

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

Samia Zahra (✉ samiazahra022@gmail.com)

GGDC Hangu: Government Girls Degree College Hangu <https://orcid.org/0000-0002-8832-053X>

Dilawar Khan

Kohat University of Science and Technology

Muhammad Nouman

Kohat University of Science and Technology

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

3 **Samia Zahra¹, Dilawar Khan², Muhammad Nouman³**

4 ¹Lecturer in Economics, Higher Education Department, KP

5 ²Associate professor at Kohat University of Science and Technology, Kohat.

6 ³M.Phil Scholar in Economics, Kohat University of Science and Technology, Kohat.

7
8 **Abstract**

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

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

30 social sectors) shrink 0.36 and 0.013% ecological footprint in the long-run in Pakistan. The
31 stability, reliability, and credibility of the ARDL model are found correct based on different
32 diagnostic tests. Variance decomposition analysis also depicts fiscal policy significantly cause
33 ecological footprint in Pakistan.

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

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52 **Introduction**

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

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

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

76 Ranging from considering the impact of environmental degradation on living standards;
77 researchers and governments have given special attention to analyzing the correlation between
78 important socio-economic indicators and environmental sustainability. In this regard correlation
79 between environment and economic growth has been explored by John and Pecchenino (1994);
80 Grossman and Krueger (1995); Byrne (1997); Bertinelli et al., 2008, Bostan (2016), Bostan et al.,
81 2010 and Burciu et al., 2010).

82 Similarly, Angelopoulos et al., 2013; Kuo et al., 2016; Vasilev (2019) and Pohoata et al., 2014

83 explored the correlation between taxation and environment; Barman and Gupta (2010); Adewuyi
84 (2016); Xie and Wang (2018); Bostan (2015) have explored the relationship between the
85 environmental condition and public or private expenditures.

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

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

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

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

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

118 **Research Methodology**

119 Discretionary fiscal policy and built-in fiscal stabilizers play an important role to achieve desirable
120 stability of macro-economic variables in different phases of economic fluctuations. To investigate
121 the impact of fiscal policy, economic growth, and energy consumption on the ecological footprint
122 in Pakistan, a time series data has been taken from 1976 to 2018. Total six exogenous variables
123 are examined to explore their impact on ecological footprint, which are further explained in Table
124 1 below

125 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)

126 Source: Author(s) calculations.

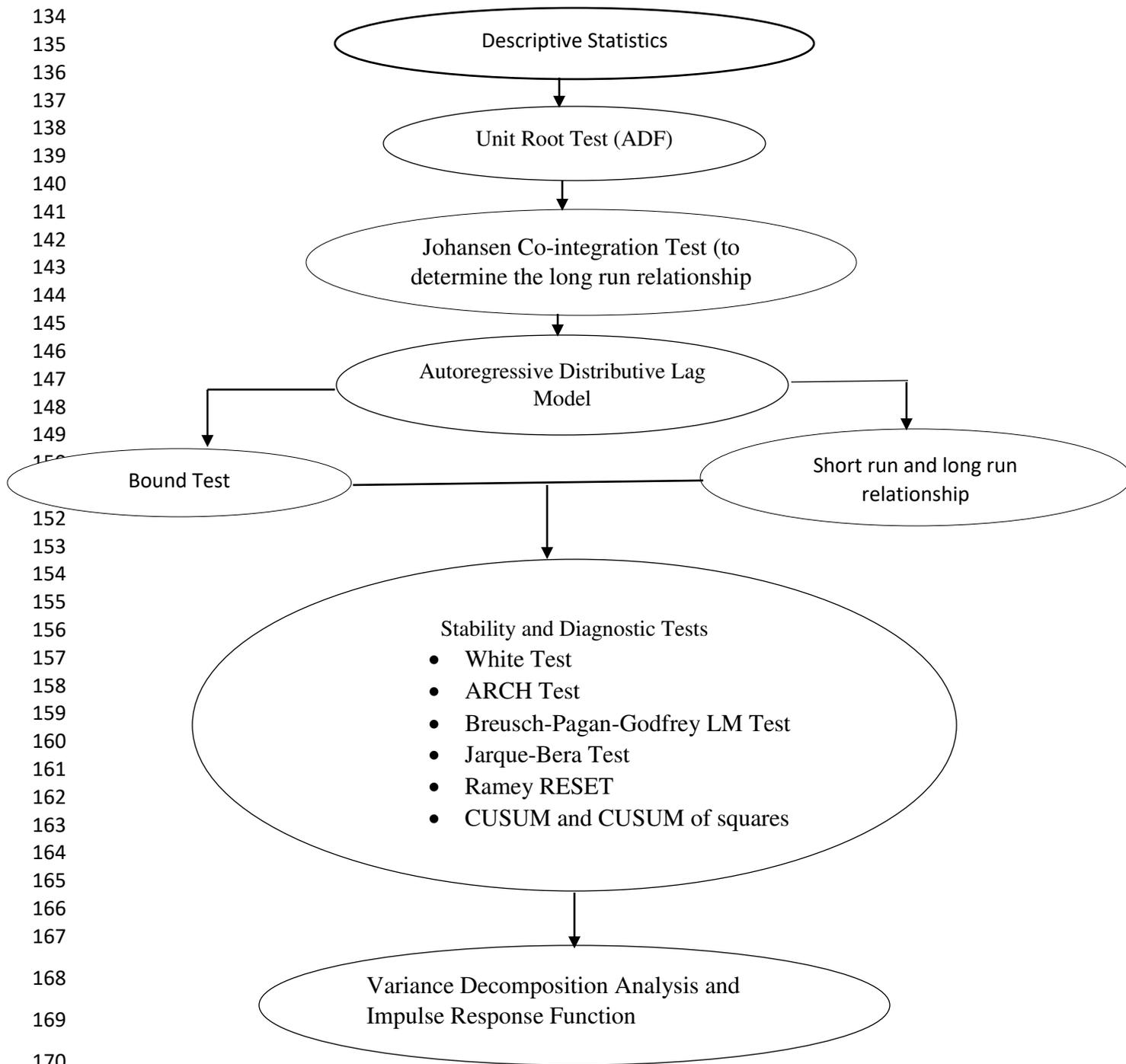
127 Both dependent and explanatory variables are converted into the natural log (Martinez- Zarzoso,
128 2011). Log-log model was selected for econometric analysis to determine the elasticity of
129 explanatory variables coefficients. EViews 9 software is used to analyze the research process.

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



171 **Fig. 1** Flowchart of research methodology.

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

177 Functionally,

$$178 \quad \text{Fiscal Policy} = f(\text{Total Public Revenue, Government Current Expenditures and Public} \\ 179 \quad \text{Development Expenditures}). \quad (1)$$

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

$$182 \quad EFP = f(\text{Fiscal Policy}, TP, GDP, EU) = f(TR, CE, DE, TP, GDP, EU) \quad (2)$$

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

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

$$194 \quad \log EFP_t = \beta_0 + \beta_1 \log TR_t + \beta_2 \log CE_t + \beta_3 \log DE_t + \beta_4 \log TP_t + \beta_5 \log GDP_t + \beta_6 \log EU_t + \\ 195 \quad e_t \quad (3)$$

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

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

202
$$k_t = \theta k_{t-1} + \epsilon_t \quad (4)$$

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

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

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

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

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

214
$$\Delta k_t = \beta_0 + \theta k_{t-1} + \sum_{i=1}^n \partial_i \Delta k_{t-1} + \epsilon_t \quad (5)$$

215
$$\Delta k_t = \beta_0 + \beta_1 t + \theta k_{t-1} + \sum_{i=1}^n \partial_i \Delta k_{t-1} + \epsilon_t \quad (6)$$

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

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

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

228 Mathematically,

$$229 \quad T_{max} (n+1) = -S \ln(1 - \partial_{n+1}) \quad (7)$$

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

232 Mathematically trace statistic can be presented as follows:

$$233 \quad T_{trace} (n) = -S \sum_{j=n+1}^r \ln (1 - \partial_{n+1}) \quad (8)$$

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

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

244 Mathematically,

$$\begin{aligned}
245 \quad \Delta \log EFP_t &= \alpha_0 + \sum_{k=1}^m \alpha_{1i} \Delta \log TR_{t-k} + \sum_{k=0}^m \alpha_{2j} \Delta \log CE_{t-k} + \sum_{k=0}^m \alpha_{3k} \Delta \log DE_{t-k} + \\
246 \quad \sum_{k=0}^m \alpha_{4l} \Delta \log TP_{t-k} + \sum_{k=0}^m \alpha_{5m} \Delta \log GDP_{t-k} + \sum_{k=0}^m \alpha_{6n} \Delta \log EU_{t-k} + \beta_1 \log TR_{t-1} + \beta_2 \log CE_{t-1} + \\
247 \quad \beta_3 \log DE_{t-1} + \beta_4 \log TP_{t-1} + \beta_5 \log GDP_{t-1} + \beta_6 \log EU_{t-1} + e_t \quad (9)
\end{aligned}$$

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

$$\begin{aligned}
254 \quad \Delta \log EFP_t &= \lambda_0 + \sum_{i=1}^m \lambda_{1i} \Delta \log TR_{t-k} + \sum_{i=0}^{m_1} \lambda_{2j} \Delta \log CE_{t-k} + \sum_{i=0}^{m_2} \lambda_{3k} \Delta \log DE_{t-k} + \\
255 \quad \sum_{i=0}^{m_3} \lambda_{4l} \Delta \log TP_{t-k} + \sum_{i=0}^{m_4} \lambda_{5m} \Delta \log GDP_{t-k} + \sum_{i=0}^{m_5} \lambda_{6n} \Delta \log EU_{t-k} + e_t \quad (10)
\end{aligned}$$

$$\begin{aligned}
257 \quad \log EFP_t &= \gamma_0 + \sum_{i=1}^m \gamma_{1i} \log TR_{t-k} + \sum_{i=0}^{m_1} \gamma_{2j} \log CE_{t-k} + \sum_{i=0}^{m_2} \gamma_{3k} \log DE_{t-k} + \sum_{i=0}^{m_3} \gamma_{4l} \log TP_{t-k} + \\
258 \quad \sum_{i=0}^{m_4} \gamma_{5m} \log GDP_{t-k} + \sum_{i=0}^{m_5} \gamma_{6n} \log EU_{t-k} + e_t \quad (11)
\end{aligned}$$

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

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

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

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

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

280 **Empirical Results and Description**

281 Time-series data is utilized to determine the impact of fiscal policies, economic growth, and energy
282 consumption for the period of 1976 to 2018 in Pakistan. The data is collected from different
283 resources such as data of World Bank, Pakistan Bureau of Statistics, 50 Years of Yearly Statistic
284 Book of Pakistan since 1976, and Global Footprint Network. It is evident from Table 2, which
285 interprets the description of all variables included in this research model, that descriptive statistics
286 are vital to understanding the overall features of the data. It also helps in comprehending the basic
287 features and trends of the ecological footprint and all other explanatory variables of the model.
288 The mean value of the dependent variable is 104.08 in million (gha) ranging from 43.62 in million
289 (gha) to 169.87 in million (gha) with a standard deviation of 39.65 used to measure dispersion in
290 the data. Similarly, average values of consolidated Federal and Provincial Government tax and
291 non-tax revenue (in millions of rupees), aggregate Federal and Provincial Government current

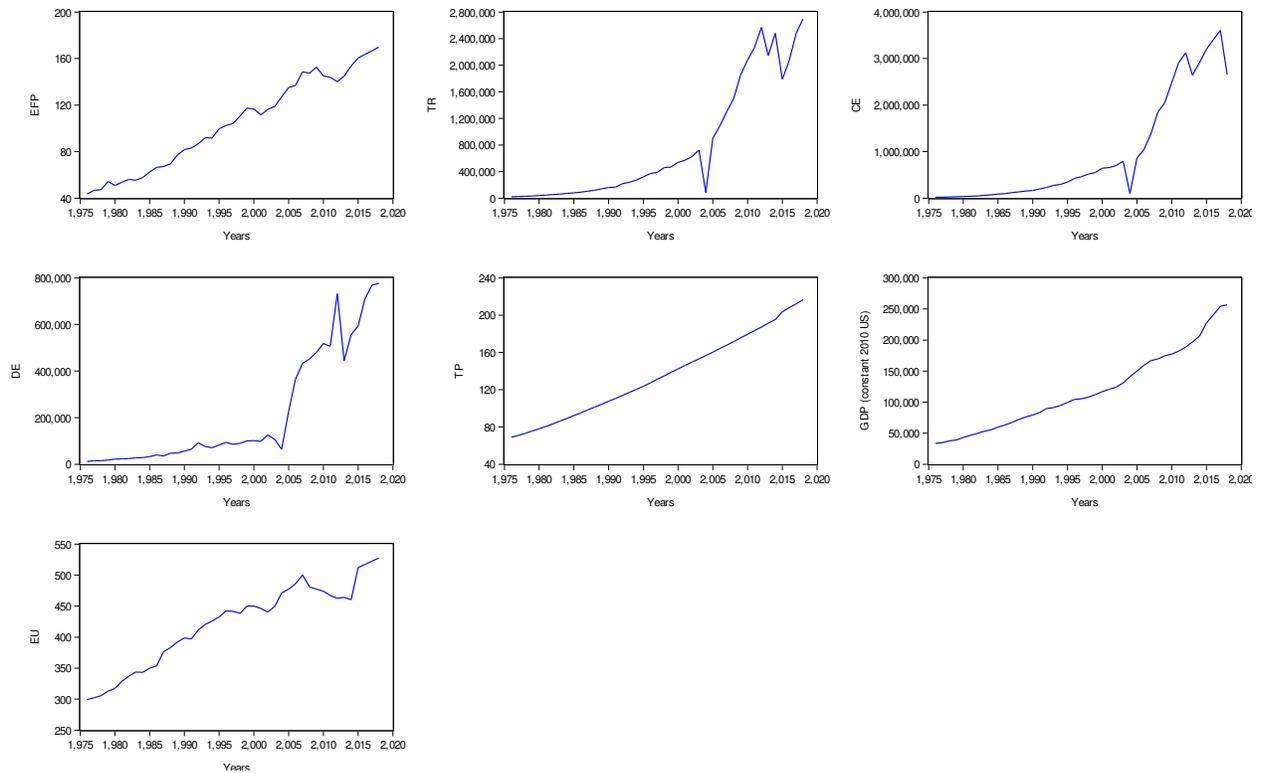
292 expenditures (in millions of rupees), public development expenditures (in millions of rupees), the
 293 total population in millions, Gross Domestic Product at constant 2010 US \$ and use of energy (oil
 294 in kg) are 782715.7, 961703.1, 215403.5, 134.58, 118183.7 and 420.69 with standard deviation (a
 295 measure of dispersion) 39.65, 889756.9, 889756.9, 1160676, 246985.3, 44.10, 63897.42 and
 296 66.24 respectively.

297 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

298 Source: Author(s) calculations.

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



304

305

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

306

The first step towards the econometric analysis of this research study is to analyze the data for

307

stationarity. The problem of unit root usually arises due to the presence of time trends in time

308

series data. Employing regression analysis with unit root trends in the data gives the results of

309

spurious regression and parameter estimation in such situations determines misleading and

310

unpredictable results (Granger and Newbold, 1974). Therefore; at first instance, the data is

311

analyzed to determine the stationarity of the data by retaining the Augmented Dickey-Fuller test

312

at constant trend (Dickey and Fuller, 1981) shown in Table 3.

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316 Table 3: Results of ADF test (constant).

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

317 *5% level of significance. Source: Author(s) calculations.

318 These results show that each one of the series has the problem of unit root at level but become
 319 stationarity at the first difference at 5% level of significance. In other words, all the variables in
 320 this research study for a period of 1976 to 2018 have the first order of integration I (1) series at
 321 0.05 level.

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

327 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 *

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

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

328

329

330 Table 4 reveals the outcomes of the Johansen co-integration test with seven co-integrated vectors
 331 at a 5% level of significance along with trace and max Eigenvalue. In both Trace and Max-Eigen
 332 value statistics null hypotheses of $H_0: j=0$, $H_0: j \leq 1$, $H_0: j \leq 2$, $H_0: j \leq 3$, $H_0: j \leq 4$, $H_0: j \leq 5$, $H_0: j \leq 6$
 333 are tested against alternative hypotheses of $H_1: j=0$, $H_1: j=1$, $H_1: j=2$, $H_1: j=3$, $H_1: j=4$, $H_1: j=5$, $H_1:$
 334 $j=6$, $H_1: j=7$.

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

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

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

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349

350 Table 5: Results of ARDL F-Bound test.

	F-Bound Test	
F-statistic	*6.66	
K	6	
Significance level	L₀ (lower bound critical value)	L₁ (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

351 *1% level of significance. Source: Author(s) calculations.

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

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

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370 Table6: Results of ARDL model.

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

371 *5% level of significance. Source: Author(s) calculations.

372

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

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

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

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

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

394 Alternatively, in the long-run total public revenue and public current expenditures are
395 insignificant at a 0.05 significance level depicting these two variables are not the major cause of
396 ecological footprint. However, both of these variables are negatively associated with an
397 ecological footprint in Pakistan in long run. It is important to note that a 1% increase in current
398 public expenditures and public revenue causes a 0.013% and 0.36% reduction in ecological
399 footprint in Pakistan respectively in long run. Concerning the results of this paper, it is quoted
400 that taxes, which is one of the vital components of fiscal policy can accelerate proficiency of
401 energy use besides incentives drivers in public taxes which have a positive impact to improve the
402 quality of the environment (Dongyan 2009; Liu et al., 2017 and Balcilar et al., 2016). As is
403 shown in table 6 that there is a negative relationship between current public expenditures and
404 ecological footprint in long run. The same results have been explored by noting that shares of
405 public expenditures in sectors of education and health (a portion of current public expenditures)
406 accelerate the level of present and prospective future income, lead to improving environmental

407 quality which is a major income effect in the environmental arena. Besides, public consumption
408 may lead to stabilizing institutions which is also a cause of environmental quality enhancement.
409 Therefore, it is concluded that government expenditures are a significant but positive
410 determinant of environmental quality (Lopez et al., 2011). In support of these conclusions, it is
411 cited that government expenditures both in direct and indirect spheres minimize sulfur emissions
412 besides the inconclusive results are noted for both direct and indirect shares of public
413 expenditures in case of CO_2 emission (Halkos and Paizanos, 2013). Adewuyi (2016) noted
414 negative but direct and indirect relationship among public expenditures and CO_2 emissions.
415 Additionally, Katircioglu and Katircioglu (2018) noted the same negative but significant
416 relationship between public spending and carbon emission in long run in the case of Turkey.

417 In long run, development expenditures, energy consumption, GDP, and the total population of
418 Pakistan have positive dominancy and are major determinants of the ecological footprint from
419 1976 to 2018. McAusland (2008) agreed to these results by exploring that there are different
420 procedures involved as fiscal policy determinants that may negatively influence environmental
421 standards. Fiscal expenditures negatively affect the quality and standards of the environment by
422 differentiating the real causes of environmental degradation in form of either consumption or
423 production produced. Similarly, in the context of China, Yuelan et al. (2019) empirically
424 explored the positive and significant relationship between environmental degradation and fiscal
425 policy tools (particularly expansionary fiscal policy tools). A positive and significant impact of
426 public expenditure in both consumption CO_2 emission and production CO_2 has been explored
427 (Muhafidin, 2020). 1% increase in development expenditures, energy consumption, GDP, and
428 the total population in long run becomes the major cause of 0.19%, 2.17%, 1.16%, and 2.17%
429 increase in ecological footprint in Pakistan in long run. Similarly, Muhafidin (2019) explored the
430 positive relationship between population and environmental degradation in Indonesia. According
431 to him because of the expansion in population, there is an increase in consumption patterns as
432 well, which may cause an increase in the use of energy, leads to intensifying greenhouse gas

433 emitters. Regarding the relationship between energy consumption and the ecological footprint of
434 this research study, the same results are explored by noting an increase in the use of different
435 sources of energy like oil and natural gas plays an essential role as a key determinant of air
436 pollution (Kristom, 2003). Similarly, Alper and Oguz (2016) have also investigated the positive
437 relationship between environmental degradation and the use of energy sources and
438 industrialization. It is explored that practically a strong positive relationship is expected between
439 energy consumption and economic growth. An increase in the use of energy leads to accelerate
440 pace of economic growth which is a major cause of environmental degradation (Alvarado and
441 Toledo, 2016). Energy consumption is one of the important determinants of environmental
442 pollution in the context of the Environmental Kuznets Curve. In most the studies noticeable
443 harmful impact of energy consumption on environmental pollution is found (Haq et al., 2019;
444 Gamage et al., 2017; Jalil et al., 2009; Shahbaz et al., 2014; Hossain, 2012; Ozturk and Mulali,
445 2015). Similarly, economic activity is considered as an important determinant of environmental
446 quality degradation which leads to an increase in income level at expenses of natural resources
447 exploitation, thus cause environmental pollution. (Guo et al., 2019). In the environmental
448 economics literature, the relationship or association between economic growth and
449 environmental degradation is studied as an important sphere of the Environmental Kuznets
450 Curve i.e. (Narayan and Narayan, 2010; Apergis and Payne, 2010; Fodha and Zaghoud, 2010).
451 It is also revealed that all the variables are less elastic except total population in short-run
452 interpret that elasticity's values are less than 1 while other factors are remaining constant. On the
453 other hand; the case is different in the long run where public revenue, public current
454 expenditures, and development expenditures are inelastic while total population, economic

455 growth, and energy consumption are more elastic in Pakistan for selected period with the
456 condition of other determinant held constant.

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

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

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

468 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)

469 Source: Author(s) calculations.

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

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

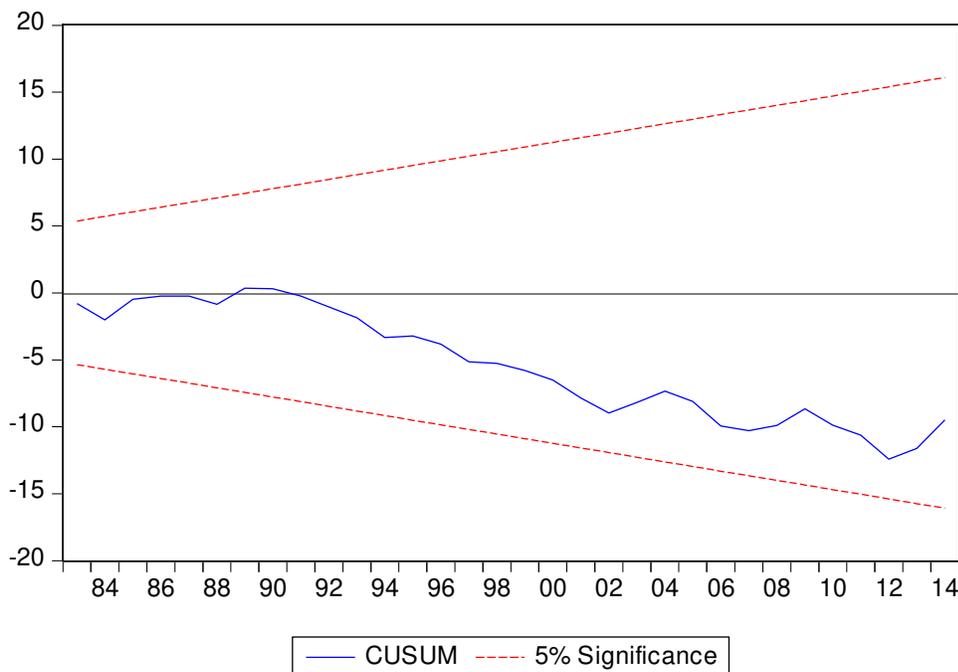
475 Table8: Results of diagnostic tests.

Test type	Statistic	Value	d.f	Prob.
White test	χ^2 statistic	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

476 Source: Author(s) calculations.

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

482

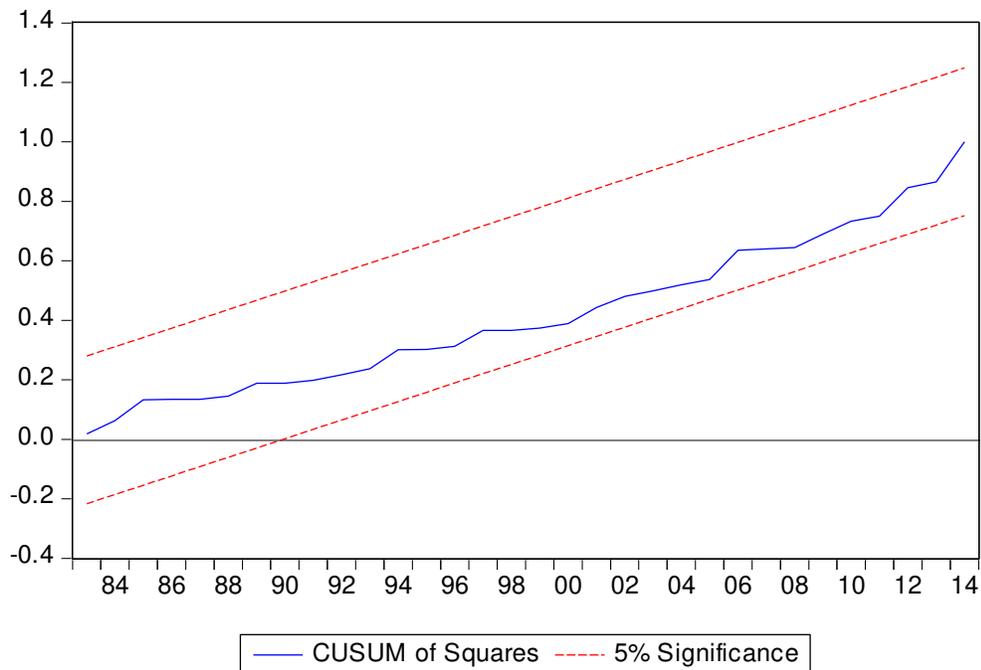


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Fig 3: Results of CUSUM test.

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Fig 4: Results CUSUMSQ tests.

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

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

493 Table 9: Results of Variance Decomposition Analysis

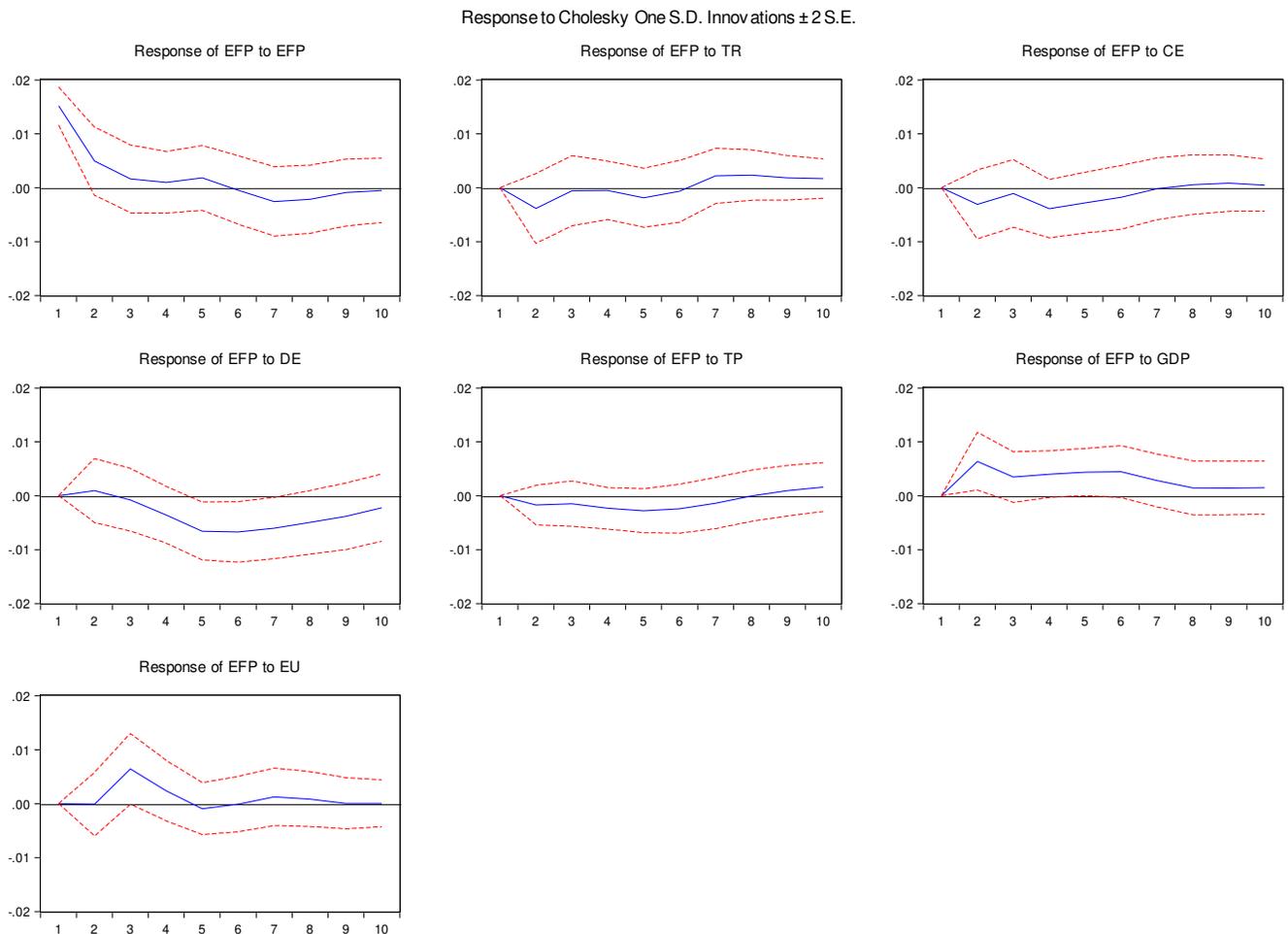
Periods	SE	EFP	TR	CE	DE	TP	GDP	EU
1	0.015	100.0	0.00	0.0	0.00	0.00	0.00	0.00
2	0.018	78.72	4.57	2.97	0.27	0.95	12.51	0.005
3	0.019	67.10	3.93	2.82	0.38	1.38	13.63	10.75
4	0.02	58.74	3.49	5.90	3.25	2.46	15.51	10.64
5	0.023	49.80	3.59	6.41	10.93	3.56	16.62	9.09
6	0.025	43.65	3.22	6.15	17.08	4.11	17.83	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

494 Source: Author's computation

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

497 6.83% variations in ecological footprint for the next ten years are because of shocks in public
 498 revenue, current public expenditure, development expenditure, total population, economic growth,
 499 and energy consumption in Pakistan respectively. These results predict that all exogenous variables
 500 contribute to the ecological footprint in Pakistan majorly.

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



504
 505 **Fig 5: Impulse Response Function.**

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

509 **Conclusion and Recommendations**

510 The core objective of this research paper is to explore the short-run and long-run impact of fiscal
 511 and some of the socio-economic indicators on the ecological footprint in Pakistan between 1976
 512 and 2018. Different econometric techniques are used to explore this association between fiscal

513 policy and ecological footprint in Pakistan. Johansen co-integration test (applying trace test as
514 standard) determines that there are six co-integrating factors at 0.05 level of significance.
515 Secondly, the ARDL model is used to explore the short-run and long-run socio-economic and
516 fiscal determinants of ecological footprint for the era of 1976 to 2018 in Pakistan. It is concluded
517 that public development expenditures, the total population of Pakistan, economic growth, and
518 energy consumption are major determinants of ecological footprint with positive dominancy,
519 depicting the increase in their values expands ecological footprint in Pakistan. Similarly, total
520 public tax and non-tax revenue and current public expenditures have a negative relationship with
521 the dependent variables in long run; determining the increase in both of them will reduce the
522 ecological footprint in Pakistan.

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

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

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

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

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

547

548

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550 Investigation, Writing-Review & Editing. **Muhammad Nouman:** Eviews Analysis. **Dr. Dilawar Khan:**
551 Helped in selection of appropriate Econometric Models.

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715

Figures

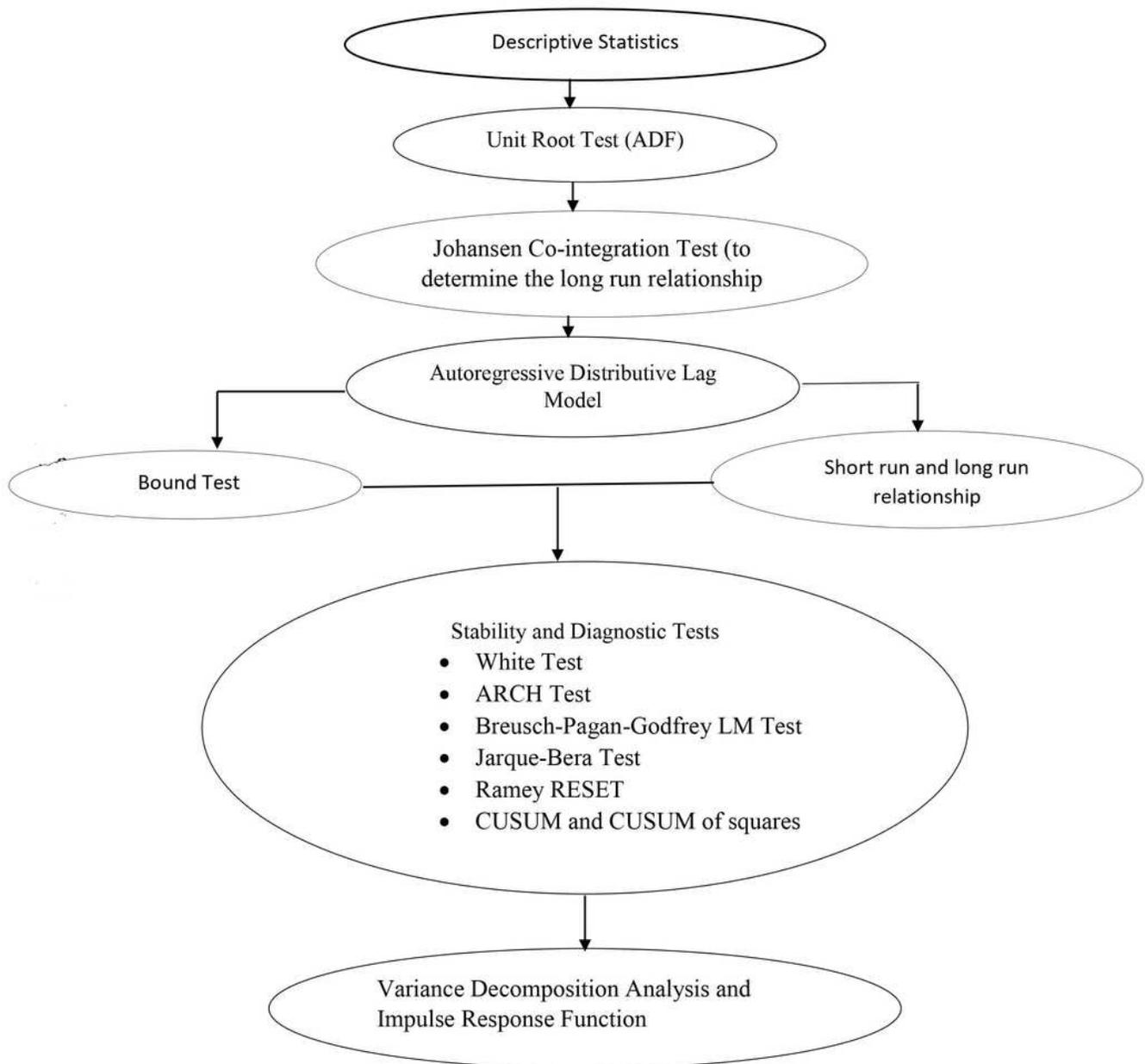


Figure 1

Flowchart of research methodology.

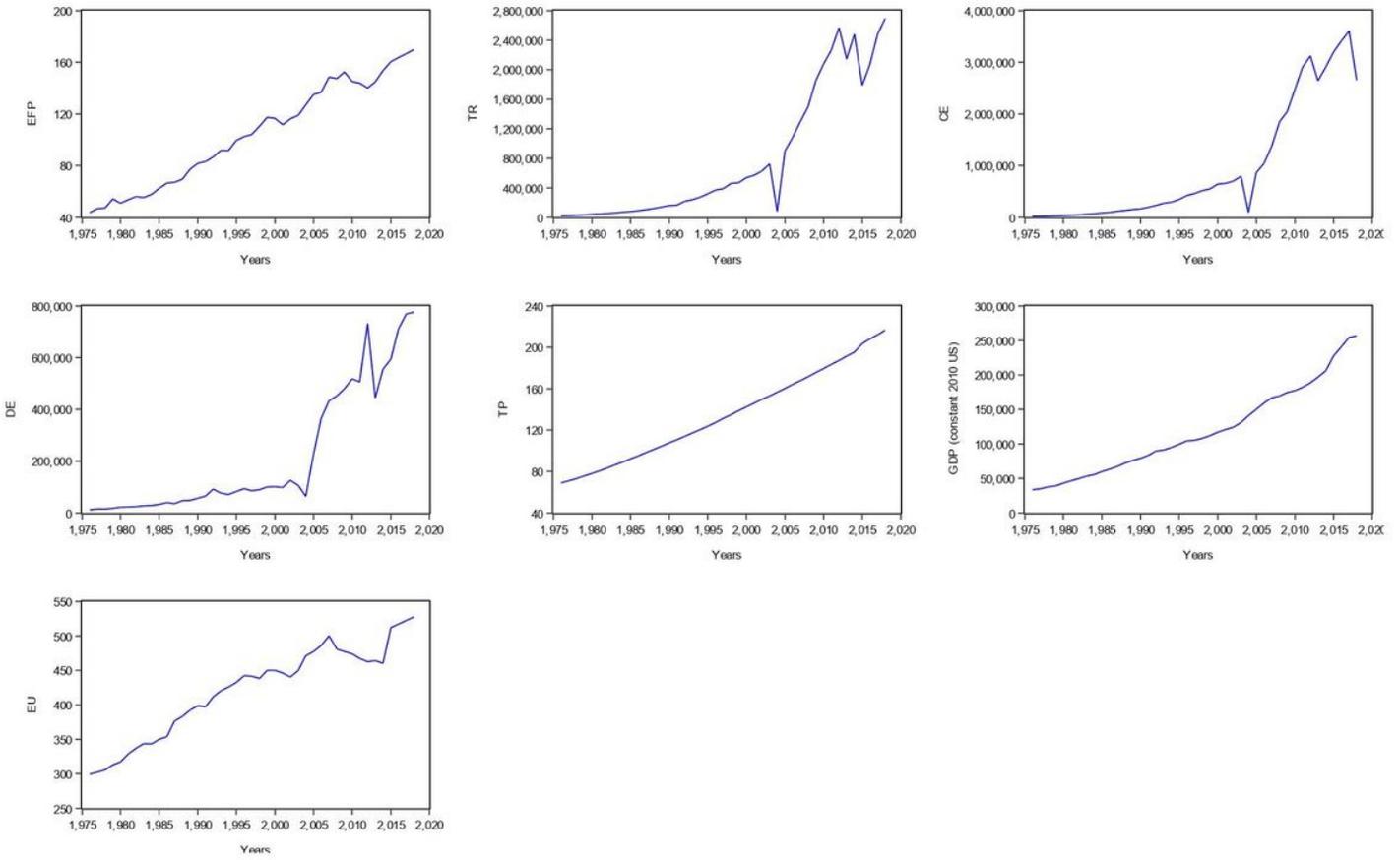


Figure 2

Periodic trends of ecological footprint and explanatory variables in Pakistan.

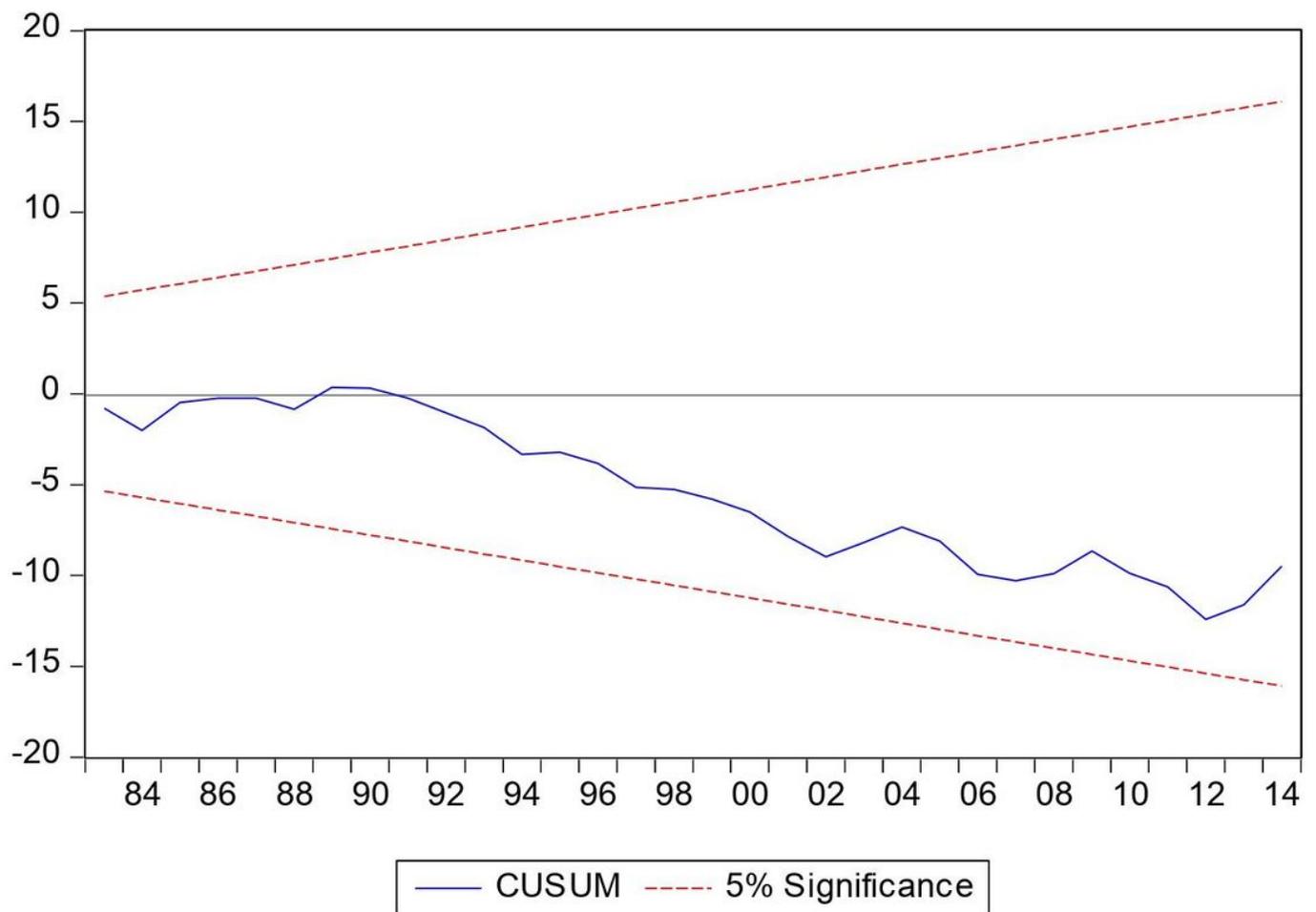


Figure 3

Results of CUSUM test.

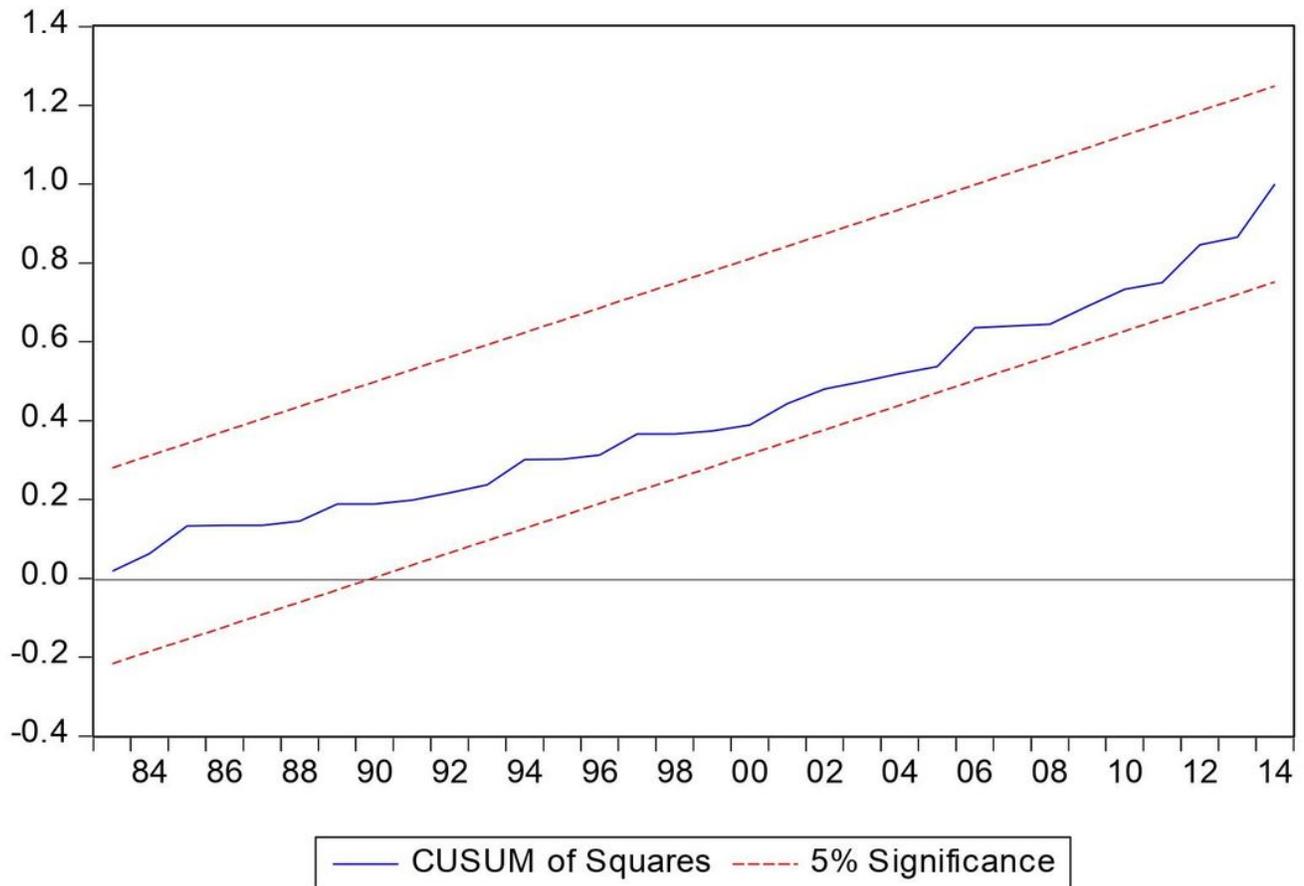


Figure 4

Results CUSUMSQ tests.

Response to Cholesky One S.D. Innovations ± 2 S.E.

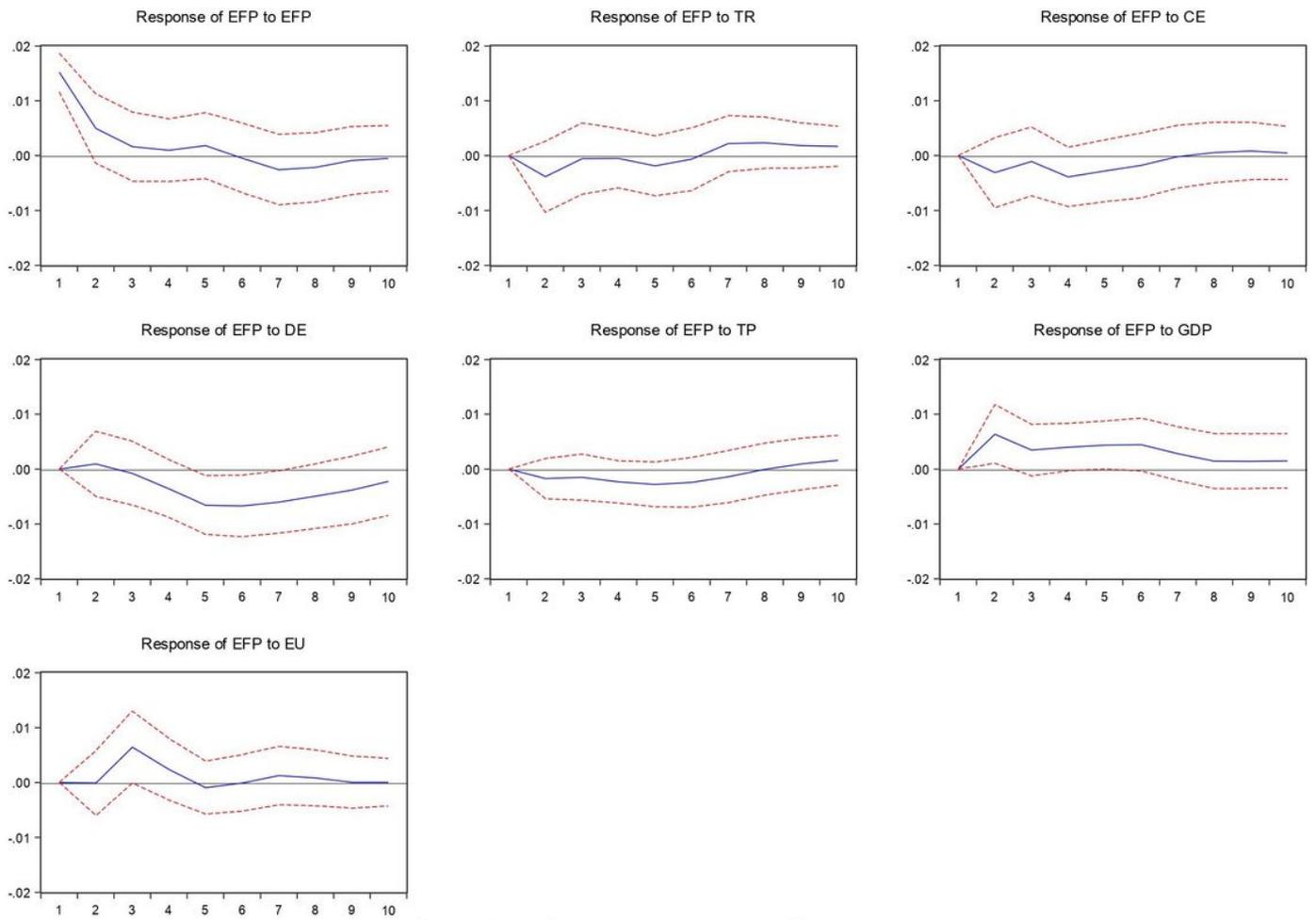


Fig 5: Impulse Response Function.

Figure 5

Impulse Response Function.