

A Step towards Environment Degradation Mitigation in the Manufacturing Sector of Pakistan: Do Energy Consumption, Foreign Direct Investment, and Financial Development Matter? Evidence from Symmetric and Asymmetric ARDL Approach

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1. Introduction

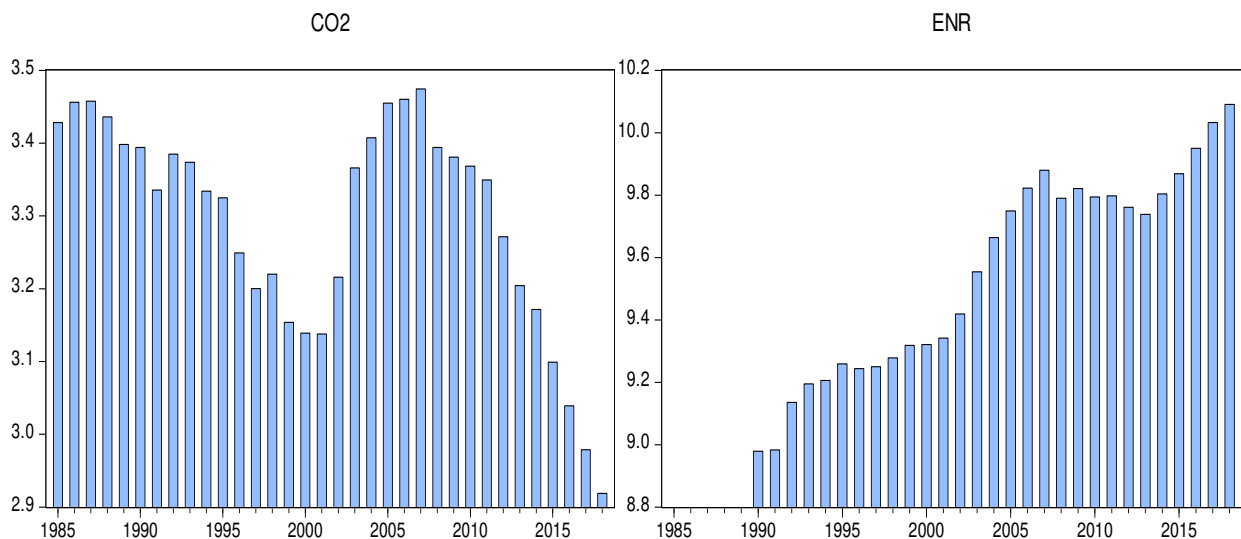
Climate change and CO₂ emissions are the basic component for the sustainable environment along with economic growth. It is a dilemma for developing and developed countries to maintain an inverse linkage between economic growth and carbon emissions (Du and Li, 2019; Yousaf and Lin, 2020). An increase in economic growth mostly enhances the carbon emissions i.e. Environmental Kuznets Curve (EKC) hypotheses. A lot of work is done on environmental degradation and economic growth (Abbasi and Riaz, 2016; Mirza and Kanwal, 2017). The EKC hypothesis is an inverted U-shaped curve that indicates a positive link between economic growth and environmental degradation Zubair et al., (2020). The latest report published by the International Energy Agency IEA(2019)proved CO₂emissions as the highest polluting gas among the greenhouse gases. The percentage share for GHG is mentioned as carbon dioxide CO₂ (90%), methane gas CH₄ (9%) and nitrogen gases N₂ with other gases constitute only (1%)IEA (2019). Additionally, Carbon emissions have adverse effects on human health, ecosystem, species, and their habitats along with negative effects on food quality, water resources, animals, and human health. Moreover, other factors are part of the increase in carbon emissions like soil erosion, climatic situations, deforestation, urbanization, industrialization, institutional quality, agriculture, etc.(Lin and Ahmad, 2017; Jawad et al., 2017).

Carbon emission ratios from the various sectors of Pakistan are mentioned as energy (25%), manufacturing (21%), agriculture (24%), vehicle combustion (14%), other energy-related (10%), and buildings (6%) Economic Survey of Pakistan (2019). The global community is keen on working for the reduction of carbon emissions and environmental protection Ahmad et al.(2019). To achieve environmental sustainability all the world countries have submitted a climate change report specified as Intended National Determined Contributions (INDCs) in the conference (COP21) held in December 2015 in Paris (Lin and Raza, 2019; Abas et al., 2017).Also, Pakistan has participated and submitted the INDC in the 21st conference (COP21) held on 29 November 2015 in Paris (Lin and Ahmad, 2017; Ahmad et al., 2019). Conforming to the “German Watch Report” in the previous 20 years, Pakistan is listed among the top ten countries where climate changes adversely affected the environment. Conferring to the climate change report of the Asian Development Bank (ADB), Pakistan's annual mean temperature raised to 0.5c which produced socio-economic effects on human health, reduction in crops productivity, rivers flow, droughts, heatwaves, and effects on hydropower generation (Malik et al., 2020; Abas et al., 2017). The report of “Global Climate Change Risk Index” (GCCRI) Pakistan indicates that it suffered a huge economic loss of 0.53 per unit GDP equals \$3792.52 due to rapid climatic changes from 1999 to 2018 Economic Survey of Pakistan (2019). Pakistan is focusing on modern strategies for coping with carbon emissions but it requires the adoption of modern technologies to be implanted in the agriculture, transport, manufacturing, and production sectors Ashraf et al.(2017).

The manufacturing sector is the backbone for enhancing the economic growth of any country (Lin et al, 2014; Zhang et al., 2020; Ali et al., 2019). The industrial sector plays a multiplier role

68 in the economic growth of the country. Pakistan's industrial sector contributes 13.6% of the
 69 overall gross domestic product of the country. Pakistan's manufacturing sector growth in 2006
 70 was 8.45 percent which is raised to 14 percent in the year 2020 Economic Survey of Pakistan
 71 (2019). Previously Pakistan's economic growth was agriculture-based that is gradually shifted
 72 towards the industrial-led economy. Ultimately, the manufacturing sector growth requires more
 73 energy production and more energy consumption. Consequently, produces more carbon
 74 emissions and bad environmental standards Mahmood et al. (2020). Moreover, industrialization
 75 accounts for a high percentage of carbon emissions which distracts the environmental
 76 sustainability (Meng et al., 2021; Munir Ahmad and Zhao, 2018).

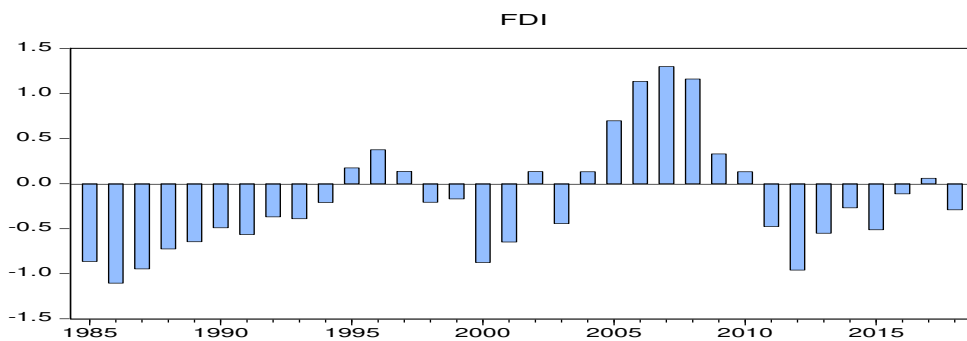
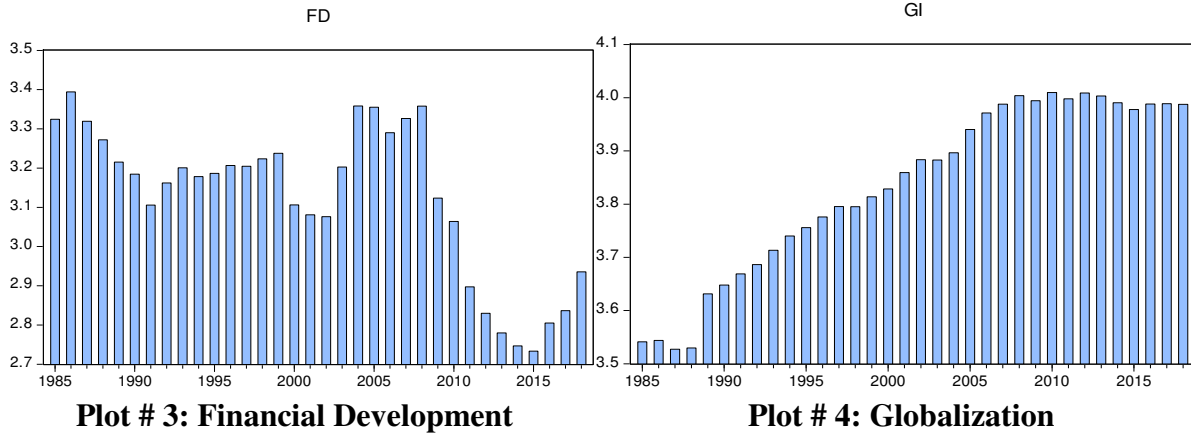
77 Due to the significance of a sustainable environment, the link between energy consumption,
 78 carbon emissions, and economic growth has been examined by various researchers in the
 79 different sectors of Pakistan (Buhari et al., 2020; Rehmann and Pablo-Romero, 2018; Yu,
 80 Zheng, and Li, 2018). It is governed that the manufacturing sector heavily relies on energy
 81 consumption and ultimately produces more carbon emissions Baz et al. (2019). Due to a lack of
 82 resources and technological advancement; Pakistan generates energy requirements by natural
 83 gas, oil, and coal. Energy consumption for the various sectors of Pakistan is given as overall the
 84 industrial sector consumes 37.7%, transport sector 32.2 %, and households consume 22.2%
 85 Baloch and Suad (2018). Pakistan's industrial output is declined by 12% due to the energy crisis
 86 Mirza and Kanwal (2017). Due to the massive production of energy from fossil fuel, Pakistan
 87 has to import Oil, LNG Gas, and other resources which result in economic decline and
 88 environmental pollution (Malik et al., 2020; Y. Zhang and Zhang, 2018). The following figures
 89 shows the trends of CO2 emission, energy consumption, foreign direct investment, financial
 90 development and globalization in Pakistan.



91
92

Plot # 1: CO₂ Emissions

Plot # 2: Energy Consumption



97 **Plot # 5: Foreign Direct Investment**

98 One way to enhance the economic growth of the country is through foreign direct investment
 99 from other countries. The relationship between CO₂ emissions and indicators of FDI (human
 100 capital, technological transfer, difference exchange rate, market size expansion) is examined by
 101 many researchers and conferred different results. (Le and Ozturk, 2020; Shahbaz.G, et al., 2019;
 102 Anser, 2019). Also, the adverse effects of FDI on CO₂ emissions are governed by various authors
 103 in the context of pollution haven and pollution halo hypothesis (Nathaniel . B, Barua, et al.,
 104 2020; Destek and Okumus, 2019; Pesaran, 2014; Khan et al., 2020). The pollution haven
 105 hypothesis works in low-income countries with weak economies and less control on
 106 environmental regulations, permits developed and developing countries to reallocate their
 107 polluting manufacturing firms in those countries, and become a haven for polluters(Bakhsh et al.,
 108 2017; Shahbaz.G, et al., 2019). As a result, FDI degrades environmental sustainability in those
 109 countries. Conversely, the pollution halo hypothesis states that FDI inflow countries strictly
 110 follow the environmental regulations, and ultimately cleaner production is possible in those
 111 countries (Ur Rahman et al., 2019; Shahbaz.B et al., 2019).

112 The present study focused on the case of Pakistan due to tremendous factors as mentioned.
 113 Firstly, Pakistan is termed as the best place in Asia for foreign direct investments (FDI) because
 114 of its strategic location. Secondly, Pakistan and China are working on the marvellous project of
 115 “China Pakistan Economic Corridor” (CPEC) with a huge investment of \$46 billion for energy
 116 and infrastructure Ur Rahman et al. (2019). CPEC tends to open modern ways of technologies,

117 new job opportunities, Foreign Direct Investments, infrastructure, corporate and private sector
118 contracts, and energy development projects. CPEC project is termed as the highest investment
119 project in the history of Pakistan. Thirdly, the Pakistan government is focused to create a friendly
120 business environment for other countries and corporate businesses (Ur Rahman et al., 2019;
121 Rasool et al., 2019). Fourthly, Pakistan has geographical importance with coastal ports, global
122 airline routes, and infrastructure for imports and exports with border sharing countries (Iran,
123 China, Afghanistan, and India) which provide the economical transit methods. These routes
124 connect the Central Asian Republic Countries (CARC) and afford economical business
125 transactions. In the future perspective, Gawadar Port (2,292 Acre Free Trade) connects trade
126 association with Europe and Asia termed as Euro-Asia Transport Link (EATL). Additionally
127 Gwadar Port will link the Middle East, China, and the United National Economic and Social
128 Commission for the Asian and Pacific region (UNESCAP) for economic strength and
129 collaboration with other countries Lin and Yousaf (2020).

130 Previous studies have focused on CO₂ emissions and financial development of Pakistan using the
131 ARDL approach (Abbasi and Riaz, 2016; Hussain and Ur, 2014), CO₂ emissions and
132 urbanization in the case of Pakistan with the ARDL method (Ali, Bakhsh, et al., 2019;
133 Acheampong et al., 2019), CO₂ emissions with energy consumption and economic growth in
134 Pakistan (B. Zhang and Wang, 2017; Jawad.S, et al., 2017; Lin and Ahmad, 2017; Mirza and
135 Kanwal, 2017; Lin and Raza, 2019), CO₂ emissions among energy consumptions from the
136 transport sector in Pakistan under ARDL technique (Baloch and Suad, 2018; Yousaf and Lin,
137 2020; Rasool et al., 2019), Carbon emissions and human activities in Pakistan by ARDL method
138 Anser (2019). Apart from this literature, there is needed to focus on the manufacturing sector of
139 Pakistan. The purpose of the paper is to seek the relationship of CO₂ emissions with energy
140 consumption, globalization, FDI, and financial development in the context of the manufacturing
141 sector of Pakistan. The paper contributes to the literature in many ways: Firstly, this is the unique
142 attempt to research the manufacturing sector of Pakistan using the ARDL and NARDL methods.
143 Secondly, this study will prove the asymmetric behaviour of energy consumption on
144 manufacturing output in CO₂ emission. Moreover, the study gives a new direction for government
145 officials and policymakers for the formulation of policies. This study tries to prove the validation
146 of the Pollution Halo or Haven Hypothesis in the case of Pakistan.

147 The remaining structure of the paper as following: The first section of the paper is given as an
148 introduction. The literature review is briefly explained in section two. The third section puts
149 lights on the descriptions of the variables, comprehensive methodology, and data sources.
150 Section four comprises empirical analysis results of the study and the last section gives the
151 conclusion of the study.

152 **2. Literature Review**

153 The Pollution haven model was first ever offered by Pethig (1976) which explained the
154 Ricardian model of a trade by supposing the trade between two identical countries. Neo-classical

155 theory of trade works in countries that generate industrial pollution like two identical countries
156 which have a difference in carbon pollution tax one is higher than the other. The pollution
157 difference is the reason for trade among these countries. The pollution haven hypothesis is first-
158 ever discussed by Kevin P (2008). One school of thought states that the Pollution haven theory
159 works for developed countries to shift own polluting industries to low-income countries and save
160 their country from environmental degradation. The FDI recipient country enhances its per capita
161 income and pollutes its environment. The other school of thought disagrees with the first
162 statement and says that with the enhance in FDI economic growth also improves. The improved
163 economic position produces technological advancements in the country and reduces carbon
164 emissions Demir and Duan(2018).

165 Many authors examined the positive and negative effects of foreign direct investment in the
166 various regions of the world under pollution haven and pollution halo hypotheses (Sun.H, et al.,
167 2020; Le.T.H, et al., 2016; Rahman et al., 2020; Shahbaz.N, et al., 2017; Hdom and Fuinhas,
168 2020). Some of the authors analyzed the effects of FDI for individual countries like Kazakhstan
169 Wada et al.(2020), Pakistan (Ali.M.U, et al., 2020; Malik et al., 2020; Baloch and Suad, 2018;
170 Abbasi and Riaz, 2016), Brazil Hdom and Fuinhas (2020), USA Shahbaz.G, et al. (2019), China
171 (Y. Zhang and Zhang, 2018; Du and Li, 2019), Nigeria Zubair et al. (2020) and several other
172 conducted research on the group of countries such as South Asia Rahman et al. (2020), MENA
173 countries Shahbaz.B, et al. (2019), Sub-Saharan Africa Acheampong et al. (2019). Both the
174 individual and group country analysis provides mixed results. The research examined by Sun.H
175 et al. (2020) discussed the connection of CO₂ emissions with environmental pollution regulations
176 and FDI from the manufacturing sector of China for annual data from 2001 to 2007. The results
177 indicate that both environmental regulation styles (expenditure style & investment style) and FDI
178 produces manufacturing pollution. Also, the study validates the EKC model for manufacturing
179 sector pollution in China.

180 The connection between energy consumption and CO₂ emissions is governed by many
181 authors(Zhang.Y, et al., 2019;Ahmad.A et al., 2016; Chang et al., 2016; Kasman and Duman,
182 2015) and found a strong positive connection in the results. The relationship between CO₂
183 emissions and energy consumption is quite important for the manufacturing sector pollutions
184 (Tian et al., 2018; Zhu and Shan, 2020; Lin et al., 2014; Zhang et al., 2020). The study of (Ma et
185 al., 2019;Zhang et al., 2020;Tian et al., 2018)urged thatthe highest quantity of carbon dioxide is
186 produced by China in the world due to the high industrial pollution.

187 The findings of Griffin and Hammond (2019) worked on the relationship of CO₂ emissions and
188 energy consumption in the industrial sector (iron & steel) of the United Kingdom. The iron and
189 steel industry of the UK accounts for the highest GHG emissions about 26% and the highest
190 energy-consuming sector. The study concluded a positive association between energy
191 consumption and carbon emissions. To reduce carbon emissions technological innovations are
192 required in the manufacturing sector i.e., bioenergy fuel switching, energy-efficient technologies,
193 and carbon capture storage Griffin and Hammond (2019). The research examined by Zhang et al.

194 (2020) focused on the connection between energy consumption from the manufacturing sector of
195 China with CO₂ emissions and CH₄ methane gas emissions. Conferring to China's statistical
196 yearbook (2019) manufacturing sector contributes 40% to the economic growth of the country.
197 The results indicate that China is a manufacturing economy, which showed remarkable energy
198 consumption in the manufacturing sector and ultimately degrades environmental sustainability.
199 The research evaluated by Zhu and Shan (2020) explores the relationship of CO₂ emissions,
200 economic growth, and energy consumption in the industrial sector of Beijing for annual data
201 from 2018 to 2020. The results determined that industrial growth leads China to meet the
202 economic growth while energy consumption and reduction in carbon dioxide emissions are not
203 truly surpassed the 13th five-year plan of government.

204 Capital formation is termed as an important factor to control the nexus of environmental
205 degradation. Financial development in a country can produce technological advancements and
206 ultimately reduction in carbon dioxide emissions. Many researchers focused on the impact of
207 CO₂ emissions on financial development using various indicators. Akalpler and Hove (2019)
208 analyzed positive results for gross capital formation and reduction in carbon emissions for the
209 Indian economy. The research investigated by Javid and Sharif, 2016; Komal and Abbas, (2015)
210 showed the association of financial development with carbon dioxide emissions and formulated a
211 positive relationship in the context of Pakistan. Zubair et al. (2020) determined the linkage of
212 CO₂ emissions with fixed capital and found a negative result for Nigeria using annual time series
213 data from 1980 to 2018. The research governed by Le and Ozturk (2020) determined a positive
214 link between financial development and carbon emissions among the Emerging markets &
215 developing countries using data period from 1990-2014. Hence financial development increases
216 CO₂ emissions due to the establishment of the industrial sector without compliance with
217 environmental standards.

218 Wang et al. (2020) examined the association of CO₂ emissions and an increase in globalization
219 various factors. First, the transport sector plays a key role in enhancing CO₂ emissions by
220 globalization. Secondly, globalization enhances industrial consumption which ultimately
221 produces high CO₂ emissions. Trade activities between countries expand industrial activities
222 which require more energy consumption and more CO₂ emissions. Shahbaz, Jawad et al. (2017)
223 inspected the factors affecting globalization on carbon dioxide emissions for Japan. The results
224 showed a negative relationship with globalization. In the case of Japan globalization posed
225 strong economic impacts with technological improvements. Mehmood (2020) examined the
226 association between CO₂ emissions and globalization and found negative results in the case of
227 Pakistan and India, on the other hand, positive relationship for Srilanka, Bangladesh, Bhutan, and
228 Afghanistan. The research inspected by Udom et al. (2020) verified a positive connection of CO₂
229 emissions with globalization for the Malaysian economy. The results suggest that the Malaysian
230 economy should make ideal policies to reduce CO₂ emissions through globalization.

231

232 The review concluded that a lot of work is done on the association between carbon dioxide
 233 emissions and energy consumption in Pakistan(Baz et al., 2019;Mirzaand Kanwal, 2017;Lin and
 234 Raza, 2019;Lin and Ahmad, 2017; Chandia et al., 2018; Javid and Sharif, 2016; Zaidi et al.,
 235 2018). The idea of carbon dioxide emissions and energy consumption in Pakistan is also
 236 analyzed in various sectors like transport and vehicles(Yousafand Lin, 2020;Baloch and Suad,
 237 2018;Lin and Yousaf, 2020;Rasool et al., 2019), financial development(Komaland Abbas,
 238 2015;Shahzad et al., 2017), urbanization (Ali.R, et al., 2019b), Agriculture sector (Qureshi et al.,
 239 2016). All the above-mentioned studies focused on the relationship between CO₂ emissions and
 240 energy consumption in the various sectors of Pakistan while so far the manufacturing sector
 241 carbon emissions have rarely been inspected byAttari et al. (2016) to a little extent. His study
 242 model was based on the carbon dioxide emissions and manufacturing sector income, apart from
 243 considering other important factors such as energy consumption, FDI, globalization, etc. which
 244 are now briefly focused on in the present study.In light of the above review, the present study
 245 endeavours to empirically analyze the effects of carbon dioxide emissions, energy consumption,
 246 FDI, globalization, and financial development in the context of the manufacturing sector of
 247 Pakistan using the linear and non-linear ARDL method.

248 3. Data and Methodology

249 The empirical analyses utilized the annual data from the period 1985 to 2018 for the
 250 manufacturing sector of Pakistan. CO₂ emissions (% of total fuel combustion) from the
 251 manufacturing sector are used to analyze environmental quality.Total energy consumption from
 252 the manufacturing sector is obtained in kilotons of oil.Foreign direct investmentis measured in
 253 percentageof GDP.Domestic credit to the private sector is obtained in the percentage of GDP as a
 254 proxy of financial development. The data for variables CO₂ emissions, FDI, Financial
 255 development, are extracted from the World Development Indicators database.Total energy
 256 consumption data is obtained from the International Energy Agency. Globalization is accessed
 257 generally, and its data is obtained from KOF Swiss Economics Institute. The details and
 258 descriptions of the variables for the present study are mentioned in Table 1.

Table 1 Variable name, symbols, descriptions, and data source.

<i>Variable</i>	<i>Symbol</i>	<i>Description</i>	<i>Data Source</i>
<i>Carbon emission</i>	<i>CBN</i>	<i>CO₂ emissions from manufacturing industries and construction</i>	<i>World Bank</i>
<i>Energy Consumption</i>	<i>ENR</i>	<i>Manufacturing Energy Consumption includes Coal, Oil, Bio-fuels, Electricity, and Natural gas (kiloton of oil equivalent)</i>	<i>International Energy Agency</i>
<i>Foreign direct investment</i>	<i>FDI</i>	<i>Foreign direct investment, net inflows</i>	<i>World Bank</i>
<i>Financial Development</i>	<i>FD</i>	<i>Domestic credit to the private sector</i>	<i>World Bank</i>
<i>Globalization Index</i>	<i>GLOB</i>	<i>Globalization index</i>	<i>Swiss Economic Institute</i>

259

3.1 Econometric Strategy

260
261 In view of research work conducted in a literature review about CO₂ emissions and energy
262 consumption in the various sectors. The present study examined an econometric model with
263 CO₂emissions from the manufacturing sector as the dependent variable. Energy consumption
264 from the manufacturing sector and FDI are analyzed as the independent variable. Financial
265 development and globalization index are focused as the explanatory variables in the present
266 research. All the variables data are converted into the natural logarithm form to get smooth
267 results. To cover the asymmetric results of positive and negative shocks of FDI, we employed
268 the NARDL method founded by Shin (2014). The non-linear ARDL approach is the extension
269 work of the ARDL method presented by Pesaran (2001). This technique evaluates the dynamic
270 asymmetries raised due to the positive and negative shocks of the econometric variables between
271 the long and short term. The importance of the NARDL approach is that it works regardless of
272 the stationary values of the series I(0), I(1), or a mixed stream of integration. Additionally, it
273 works for the small sample size of the data and provides the hidden co-integration values
274 detected by Granger (2002). Therefore, the difference between the typical ARDL and the non-
275 linear ARDL approach gives multiplier advantages that's why many researchers implemented
276 the NARDL approach for econometric analysis (Ur Rahman et al., 2019; Mahmood et al., 2020;
277 Malik et al., 2020).

278 The present study employed the linear-ARDL approach leading towards the non-linear ARDL
279 method. ARDL approach is used to find the long-run and short-run relationship of the variables.
280 ARDL approach has several advantages over the former techniques like Granger and Engle
281 model for (two variables). Conversely, the Johansen co-integration technique works for (more
282 than two variables). ARDL technique has various advantages over the traditional econometric
283 methods like Johansen and Julius co-integration and Engle and Granger techniques. Firstly, the
284 ARDL approach is employed on the small data size. Secondly, it works for the variables for
285 stationary at level, first difference, and mixed order co-integration. Thirdly, the data generation
286 process (DGP) works on appropriate lags of the data. Fourth, by simple ordinary least square
287 (OLS) technique, it gives the Error Correction Term (ECM) by applying the bounding test. ECM
288 provides separate details about the long-run and short-run interactions of the variables. Fifth,
289 ARDL techniques give unbiased long-run results while using the dependent variable as
290 repressors. Moreover, the ARDL approach makes the model dynamic by using different lag
291 values.

292 The foundation of Pesaran (2001) is based on greater F statistic value than upper bound 1(0).
293 Error correction term reported by Banerjee et al. (1998) provides a good way to verify the
294 existence of a long-run relationship for variables under investigation. The ECM term must be
295 significant and with a negative coefficient value for the validation of the long-run relationship.
296 Finally, the ARDL techniques employ stability tests for the short-run and long-run relationships
297 of the variables by the two criteria. These stability tests criteria's are Cumulative Sum of values

298 (CUSUM) and Cumulative Sum of Square values specified by Brown et al. (1975). Further,
 299 ARDL method extended by Shin et al (2014) to check the asymmetric association of variables.

300 **3.2 Model Specification**

301 The present study examined the relationship between CO₂ emissions, total energy consumption
 302 from the manufacturing sector, FDI, globalization, and financial development in the case of
 303 Pakistan. The model is specified below.

$$304 \quad CO_2 = f(ENR, FDI, FD, GLOB) \quad (1)$$

305 Where CO₂ is the carbon emissions from the manufacturing sector, ENR is the energy
 306 consumption from the manufacturing sector, FDI is the foreign direct investment net inflows, FD
 307 is the proxy of financial development which is taken in terms of domestic credit to the private
 308 sector, and GLOB is the globalization index. CO₂ emissions have a strong link with energy
 309 consumption, financial development, globalization, and FDI Le & Ozturk, (2020) and Rasool et
 310 al. (2019). The manufacturing sector's carbon emissions and energy consumption are increasing
 311 at a fast rate Gao et al. (2017) and Yang et al. (2020). The manufacturing sector mainly relies on
 312 the oil sector for energy consumption. Globalization is used as the control variable in the study to
 313 examine the international level growth in the FDI from developed countries.

$$314 \quad CO_{2t} = \beta_1 + \beta_2 ENR_t + \beta_3 FDI_t + \beta_4 FD_t + \beta_5 GLOB_t + \mu_t \quad (2)$$

315
 316 The coefficients $\beta_2, \beta_3, \beta_4,$ and β_5 are the elasticities of CO₂ emission concerning energy
 317 consumption, foreign direct investment, financial development, and globalization. The study
 318 implemented ARDL and NARDL (for asymmetric behaviour) approaches to estimate our results.
 319 This is unique methodology gives results for different lag values, works for the small size of
 320 data, convenient to use, and provides good results of estimations (Pesaran, 2001; Faheem and
 321 Chin, 2021). To estimate the above model, we apply the ARDL bounds approach by using the
 following specified model:

$$322 \quad \Delta CO_{2t} = \alpha_0 + \sum_{i=1}^l a_i \Delta CO_{2t-i} + \sum_{i=0}^p \alpha_{2i} \Delta ENR_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta FDI_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FD_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta GLOB_{t-i} +$$

$$323 \quad + \beta_1 CO_{2t-1} + \beta_2 ENR_{t-1} + \beta_3 FDI_{t-1} + \beta_4 FD_{t-1} + \beta_5 GLOB_{t-1} + \mu_t \quad (3)$$

324 In the above-mentioned equation, Δ indicates the first difference estimate of the concerned
 325 variable and the determined drift parameter equations α_0 .

The unrestricted error correction model (ECM) estimated as follows:

$$326 \quad \Delta CO_{2t} = \alpha_0 + \sum_{i=1}^l a_i \Delta CO_{2t-i} + \sum_{i=0}^p \alpha_{2i} \Delta ENR_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta FDI_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FD_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta GLOB_{t-i}$$

$$327 \quad + \lambda ECT - 1 + vt_t \quad (4)$$

328 In the above-mentioned equation, λ defines the speed of adjusting parameter and error correction
 329 term which describes the residual values from the estimation model. Further, the non-linear
 model is estimated that shows asymmetric behaviour of energy consumption conforming to the

330 non-linear autoregressive distributed lag technique where energy consumption is decomposed
 331 into positive and negative sections.

$$CO_{2t} = \beta_1 + \beta_2^+ ENR_t^+ + \beta_2^- ENR_t^- + \beta_3 X_t + \mu_t \quad (6)$$

334 Based on the non-linear model Equation (6), β_2^+ shows energy consumption impact on
 335 CO₂ emission in long run equation (7), which is expected to be positive. And β_2^- in equation (8)
 336 indicates the reducing impact between energy consumption and CO₂ emission.

$$\beta_2^+ ENR_t^+ = \sum_{j=1}^t \Delta ENR_j^+ = \sum_{j=1}^t \max(\Delta ENR_j, 0) \quad (7)$$

$$\beta_2^- ENR_t^- = \sum_{j=1}^t \Delta ENR_j^- = \sum_{j=1}^t \max(\Delta ENR_j, 0) \quad (8)$$

339 The main objective is to examine whether energy consumption symmetrically or asymmetrically
 340 impacts CO₂ emissions. Shin et al. (2014) introduced NARDL setting with the extension of ARDL
 341 as:

$$\Delta CO_{2t} = \alpha_0 + \sum_{i=1}^l a_i \Delta CO_{2t-i} + \sum_{i=0}^{p1} \alpha^+_{2i} \Delta ENR^+_{t-i} + \sum_{i=0}^{p2} \alpha^-_{2i} \Delta ENR^-_{t-i} + \sum_{i=0}^q \alpha_{3i} \Delta FDI_{t-i} + \sum_{i=0}^r \alpha_{4i} \Delta FD_{t-i} + \sum_{i=0}^s \alpha_{5i} \Delta GLOB_{t-i} + \beta_1 CO_{2t-1} + \beta_2^+ ENR_{t-1}^+ + \beta_2^- ENR_{t-1}^- + \beta_3 FDI_{t-1} + \beta_4 FD_{t-1} + \beta_5 GLOB_{t-1} + \mu_t \quad (9)$$

343 Equation (9) captures the positive and negative shocks of energy consumption on the CO₂
 344 emissions for the manufacturing sector of Pakistan. The long-run and short-run asymmetry is
 345 measured by β_2^+ and β_2^- , α_2^+ and α_2^- respectively by taking the following hypotheses:

$$346 H_0: \beta_2^+ = \beta_2^- = 0$$

$$347 H_0: \sum_{i=0}^{p1} \alpha^+_{2i} = \sum_{i=0}^{p2} \alpha^-_{2i}$$

348 For all values $i=0, \dots, p$.

349 4. Results and Discussion

351 4.1 Descriptive Statistics and Correlation matrix

352 Descriptive statistics and correlation of the variables are discussed in table 2. Descriptive
 353 statistics include mean, median, maximum, minimum, skewness, standard deviation, and
 354 probability values. The highest value of mean is for energy consumption and the lowest value is
 355 for foreign direct investment. Conforming to the Jarque-Bera statistics all the values are normally
 356 distributed. The values for carbon emissions, energy consumption, financial development, and
 357 globalization index are negatively skewed on the other hand FDI is positively skewed. It is seen
 358 from the summary of correlations that CO₂ emissions are negatively correlated with energy
 359 consumption. Financial development has a positive correlation with CO₂ emissions while
 360 negatively correlated with energy consumption. The foreign direct investment shows a positive
 361 correlation with CO₂ emissions, energy consumption, and financial development. Globalization

362 index examined positive correlation with energy consumption and FDI, while negatively
 363 correlated with CO₂ emissions and financial development.

Table 2 Descriptive statistics:

	<i>CO2</i>	<i>ENR</i>	<i>FD</i>	<i>FDI</i>	<i>GLOB</i>
<i>Mean</i>	3.2690	9.5533	3.0963	-0.0609	3.8825
<i>Median</i>	3.3248	9.6639	3.1619	-0.2062	3.8964
<i>Maximum</i>	3.4745	10.090	3.3581	1.2997	4.0095
<i>Minimum</i>	2.9188	8.9789	2.7334	-0.9601	3.6479
<i>Std. Dev.</i>	0.1461	0.3267	0.1936	0.5761	0.1199
<i>Skewness</i>	-0.6554	-0.1695	-0.5557	0.8698	-0.5211
<i>Kurtosis</i>	2.6386	1.7061	2.1296	3.2241	1.8630
<i>Jarque-Bera</i>	2.2343	2.1619	2.4083	3.7179	2.8747
<i>Probability</i>	0.3272	0.3392	0.2999	0.1558	0.2375
<i>Sum</i>	94.8017	277.0463	89.7949	-1.7663	112.5927
<i>Sum Sq. Dev.</i>	0.5982	2.9902	1.0496	9.2951	0.4027
<i>Observations</i>	29	29	29	29	29
<i>CO2</i>	1				
<i>ENR</i>	-0.251	1			
<i>FD</i>	0.656	-0.411	1		
<i>FDI</i>	0.433	0.310	0.562	1	
<i>GI</i>	-0.194	0.953	-0.415	0.278	1

364
 365 **4.2 Unit Root Test**
 366 ARDL approach works if the variables are stationary at the level and first difference. However,
 367 the study of Ouattara (2004) examined that ARDL does not accept the stationary values of the
 368 variables at the second difference I(2). Due to this reason, all the variables of the study are
 369 checked by the unit root test that none of the variables is stationary at I(2) difference. For the
 370 sake of unit root test two tests are implemented that are Augmented Dickey-Fuller test (ADF),
 371 and the Phillips-Peron test (PP). All the variables of the study found stationary at first difference.
 372 Details of the unit root test are mentioned in Table 4.

Table 4 Unit root tests:

<i>Variables</i>	<i>Level</i>		<i>First difference</i>	
	<i>ADF</i>	<i>PP</i>	<i>ADF</i>	<i>PP</i>
<i>Log CO₂</i>	2.957110	-2.954021	-2.957110*	-2.957110*
<i>Log FDI</i>	-2.963972	-2.954021	-2.957110*	-3.653730**
<i>Log FD</i>	-2.957110	-2.954021	-2.957110*	-3.653730**
<i>Log ENR</i>	-2.981038	-2.981038	-3.724070**	-2.986225*
<i>Log GLOB</i>	-2.105256	-2.195449	-3.653730**	-2.957110*

373 Note: *and ** for 5% and 1 % respectively.

374
 375 **4.3 ARDL Bound Test Results**
 376 Incorporating the results from F-statistic and bound test values from table 5, it is clear that there
 377 is a long-run relationship among the variables of the present study for equation (2). F-statistic

378 values in table 5 are above than the upper critical values of Narayan (2005) table at constant
 379 values and significant. Another way of examining the long-run relationship of the variables is
 380 through the error correction term. It is commended that if the error correction term gives a
 381 significant statistic value with a negative sign Pesaran, (2001) validates the existence of a long-
 382 run association of variables.

Table 5: Bounds test estimates: (ARDL)

<i>F</i> -bounds test statistic		<i>Null hypotheses: No level relationships</i>		
		<i>Significance</i>	<i>I(0) Bound</i>	<i>I(1) Bound</i>
<i>F</i> -statistic	14.938**	10%	2.45	3.52
<i>k</i>	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06

383 Note: *, **, ****, and ***** for 10%, 5%, 2.5% and 1 % respectively.

384 **4.4 Linear ARDL Estimation Results**

385 Long-run and short-run dynamics are examined in Table 6. The ARDL results for the
 386 relationship of CO₂ emissions is significant and positive with total energy consumption for both
 387 the long and short-run in the scenario of the manufacturing sector of Pakistan, thus suggests that
 388 an increase in energy consumption degrades the environment badly in the short and long-run.
 389 Our results are in line with the previous work of Munir Ahmad and Zhao (2018) in China, Pata
 390 (2018) for Turkey, Shahbaz.G, et al. (2019) for the United States of America, (A. Ahmad et al.,
 391 2016) for India, Lin and Raza, (2019) and Mirza and Kanwal (2017) for Pakistan. Previously,
 392 Pakistan's economy was based on agriculture which is gradually shifted toward an industrial
 393 economy. The development of the manufacturing sector in Pakistan produces environmental
 394 degradation. Pakistan is still based on conventional sources (80%) for energy production like
 395 Coal, Natural Gas, and Oil, which badly pollutes the environment. As the global economies are
 396 focusing on renewable energy production mechanisms, the government of Pakistan should need
 397 to invest in renewable energy resources to mitigate the climate-changing effects.

398 In the case of financial development there exists a positive significant relationship with CO₂
 399 emissions in both the and long and short-term. Our results support the previous researches
 400 conducted by Abbasi and Riaz (2016) in the case of Pakistan, Manzoor Ahmad et al. (2019) for
 401 China, Le and Ozturk (2020) for Emerging markets and developing countries EMDCs, Pata
 402 (2018) for Turkey, and Ahmad.N and Du (2017) for Iran. The results indicate that the increase of
 403 financial development in Pakistan would enhance the CO₂ emissions in the short and long-run.
 404 Financial development improves the purchasing power of the communities. Financial
 405 development provides modern ways of investments in various projects and industrialization
 406 development. Pakistan is a country that is based on old technologies in the transportation, energy
 407 production, and industrialization sector which deteriorate environmental sustainability.

408 For FDI and CO₂ emissions our results showed a significant negative relationship in the long-run
 409 and a significant positive relationship in short term. The findings revealed that 1% increase in

410 FDI inflows decreases CO₂ emissions by 0.626%. Our results are the same as Acheampong et al.
 411 (2019) for Sub-Saharan African countries, Zubair et al. (2020) for Nigeria, and Zakaria & Bibi
 412 (2019) for South Asia. Also, the long-term positive results validate the existence of the pollution
 413 halo hypothesis in Pakistan. The short-run findings indicate a significant positive association
 414 between FDI and CO₂ emissions. In short-run FDI imparts bad impacts on the environment but
 415 in the long-run with the continuous inflow of FDI will improve the financial development which
 416 ultimately provides better conditions for improvements in production technologies of Pakistan.
 417 Comparative findings demonstrated that FDI inflow will improve sustainable technologies and
 418 reduce CO₂ emissions. The long-run result of FDI suggests that Pakistan is moving towards good
 419 policies for environmental sustainability. Additionally, the present study validates the pollution
 420 halo hypothesis for Pakistan. On the other hand, some authors find a positive relationship
 421 between FDI and CO₂ emissions (pollution haven) in the various regions of the world like Y.
 422 Zhang and Zhang (2018) for China, Shahbaz.B et al. (2019) for Middle-East and North African
 423 countries (MENA), and (Baloch & Suad, 2018; Malik et al., 2020) for Pakistan.

424 The results demonstrated that globalization has a significant negative relationship with CO₂
 425 emissions in both the short and long-run. Surprisingly our results are consistent with the studies
 426 i.e., Shahbaz, Kumar et al. (2019) for 87 countries of the world including high developed,
 427 medium developed, and low developed countries, You and Lv (2018) for 83 world
 428 countries, Shujah-ur-Rahman et al. (2019) for Central and European countries, Zaidi et al.
 429 (2019) for Asia Pacific countries, Mehmood (2020) showed the negative relationship of
 430 globalization and CO₂ emissions for Pakistan and India, Shahbaz, Jawad et al. (2017), and Umar
 431 et al. (2020) for China. The justification of the negative association of CO₂ emissions with
 432 globalization in Pakistan suggests that globalization reduces CO₂ emissions with technological
 433 advancements and expert manpower. Moreover, Pakistan is adopting modern ways of energy
 434 production, technological improvements, and economic corridors. CPEC project is one of the
 435 milestones for Pakistan that is a live example of globalization. Conforming to the CPEC project
 436 many energy productions, road infrastructure, and development projects are initiated in Pakistan.

437

Table 6: Long-run and Short-run dynamics estimates (ARDL)

Long-run estimates					
Variables	Coefficient	Std. Error	t-Statistic	Prob.	
ENR	3.037***	0.431	7.040	0.005	
FD	4.224***	0.353	11.942	0.001	
FDI	-0.626***	0.098	-6.385	0.007	
GLOB	-6.411***	0.879	-7.288	0.005	
CONSTANT	-13.737***	1.887	-7.277	0.005	
Short-run estimates					
Variables	Coefficient	Std. Error	t-Statistic	Prob.	
D(ENR)	1.116***	0.113	9.855	0.002	
D(ENR(-1))	0.017	0.182	0.095	0.929	
D(ENR(-2))	-0.610**	0.202	-3.020	0.056	

<i>D(ENR(-3))</i>	-0.293	0.140	-2.085	0.128
<i>D(FD)</i>	0.740***	0.112	6.593	0.007
<i>D(FD(-1))</i>	-1.418***	0.202	-7.013	0.006
<i>D(FD(-2))</i>	0.292**	0.084	3.449	0.040
<i>D(FD(-3))</i>	-1.443***	0.213	-6.772	0.006
<i>D(FDI)</i>	0.085**	0.029	2.916	0.061
<i>D(FDI(-1))</i>	0.133***	0.021	6.273	0.008
<i>D(FDI(-2))</i>	0.099**	0.028	3.499	0.039
<i>D(FDI(-3))</i>	0.116***	0.022	5.080	0.014
<i>D(GGLOB)</i>	-7.069***	1.330	-5.313	0.013
<i>D(GLOB(-1))</i>	6.956***	0.945	7.355	0.005
<i>D(GLOB(-2))</i>	-6.495***	1.060	-6.125	0.008
<i>D(GLOB(-3))</i>	-0.466	0.473	-0.985	0.397
<i>ECT</i>	-0.626***	0.112	-5.587	0.011

438 *Shows 10%, **Shows 5%, and ***Shows 1% significance level, respectively.

439

440

4.5 Diagnostic Tests Results

441 Diagnostic results are demonstrated Table 7 that shows the estimated model is free from issues
442 like heteroscedasticity, autocorrelation and model is structurally stable.

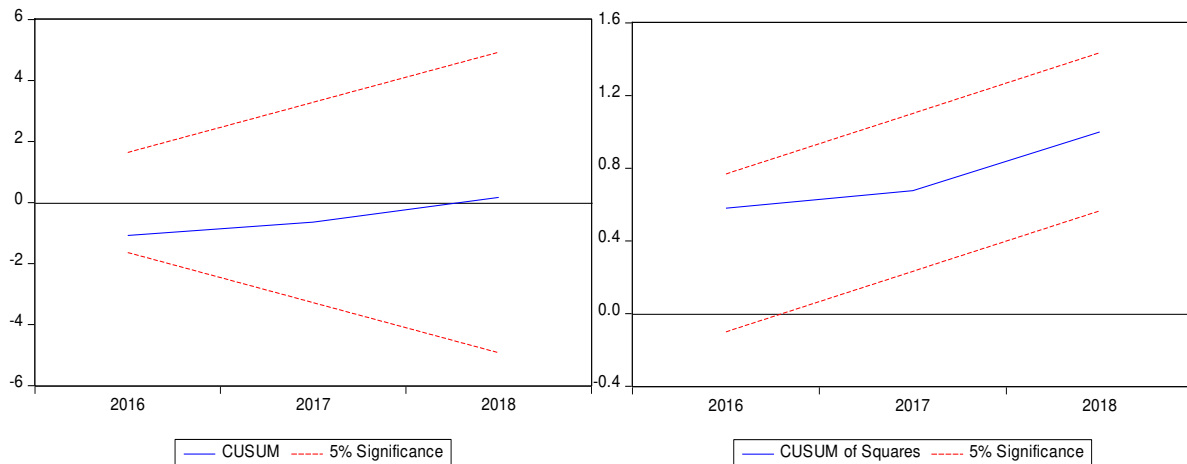
Table 7: Diagnostic Tests

<i>Diagnostic tests</i>	<i>Statistics</i>
<i>R²</i>	0.999
<i>Adj R²</i>	0.995
<i>D.W Stat</i>	2.588
<i>LM test</i>	14.46746 (0.182)
<i>J.B test</i>	0.230046 (0.891)
<i>Hetro test</i>	1.552552 (0.474)
<i>Ramsey reset test</i>	0.006827 (0.9417)

443 Note: P-value is in parenthesis ().

444

445 However, CUSUM and CUSUMQ indicated stability in our model showed in plots 6 and 7.



446

447

Plot # 6: CUSUM

Plot # 7: CUSUMQ

448 **4.5 Linear ARDL Estimation Results**

449 The non-linear ARDL bound test results are represented in Table 8 which shows the F-
 450 statistic value is significant at a 5% level and greater than the upper bound that is surety of
 451 long-run association.

452

<i>F-bounds test statistic</i>		<i>Null hypotheses: No level relationships</i>		
		<i>Significance</i>	<i>I(0) Bound</i>	<i>I(1) Bound</i>
<i>F-statistic</i>	11.0555**	10%	2.75	3.79
<i>k</i>	5	5%	3.12	4.25
		2.5%	3.49	4.67
		1%	3.93	5.23

453 Note: *, **, ****, and **** for 10%, 5%, 2.5% and 1 % ,respectively.

454 The non-linear ARDL results for the long and short-run are represented in Table 9. The long-run
 455 results declare a significant positive estimation for an increase in energy consumption and also
 456 positive for a decrease in energy consumption with insignificant value. The results of estimated
 457 elasticity for both increase and decrease suggest that 1% increase in CO₂ emissions makes
 458 (0.4146) percent energy consumption, while a decrease in value is insignificant. The results
 459 suggest that an increase in energy consumption produces more CO₂ emissions also;a decrease in
 460 energy consumption gives positive insignificant results. Pakistan needs to focus on the energy
 461 consumption sources which require moving from non-renewable energy resources towards
 462 renewable energy sources. Financial development shows negative insignificant results. FDI
 463 imparts a negative significant relationship with CO₂ emissions, 1% increase in FDI reduces 0.15
 464 percent of CO₂ emissions.The negative relationship of FDI shows the validation of the Pollution
 465 Halo hypothesis in the case of Pakistan. Our results for the pollution halo hypothesis are similar
 466 for Repkine and Min(2020) foreign enterprises in China, Zubair et al. (2020) for
 467 Nigeria,Vadlamannati et al. (2009) for BRICS countries, and Zakaria and Bibi, (2019) for South
 468 Asian countries. In contrast, some studies proved the pollution haven hypothesis in Pakistan
 469 (Kamran et al. 2019;Malik et al. 2020). The reason for validation of the Pollution Halo-
 470 hypothesis in Pakistan is that the country is much more focused on environmental sustainability,
 471 and adopting strict measures for improvements in technology. Globalization significantly
 472 increases CO₂ emissions in the case of Pakistan.

473
 474 On the other hand, short-run results for positive and negative energy consumption show that
 475 positive energy consumption significantly enhances CO₂ emissions, however, negative energy
 476 consumption has insignificant positive results. Financial development shows negative
 477 insignificant results, FDI shows positive significant results, and globalization gives significant
 478 positive results for Pakistan. In the next, it is determined that a significant error correction term
 479 with a negative coefficient validates the existence of the long-run relationship between variables

480 Pesaran (2001). The ECT obtained (-0.4434) gives negative and significant results for non-linear
 481 ARDL.

Table 9: Short and Long-Run dynamic estimates (NARDL)

Long Run Coefficients				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
ENR ⁺	1.4146***	0.2542	5.5638	0.0000
ENR ⁻	0.4104	0.7320	0.5606	0.5828
FD	-0.1316	0.1620	-0.8122	0.4285
FDI	-0.1572***	0.0443	-3.5434	0.0027
GLOB	4.6080***	0.6169	7.4688	0.0000
C	-12.6535***	2.2488	-5.6266	0.0000
TREND	-0.1326***	0.0130	-10.1646	0.0000
Short Run estimates				
<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-Statistic</i>	<i>Prob.</i>
D(ENR ⁺)	1.3642***	0.2019	6.7555	0.0000
D(ENR ⁻)	0.1820	0.2951	0.6168	0.5460
D(FD)	-0.0583	0.0712	-0.8197	0.4244
D(FDI)	-0.0349***	0.0148	-2.3543	0.0317
D(GLOB)	0.4758	0.5763	0.8254	0.4212
D(TREND())	-0.0588***	0.0167	-3.5097	0.0029
ECT	-0.4434***	0.1309	-3.3860	0.0038

482 *Shows 10%, **Shows 5% , and ***Shows 1% significance level, respectively.

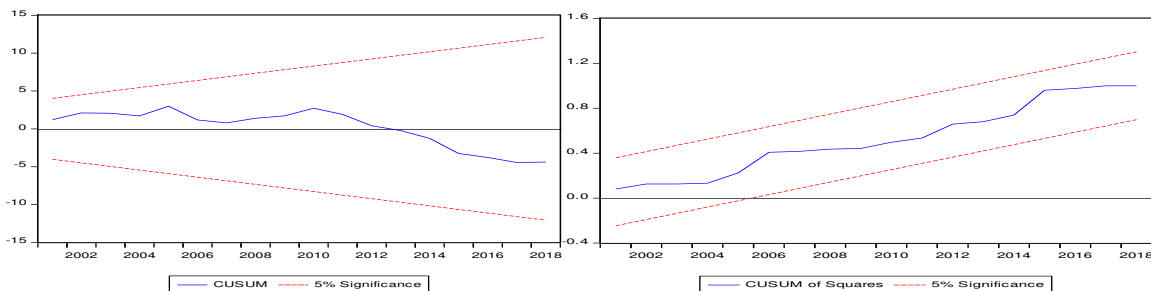
483
 484 Diagnostic test estimates are presented in Table 10 that shows model is clear from all problem.
 485 The model's stability is verified by CUSUM and CUSUMQ in Plot 8 and 9 respectively. Both the
 486 graphs are stable and remained in boundary lines.

Table 10: Diagnostic Tests (NARDL)

<i>Diagnostic tests</i>	<i>Statistics</i>
R ²	0.235
Adj R ²	-0.418.
LM test	2.1619 (0.152)
J.B test	0.0657 (0.967)
Hetro test	0.5036 (0.863)
Ramsey reset test	1.7323 (0.1037)

487 Note: P-value is in parenthesis ().

488



489

490

Plot # 8: CUSUM (NARDL)

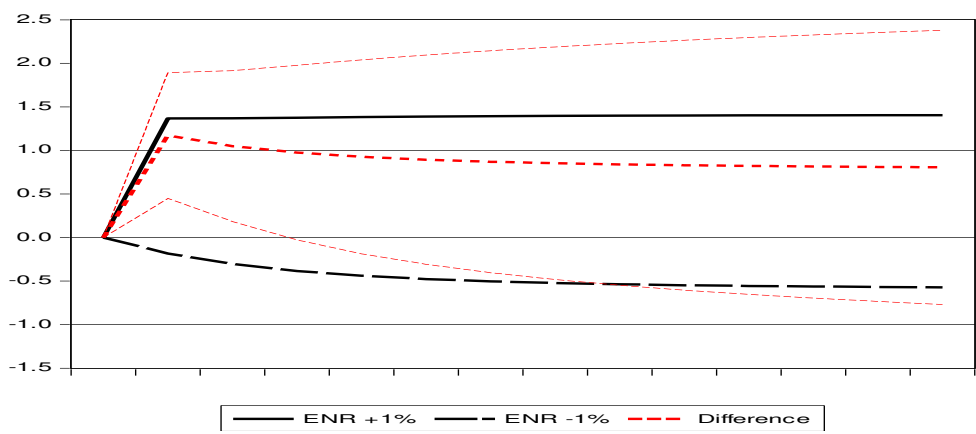
Plot # 9: CUSUMQ (NARDL)

491 Additionally, the results of the Wald test in Table 11 determine that long estimated null
 492 hypotheses of the symmetric are accepted, but short-run does not exists. Verifying the existence
 493 of long-run effects of energy consumption. Additionally, the dynamic cumulative multiplier
 494 graph is obtained for positive and negative shocks for energy consumption.
 495

Table 11: Non-Linear Wald test

Test	F-statistic	Probability	Decision
W_{LR}	6.7678	0.0167	Long-run asymmetry association exists
W_{SR}	1.0308	0.3215	Short-run asymmetry association does not exists

496 Note: W_{LR} donates the Wald test for long-run symmetry hypotheses testing, and W_{SR} represents
 497 the Wald testing results for short-run symmetry hypotheses evaluation.



Plot # 10: Cumulative effects of Energy Consumption on CO₂ Emissions.

498
 499
 500

5. Conclusion and Policy Implications:

502 Our study examined the symmetric and asymmetric effect of energy consumption with
 503 environmental degradation in the manufacturing sector of Pakistan with foreign direct
 504 investment, financial development, and globalization as control variables for the period 1985 to
 505 2018. The paper made a unique attempt to focus on the manufacturing sector of Pakistan apart
 506 from past work which is done on the various other sectors like transport, energy consumption,
 507 and financial development (Abbasi and Riaz, 2016; R. Ali et al., 2019a; Bin Zhang and Wang,
 508 2017; Baloch and Suad, 2018; Rasool et al., 2019; Anser, 2019; Yousaf and Lin, 2020; Komal and
 509 Abbas, 2015; Lin and Raza, 2019; Shahzad et al., 2017; Mirza and Kanwal, 2017). The ARDL
 510 results of the study shows that energy consumption significantly shows positive relationship with
 511 CO₂ emissions both in long and short-run. In terms of energy consumption, Pakistan needs to
 512 move towards updated energy sources i.e. renewable energy sources like solar energy on large
 513 scale with cheap costs. In case of FDI, CO₂ emissions showed a significant negative relationship
 514 for FDI inflows in long run and show significant positive results in the short-run. The results for
 515 the validation of the pollution halo hypothesis for FDI suggest that Pakistan is taking good
 516 initiatives for environmental sustainability. Moreover, Pakistan's vision (2018) focused on the
 517 modern ways of energy production, mitigation of climate change, and self-sufficient in energy

518 requirements. The government of Pakistan has initiated many environmental sustainability
519 activities. First, it launched an Eco-system restoration initiative for moving Pakistan to green
520 environment and adopting climate friendly strategies. Second, “Clean Green Cities Index” is
521 operated in the 20 big cities where no use of plastic bag is strictly followed. Due to this project
522 burning of plastic bags is strictly reduced to a great extent. Third, it established a National
523 Committee on Establishment of Carbon Market (NCECM). Fourthly, under a big environmental
524 friendly project launched in 2017 “Green Pakistan” by which 100 million trees are to be planted
525 till the year 2021 Economic Survey of Pakistan (2019). Financial development determines
526 significant positive association with carbon emissions both in long and short-term. Pakistan
527 requires to working on the technological improvements with the financial development. In terms
528 of globalization, it gives a significant negative relationship with CO₂ emissions both in the short
529 and long-term. This implies that globalization improves Pakistan’s environmental conditions. As
530 Pakistan is a developing country, so it needs to focus on globalization to become a developed
531 nation.

532 The asymmetric results of the study focused on the positive and negative shocks of energy
533 consumptions in the manufacturing sector of Pakistan with CO₂ emissions. Our results indicate
534 that in the long-run increase in energy consumption significantly enhances carbon emissions
535 while in the short-run decrease in energy consumption insignificantly increases CO₂ emissions in
536 the manufacturing sector of Pakistan. The study results are in line with R. Ali et al. (2019b) for
537 Pakistan, Le and Ozturk (2020) for Emerging markets and developing countries (EMDCs), and
538 Munir Ahmad and Zhao(2018) for China. Financial development gives insignificant negative
539 results with carbon emissions both in the short and long-run. In the case of FDI asymmetric
540 results are in line with symmetric that FDI mitigates environmental sustainability significantly
541 both in the short and long-term. The results for FDI are consistent with the study of Zubair et al.
542 (2020) for Nigeria, and Zakaria and Bibi (2019) for South Asian countries. Conversely, for
543 globalization, asymmetric results indicate globalization shows a significant positive relationship
544 with CO₂ emissions in the long-term, while in the short-run globalization gives positive
545 insignificant results.

546 Pakistan should provide subsidies at the government level for renewable energy installation
547 projects to reduce the energy crisis and sustainable energy productions for the manufacturing
548 sector. The government should make standards for the manufacturing sector technological
549 improvements and environmentally friendly production processes. Transformation towards
550 renewable energy sources will improve the efficiency of the manufacturing sector with low-cost
551 products. The policymakers should focus on the financial development structures to strengthen
552 renewable energy productions. The government of Pakistan and bureaucrats should involve
553 technical professionals for initiating modern technologies for the production sector. The proper
554 utilization of financial resources will make Pakistan's Asian Tiger in the Asian region of the
555 world. The policymakers in Pakistan should reserve some specific budget for the technological
556 advancements in the manufacturing sector of Pakistan to get rid of the energy crisis and

557 environmental sustainability. Right now, Pakistan formulated good strategies for the utilization
558 of FDI inflows which make Pakistan a pollution halo country. Still, Pakistan needs to work to
559 enhance the FDI inflows by creating friendly relationships with neighboring countries. Most of
560 the developed countries of the world make environmental improvements through high inflows of
561 investments. Pakistan launched an exemplary economic corridor project with China known as
562 the CPEC project. China Pakistan's economic corridor is a big example of globalization. The
563 policymakers in Pakistan need to get maximum benefits for the development in the
564 manufacturing sector and renewable energy mix productions through this project.

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571

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573 The authors declare that there is no financial interest and competition among each other that
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576 It is stated that the manuscript is only submitted in ESPR. The submitted manuscript is original
577 and not forwarded any where for proof reads or other. ESPR is authorized to verify plagiarism of
578 the manuscript.

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580 All the authors are agreed to submit the manuscript with affiliations of institutes mentioned in the
581 manuscript, also agreed to submit in ESPR.

582 **Consent to Participate:**

583 All the authors have personel consent to perform the completion of manuscript. No any authors
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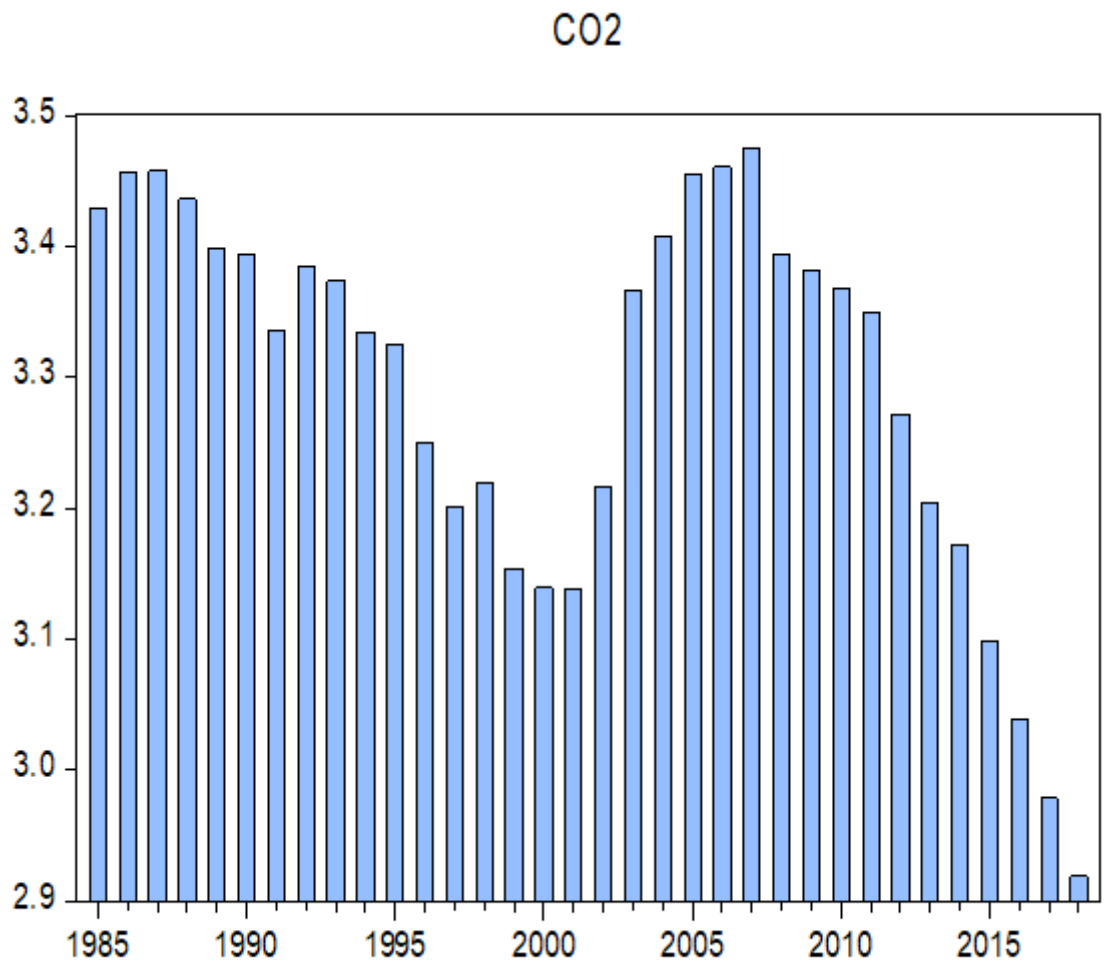
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Figures

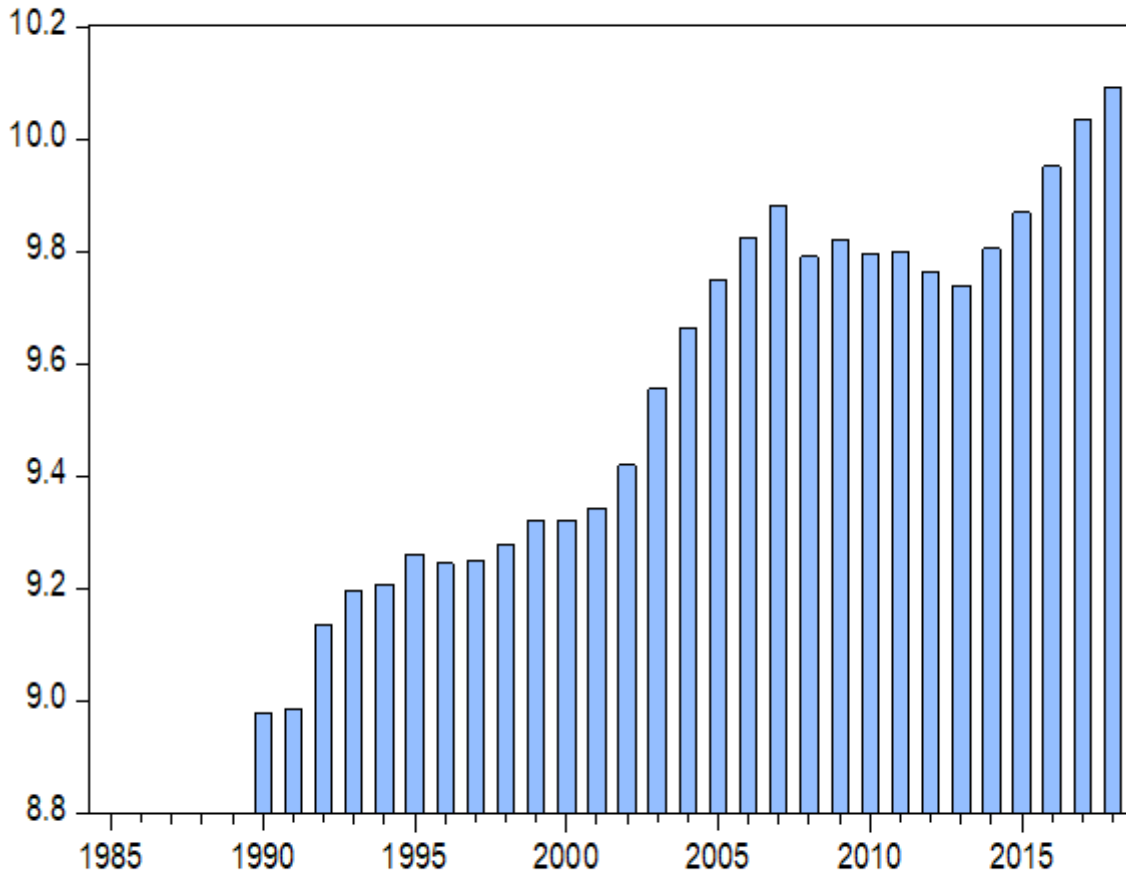


Plot # 1: CO₂ Emissions

Figure 1

Plot # 1: CO2 Emissions

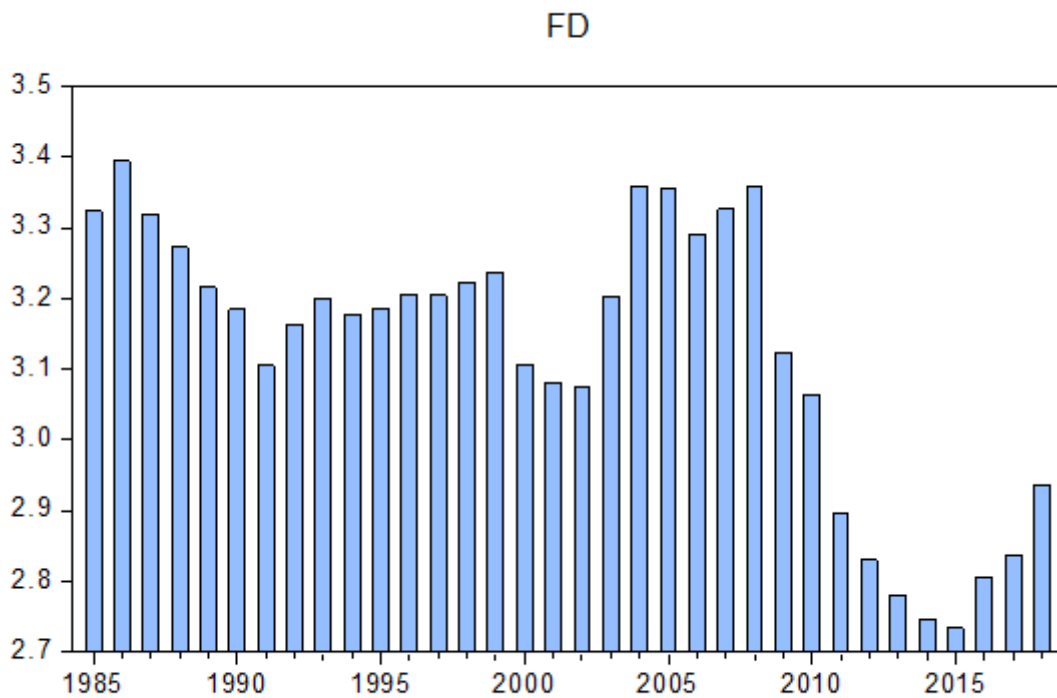
ENR



Plot # 2: Energy Consumption

Figure 2

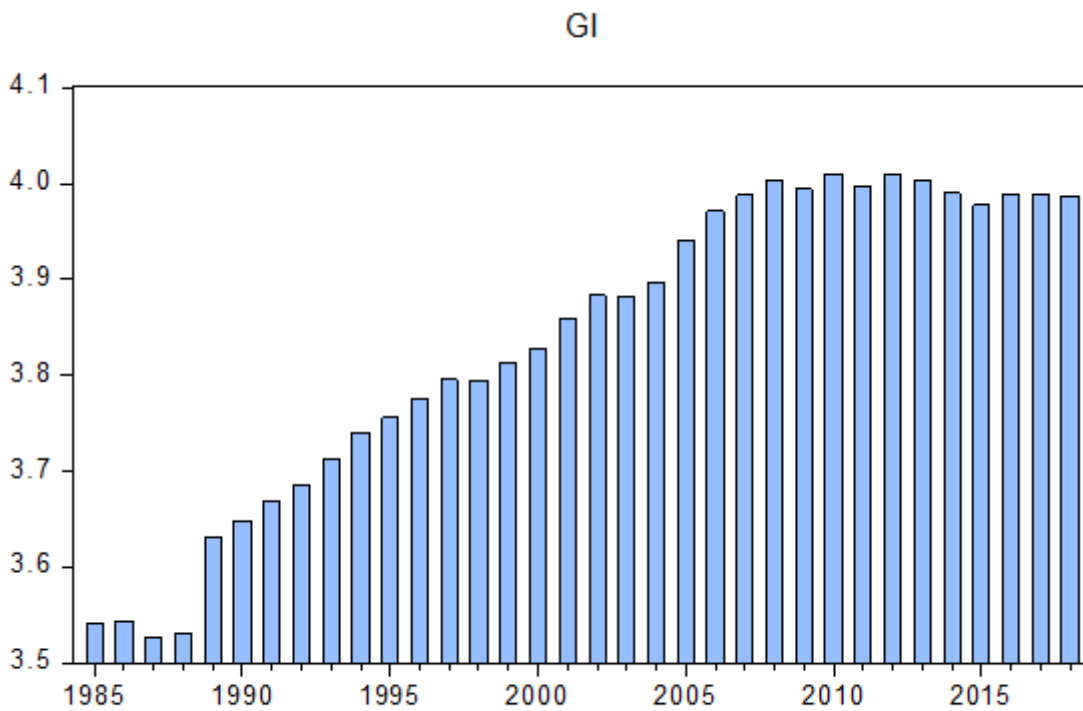
Plot # 2: Energy Consumption



Plot # 3: Financial Development

Figure 3

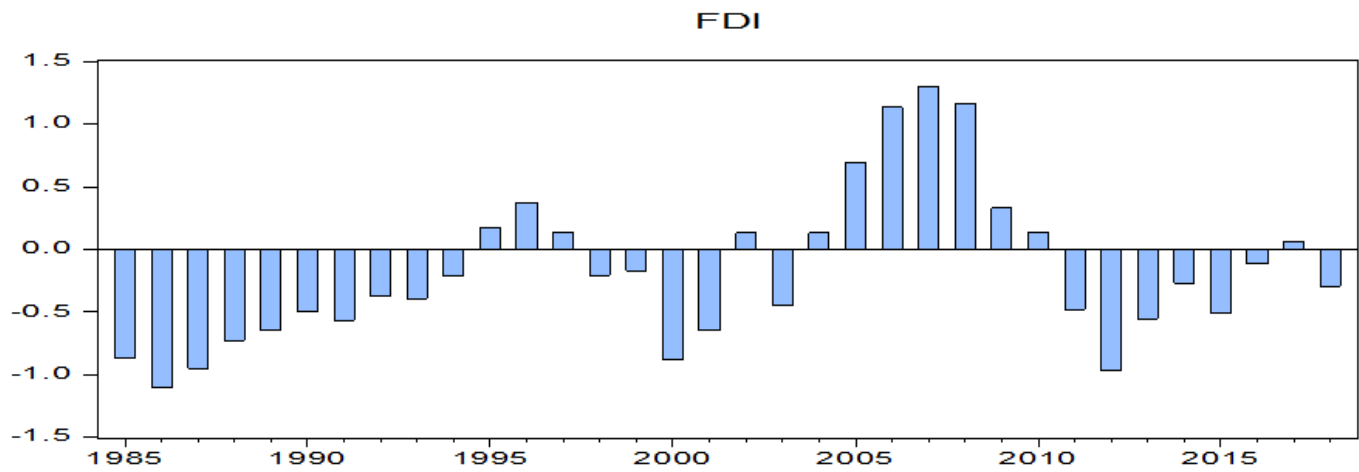
Plot # 3: Financial Development



Plot # 4: Globalization

Figure 4

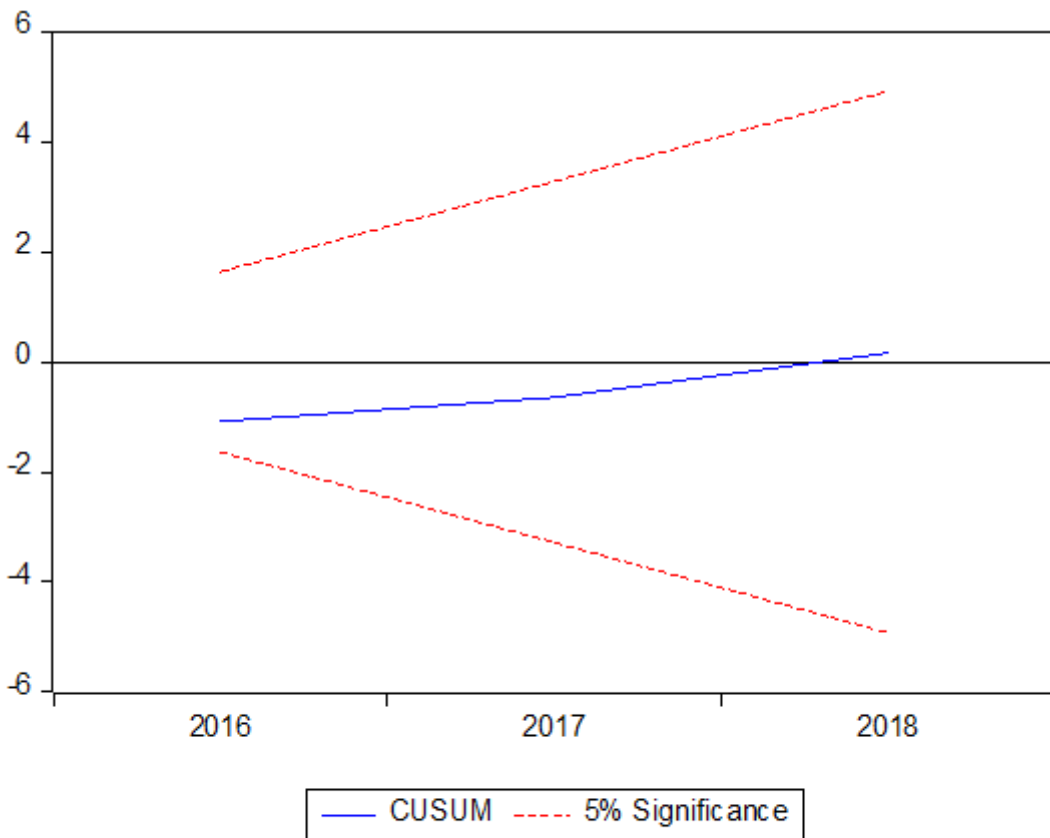
Plot # 4: Globalization



Plot # 5: Foreign Direct Investment

Figure 5

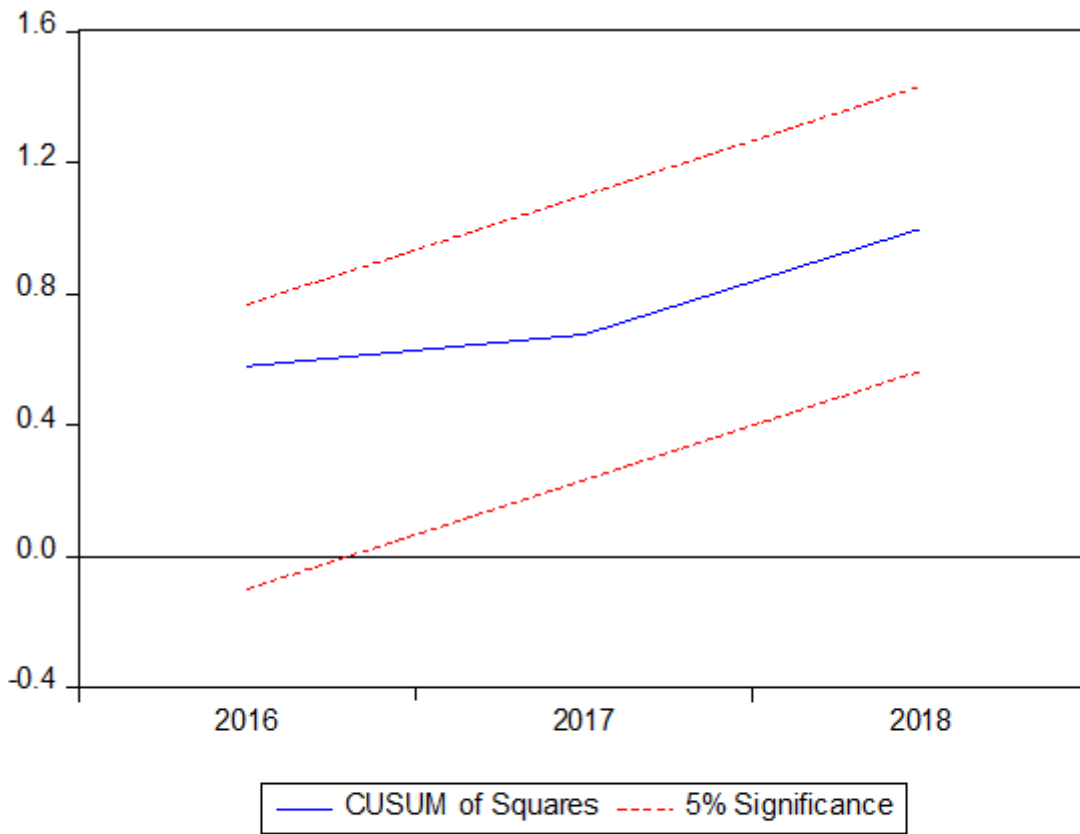
Plot # 5: Foreign Direct Investment



Plot # 6: CUSUM

Figure 6

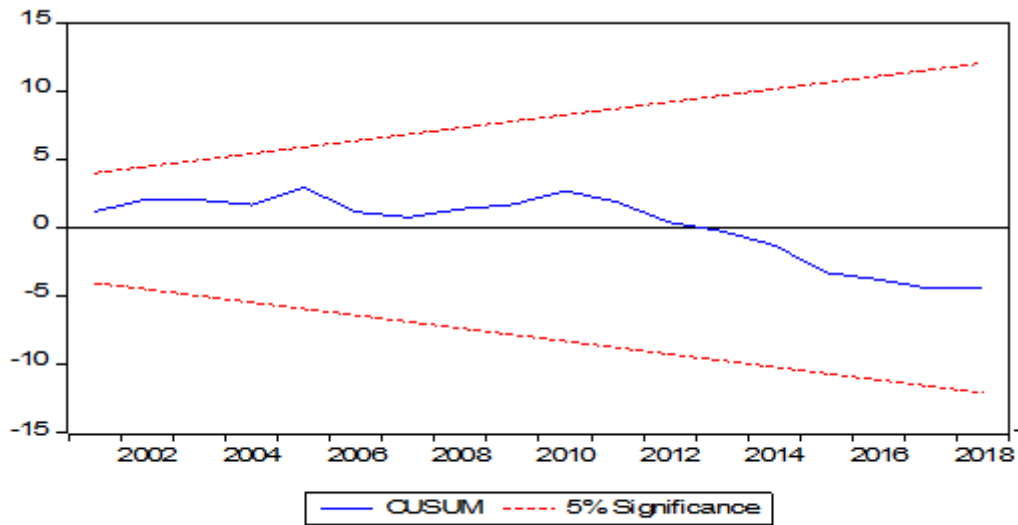
Plot # 6: CUSUM



Plot # 7: CUSUMQ

Figure 7

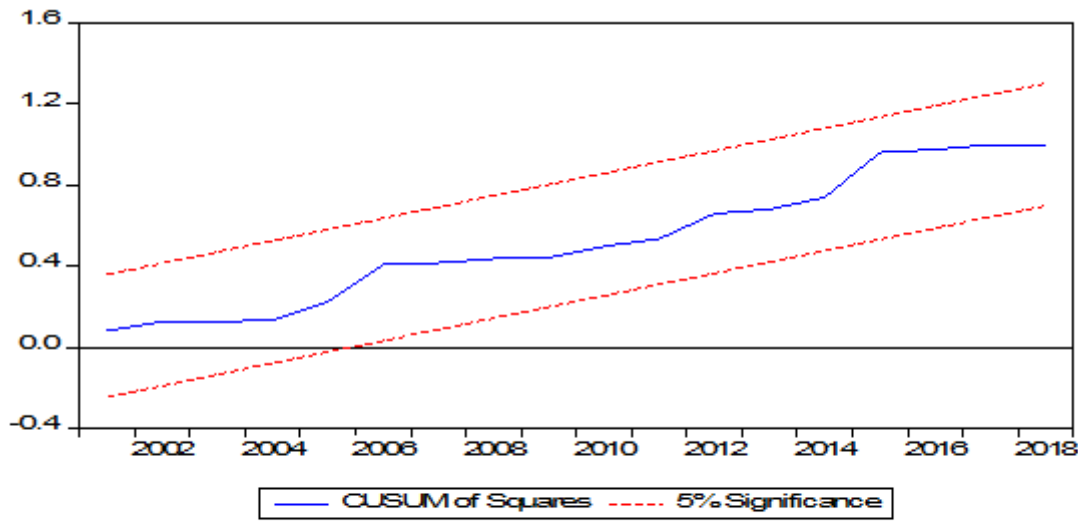
Plot # 7: CUSUMQ



Plot # 8: CUSUM (NARDL)

Figure 8

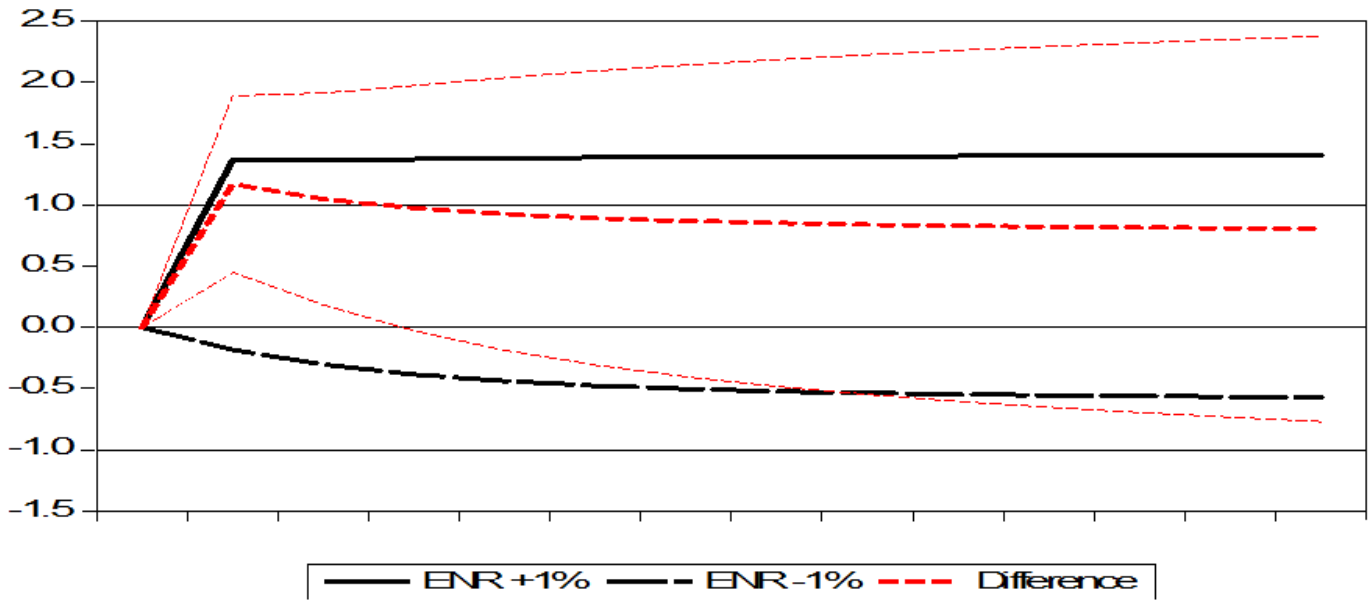
Plot # 8: CUSUM (NARDL)



Plot # 9: CUSUMQ (NARDL)

Figure 9

Plot # 9: CUSUMQ (NARDL)



Plot # 10: Cumulative effects of Energy Consumption on CO₂ Emissions.

Figure 10

Plot # 10: Cumulative effects of Energy Consumption on CO₂ Emissions.