well as impulses in all other factors. It is evident that 4.87, 5.22, 24.98, 4.08, 16.56, and

6.83% variations in ecological footprint for the next ten years are because of shocks in public revenue, current public expenditure, development expenditure, total population, economic growth, and energy consumption in Pakistan respectively. These results predict that all exogenous variables contribute to the ecological footprint in Pakistan majorly.

The function of the impulse response is employed to check how a certain variable (particularly dependent variable) responds to modifications introduced to other factors or variables. Based on Cholesky's analysis of impulse response functions can be seen in Fig 5.

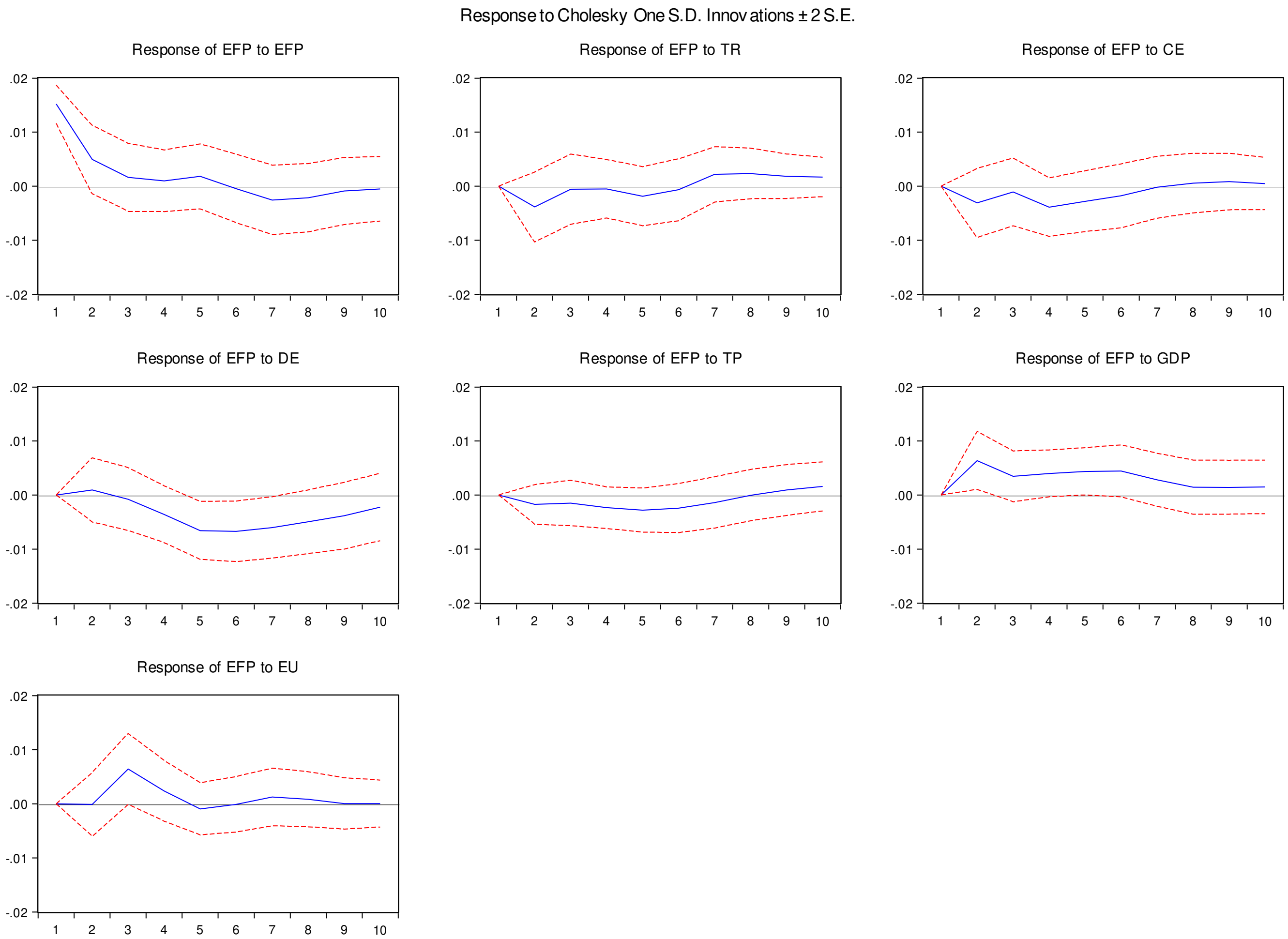

Fig 5: Impulse Response Function.

As shown in Fig 5 it is concluded from the results of the effects of shocks the adjustment path of the variables that the reaction of ecological footprint to independent variables seems significant and positive.

Conclusion and Recommendations

The core objective of this research paper is to explore the short-run and long-run impact of fiscal and some of the socio-economic indicators on the ecological footprint in Pakistan between 1976 and 2018. Different econometric techniques are used to explore this association between fiscal policy and ecological footprint in Pakistan. Johansen co-integration test (applying trace test as standard) determines that there are six co-integrating factors at 0.05 level of significance. Secondly, the ARDL model is used to explore the short-run and long-run socio-economic and fiscal determinants of ecological footprint for the era of 1976 to 2018 in Pakistan. It is concluded that public development expenditures, the total population of Pakistan, economic growth, and energy consumption are major determinants of ecological footprint with positive dominancy, depicting the increase in their values expands ecological footprint in Pakistan. Similarly, total public tax and non-tax revenue and current public expenditures have a negative relationship with the dependent variables in long run; determining the increase in both of them will reduce the ecological footprint in Pakistan.

For policy implications and recommendations, these results focus on adorable and practical fiscal policy significance to achieve environmental targets in Pakistan. It is suggested to increase the share of public current expenditures in the total sphere of public expenditures. Therefore in developing countries like Pakistan, it is necessary to increase public spending in public and social sectors such as health, education, environmental safety, and other important social sectors. This will increase the share of current expenditures by the Government of Pakistan in total public spending, which will reduce the ecological footprint in Pakistan in the long-run.

Similarly, an increase in public revenue can cause a decrease in ecological footprint in Pakistan, insisting the policymakers increase the tax net and tax base. Special concentration is required to bring more and more taxpayers into the tax net in Pakistan.

Green banking is an environmental strategy to accelerate the capital for clean energy projects to improve environmental quality and to reduce the ecological footprint. However, in Pakistan economic policies to invest in green production along with the decrease in carbon emission is being struggled to design by administration and academics (Ullah et al., 2020). Therefore, more concrete and elaborative efforts are required in this field to achieve environmental targets. So, public investment in green production is suggested.

It is also recommended to introduce new economic paradigms and effective domestic and international institutions to achieve sustainable economic development coupled with environmental sustainability. As ecological footprint has the issue of environmental convergence in the whole world.

Concentration to improve renewable energy sources than rely on fossil fuel only is also suggested to decrease ecological footprint in Pakistan and to improve environmental quality. Similarly, along with an increase in investment in the sphere of renewable energy, capital is also required to improve the existing fossil fuels energy plants.

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Data Availability: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards:

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Figures

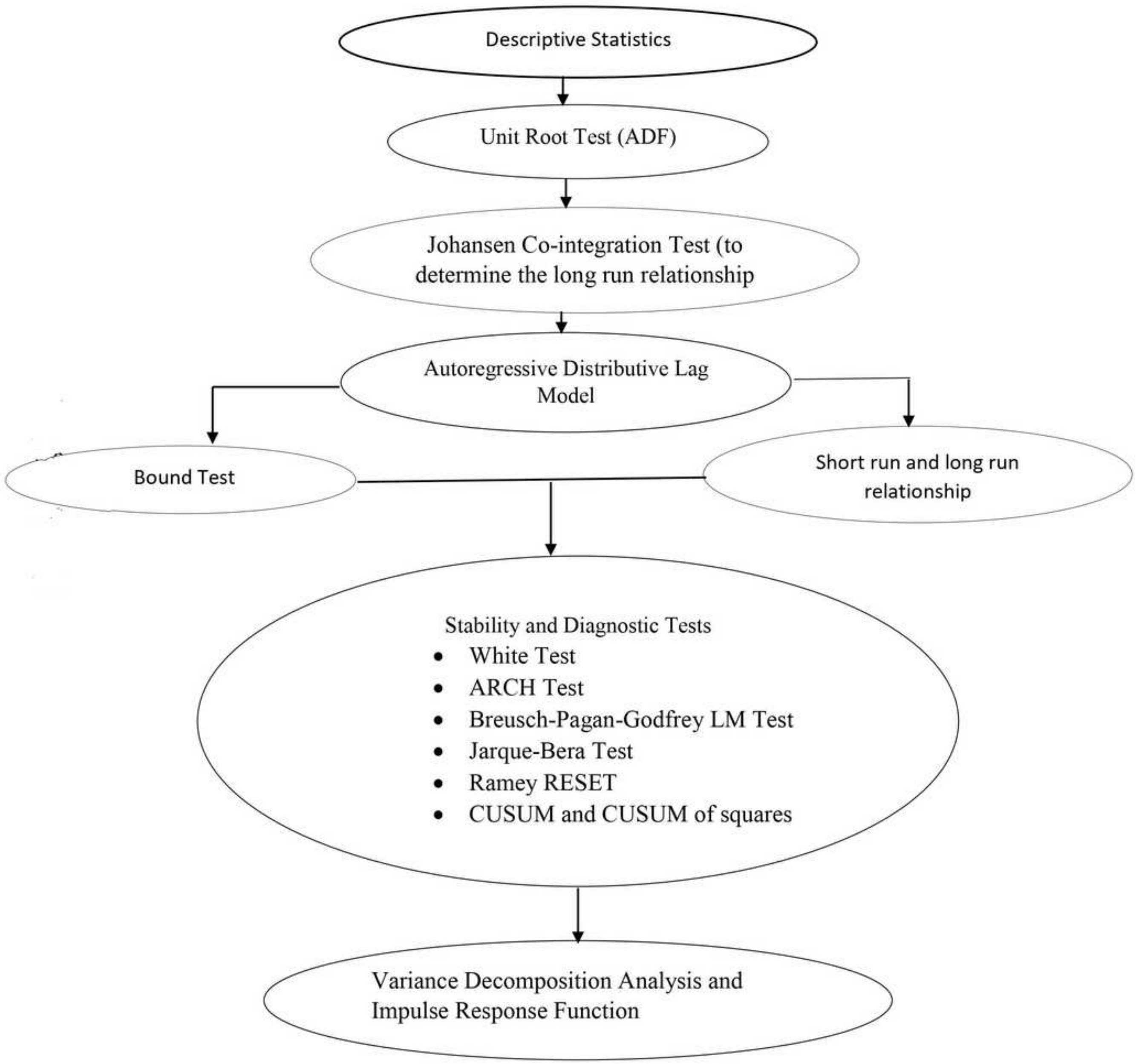

Figure 1

Flowchart of research methodology.

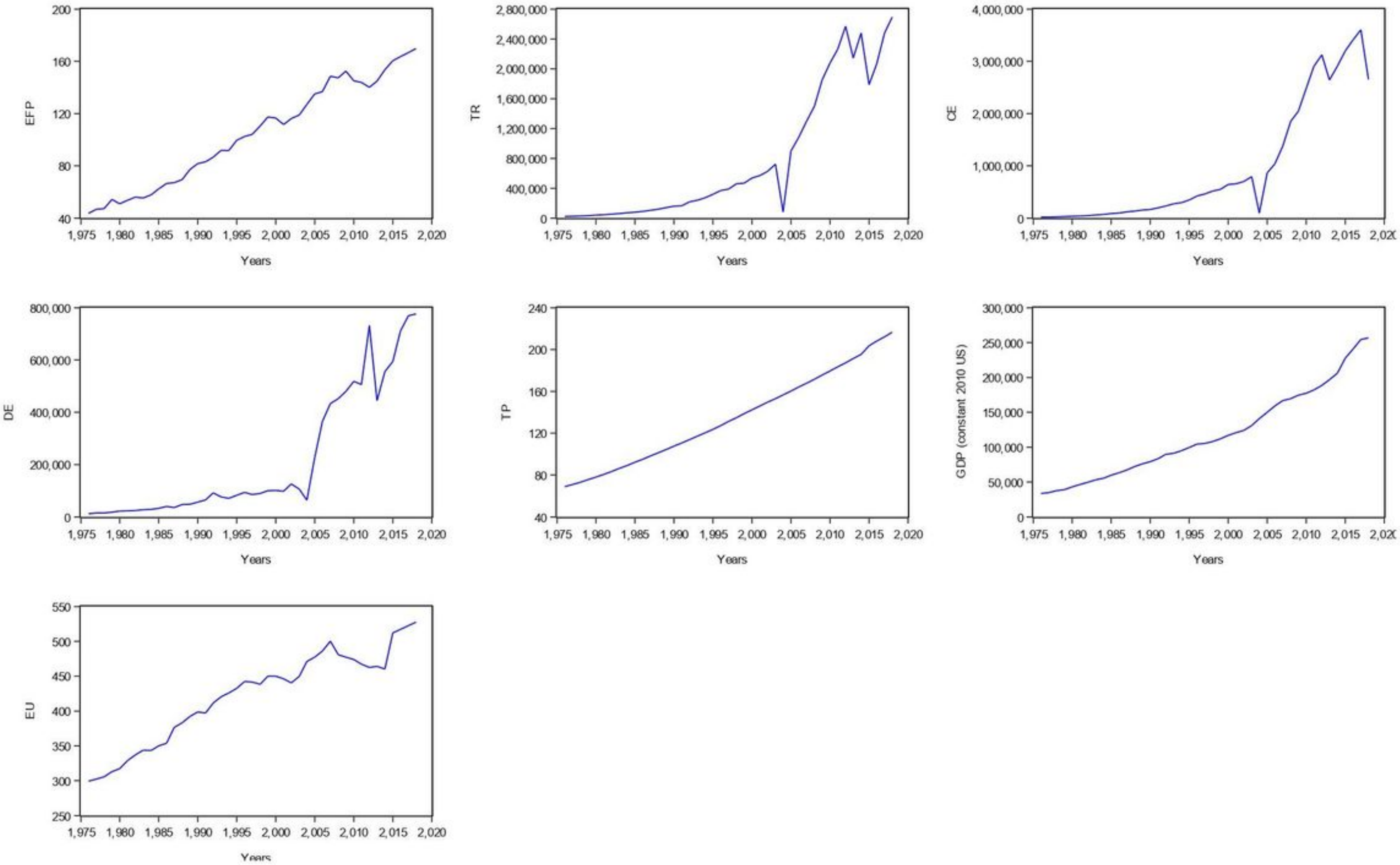

Figure 2

Periodic trends of ecological footprint and explanatory variables in Pakistan.

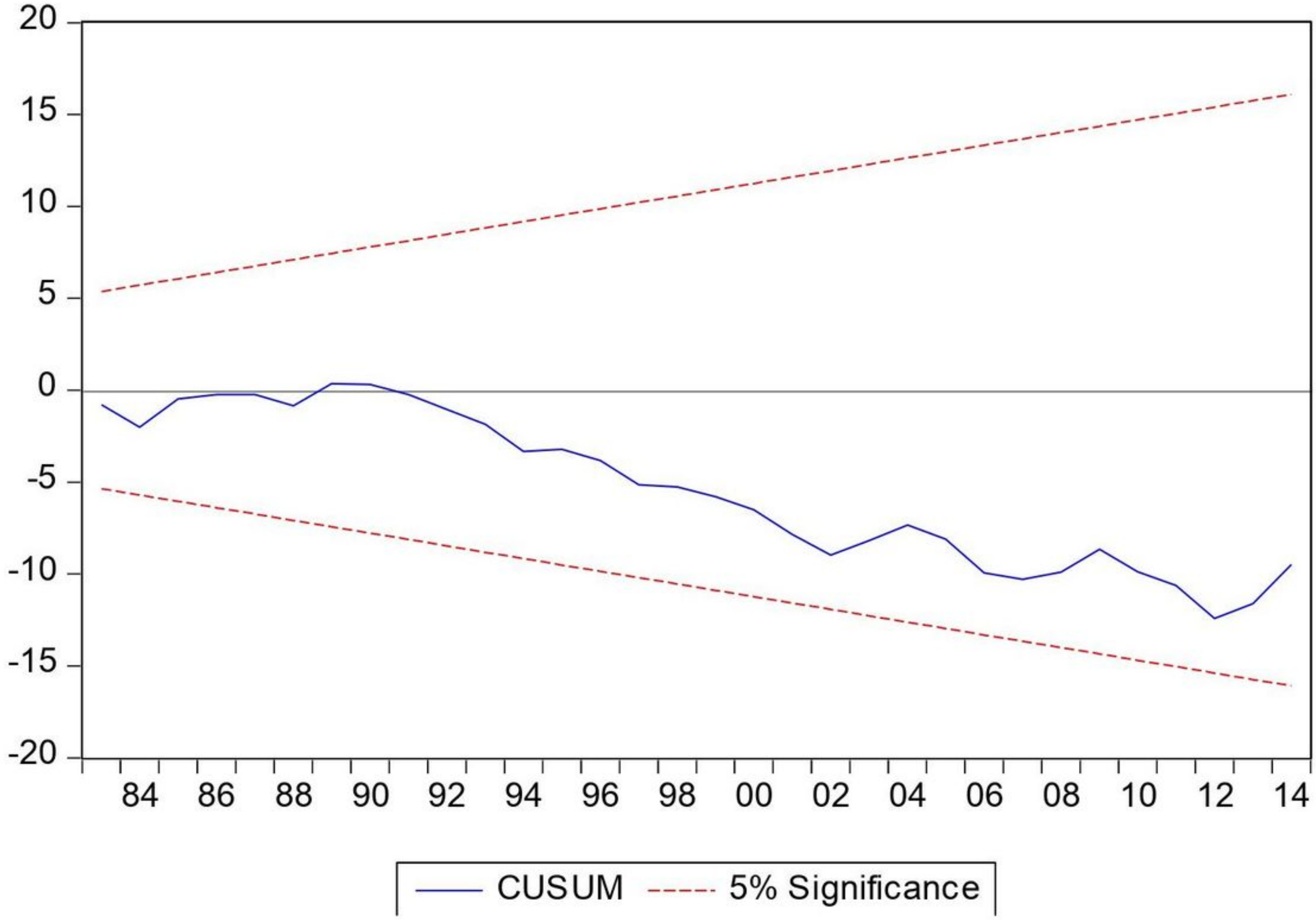

Figure 3

Results of CUSUM test.

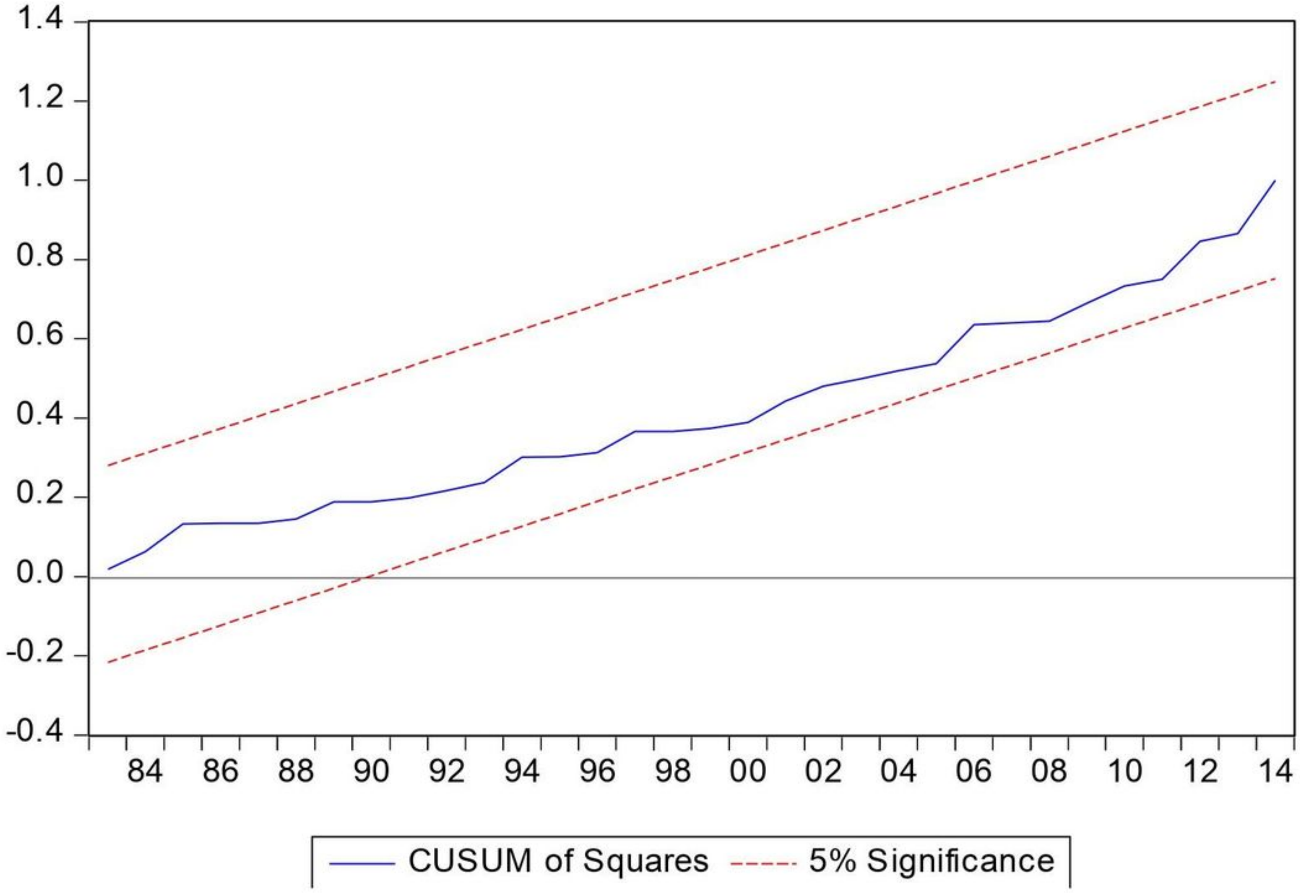

Figure 4

Results CUSUMSQ tests.

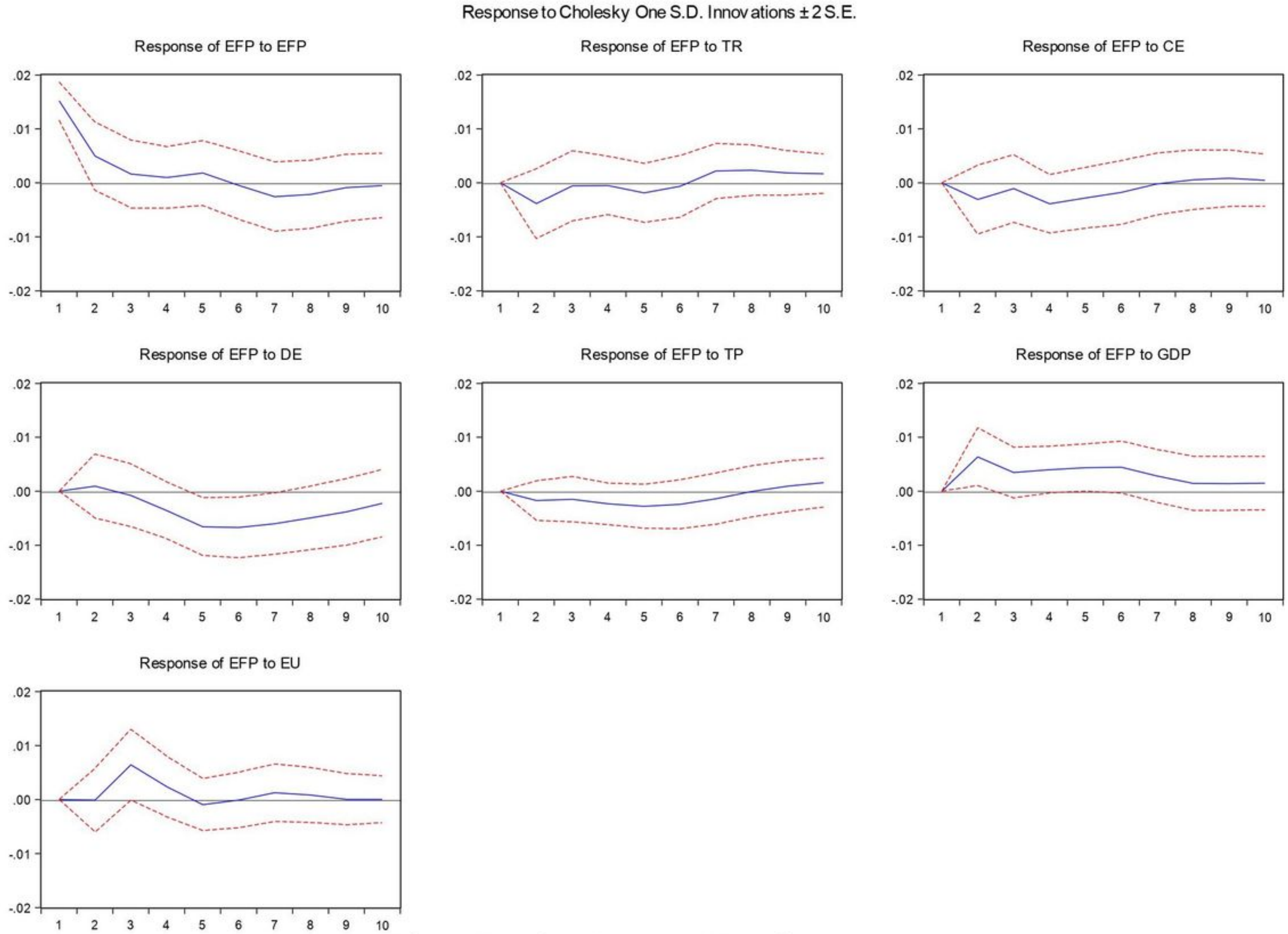

Fig 5: Impulse Response Function.

Figure 5

Impulse Response Function.