https://doi.org/10.52131/jee.2023.0401.0033

*i*RASD Journal of Energy & Environment

Volume 4, Number 1, 2023, Pages 30 - 41

Journal Homepage:
https://journals.internationalrasd.org/index.php/jee

Impact of Electricity Power Consumption, GDP, Trade, Urban Population, Foreign Direct Investment and Renewable Energy Consumption on CO2 Emissions: Evidence from Pakistan

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ARTICLE INFO

Article History:

Received: February 27, 2023
Revised: April 29, 2023
Accepted: April 30, 2023
Available Online: June 30, 2023

Keywords:

CO2 emissions
Greenhouse gases
Trade
Foreign direct investment
Renewable energy consumption
Electricity power consumption
Economic growth

JEL Classification Codes:

F43, Q41, Q42, P33, R11

Funding:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Over the last few decades, the contribution of CO2 emissions to the environment has shown an increasing trend. The greenhouse gases increase the temperature of the environment globally and particularly in Pakistan. History is witness that the activities of humans mostly affect the environment. The goal of this study is to explore the link between variables such as Trade, FDI (Foreign Direct Investment), REC (Renewable Energy Consumption), EPC (Electricity Power Consumption), Economic Growth, Urban Population, and Carbon Emissions inside Pakistan over the time period of 1990 to 2022. The Auto Regressive Distributed Lag (ARDL) technique is utilized for estimation. The result shows that the long-run relationship exists between these variables. The REC, Economic Growth, and FDI significantly affect CO2 emissions, while the remaining variables have insignificant effects on carbon emissions. Moreover, based on the findings of this study recommends that the government adopt strict policies and strategies to overcome climate problems and control pollution.

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Citation: Tahir, Z. (2023). Impact of Electricity Power Consumption, GDP, Trade, Urban Population, Foreign Direct Investment and Renewable Energy Consumption on CO2 Emissions: Evidence from Pakistan. *IRASD Journal of Energy & Environment*, *4*(1), 30–41.
https://doi.org/10.52131/jee.2023.0401.0033

1. Introduction

CO2 emissions are affected by many variables, like GDP, Trade, FDI, electricity power consumption, and many more. There is a rapid increase in the expansion of natural resources such as fossil fuels. This expansion can cause serious concerns, climate change, an increase in CO2 emission, and impact on growth (economic). Most countries are adopting policies based on sustainable development goals to control the CO2 emission in an atmosphere that causes many health issues. In Pakistan EPA (Environmental Protection Agency) has the authority to control greenhouse gas emissions in the environment, established on Dec 31, 1983, under the Pakistan environmental protection ordinance. It controls the health of people and the environment by enforcing and writing regulations in parliament's power of law. The fifth assessment report of the Intergovernmental Panel on climate change (IPCC) stated that human activities are the main reason for climate change, especially fossil fuel burning. Developing countries are the primary source of high CO2

emissions in the atmosphere, and they are more in red code because they cannot bear the damage and disaster costs. For the development purpose high intake of energy consumption is required that causes CO2 emission, such as increased production; the energy consumption also raises and causes CO2 emission. The rising rate of the population also influences CO2 emissions. In many ways, it significantly impacts carbon emissions, while in some ways, it has insignificant impacts.

In Pakistan, energy use and production affect carbon emissions (Rehman et al., 2021). Although Pakistan has less contributed toward global CO2 emissions, that is 0.9 percent and 158th country in the ranking of making carbon emissions. According to the World Development Indicator (WDI) report, almost 6% of GDP goes to annual environmental degradation costs of almost 365 billion RS. Moreover, Pakistan is the 12th country in the world to face many consequences of climate change (Khan, Ghauri, Jilani, & Rahman, 2011; Shafiq, Gillani, & Shafiq, 2021). In addition, the GDP, trade, urban population, and foreign direct investment are the factors that contribute to Green House Gasses emissions and impact the climate. Previous literature was established to elaborate on the relation between these factors. Various questions rise from this literature discussion: How GDP growth effect CO2 emissions? Is there an Environmental Kuznets curve exists?

This study elaborates on the effects of dependent variables like GDP, Trade, FDI, Urban Population, Electricity Power and Renewable energy consumption on CO2 emission in Pakistan. More specifically, there are more objectives: 1) Explore the CO2 emission trend in Pakistan. 2) Examine the Environmental Kuznets Curve (EKC) hypothesis using the ARDL bounding testing approach for Pakistan by taking data over the time period from 1990-2022. 3) Examine the effect of Urban Population, Trade, Electricity, Power Renewable Energy consumption and FDI on carbon emission?

This paper acknowledges that using renewable energy resources to produce electricity, create a sustainable climate, and control CO2 emission in Pakistan is essential. In addition, many studies have been done to highlight the relationship between the CO2 emission and variables such as GDP, FDI, and Electricity power and Renewable energy consumption, and urbanization. We use the ADF unit root test, and an ARDL bounds testing approach to cointegration was utilized on variables to check their long-term and short-term causality dynamics. Moreover, at last, we recommended that the government of Pakistan make strict policies and infrastructure which control the carbon emission in the atmosphere and pollution. Pakistan is promoting the strategies by which the people should start moving toward a sustainable environment.

2. Literature Review

Muhammad, Long, Salman, and Dauda (2020) investigated the impact of international trade and urbanization on CO2 emission sixty-five countries of the Belt and Road Initiative (BRI). The result showed that the imports in developing (low-income) countries increase CO2 emission while decreasing it in middle-high income countries. Export decreases CO2 in low-high countries while increases in lower-middle countries. On the other side of Urbanization, Energy consumption and Population have a positive relationship with CO2, while Economic growth has a negative relationship with CO2. Mahmood, Alkhateeb, and Furqan (2020) explore the impact of Urbanization and Industrialization on CO2 emission per capita in Saudi Arabia. They use unit root tests, ARDL and Non-linear ARDL model to analyze the time-series data varies 1968-2014 in Saudi Arabia. The result showed that the high rate of urbanization and industrialization had a negative impact on the environment because of the exploitation of natural resources, and CO2 emission increased by this act.

Ali, Bakhsh, and Yasin (2019) evaluate the urbanization impact on CO2 emission in Pakistan. They use the ARDL bound testing approach and VECM model to analyze the time series data from 1972-2014 collected from Pakistan. The result showed that the continuous increase of urbanization determines Pakistan and energy consumption, and economic

growth also negatively affects it. Abbasi, Shahbaz, Jiao, and Tufail (2021) explored the relationship between some variables and CO2 emission with GDP. They use the ARDL method to analyze the time series data from 1972-2018. The result showed that urbanization and CO2 emission have short-rum impacts on economic growth. On the other hand, electricity significantly affects Economic growth, while Electricity prices have an insignificant effect on it, and at last, the industrial is positively connected to economic growth. Nazir, Gillani, and Shafiq (2023) found that environmental regulations reduced the emissions. Another study found that environmental regulation not only good for the environment but also have positive affect on health (Wang, Gillani, Nazir, & Razzaq, 2023).

Adams, Boateng, and Acheampong (2020) investigate the relationship between Urbanization, Transport Energy consumption, and CO2 emission in 19 African sub-Saharan countries. The result showed that transport energy consumption, electricity consumption, population growth rate, and urbanization positively relate to CO2 emission, while FDI and regulation quality negatively correlate with CO2 emission (Gillani & Sultana, 2020). W. Sun and Huang (2020) evaluate China's carbon emission efficiency. They used the stochastic frontier analysis technique to examine the panel data from 2000-2016 of 30 provinces of China. The result showed that the industrial structure negatively relates to carbon emission efficiency, while Economic Development, Urbanization, Foreign Trade, Energy Consumption structure, and Government intervention positively affect CO2 emission efficiency. Shafiq, ur Raheem, and Ahmed (2020) examined that the use of renewable energy reduces the CO2 emissions in ASEAN countries. Ridzuan, Marwan, Khalid, Ali, and Tseng (2020) explore the relationship between the emission of CO2 with the Economic growth, Renewable Energy, and Agricultural and Urbanization sub-sectors, including livestock, crops, and fisheries in Malaysia. They use the ARDL test to analyze time series data from 1908-2016. The result showed that the GDP per capita, agriculture, and GDP^2 have a positive relationship with CO2 emission, while Renewable energy, urbanization, livestock, crops, and fisheries have a negative relation with CO2 emission.

Rahman and Vu (2020) investigate a link between REC (Renewable Energy Consumption), Economic growth, Trade, Urbanization, and CO2 emissions. They used the ARDL and VECM Granger causality test to analyze time series data from 1960-2015 in Canada and Australia. The result showed that in Australia, economic growth is directly related to CO2 emission, while Trade and Renewable Energy have a negative relation with CO2 emission. Conversely, In Canada, CO2 emissions increase due to Economic growth, Trade and Urban population (Ahmad, Bhatti, Urooj, & Javed, 2022; Bhatti & Fazal, 2021). Adebayo, Awosusi, and Adeshola (2020) investigate the interlinkage between Energy usage, Trade, Urbanization, and Economic growth on CO2 emission using the ARDL PMG technique to analysis the panel data collecting from countries of MINT (Mexico, Indonesia, Nigeria and Turkey) varies from 1980-2018. The result showed the direct relation of Energy usage, Economic growth, and Urbanization with CO2 emission. On the other hand, it showed a negative relation between trade and CO2 emission. Similar findings are found by the other researchers (Hanif, Nawaz, Hussain, & Bhatti, 2022; Nawaz, Ahmad, Hussain, & Bhatti, 2020)

Odugbesan and Rjoub (2020) explore the relationship among Economic growth, Carbon emission, urbanization, and Energy consumption using ARDL bound test approach to analyze the data from 1993-2017 of MINT countries sourced by World Bank Development Indicators. The results showed a significant effect of GDP per capita, Energy consumption and Urbanization on Economic growth. While showing insignificant relation between economic growth with CO2 emission in MINT countries. Farooq, Gillani, Subhani, and Shafiq (2023) investigated that in case of BRICS economics economic policy uncertainty increases the CO2 emissions. M. K. Khan, Teng, Khan, and Khan (2019) explored the effect of Globalization, Economic factors and Energy consumption on CO2 emission by utilizing the ARDL simulations model. The result shows that Energy consumption, Trade, Financial Development, FDI, and Economic, Social and Political globalization positively relate to Carbon emission, while on the other hand, Urbanization, Economic growth and innovation has an indirect relationship with CO2 emission in Pakistan.

Rehman et al. (2021) took the China region to investigate the skewness impact of Urbanization, Energy utilization, Fossil Fuel energy and CO2 emission on its economic progress. After applying the unit root test, they verified that the stationarity of variables taking annual time series data varies from 1975 to 2017. The result showed a positive relation between energy utilization, urbanization, GDP per capita, and economic growth. While showing a negative relationship between CO2 emission and Fossil Fuel Energy consumption toward economic growth in Pakistan. Waheed, Chang, Sarwar, and Chen (2018) investigated the effect of Agriculture production, Forest and Renewable Energy consumption on carbon emission in Pakistan. They employed Elliot and Harackiewicz (1996) and Ng and Perron (2001) unit root tests to examine stationarity for each time series and the ARDL technique used to find the long-run and short-run relationship between variables. Furthermore, the result showed an indirect relation between Renewable Energy consumption and Forest with the CO2 emission and a negative relation between Agriculture consumption in Pakistan.

Rehman, Ma, Ozturk, and Radulescu (2022) investigated the link between Fossil Fuel energy, Electricity production from nuclear sources, Renewable energy, Carbon emission and Economic growth in Pakistan. The unit root tests, Phillips-Perron and augmented Dickey-Fuller, confirmed stationarity by applying time series data, and its range is from 1975 to 2019 in Pakistan. The result showed that fossil fuel energy, Renewable Energy consumption, CO2 emission, and GDP per capita positively affect Economic growth. On the other hand, electricity produced from nuclear sources, Electricity consumption, and Energy utilization have an insignificant impact on the economic growth of Pakistan. Saleem, Khan, and Shabbir (2020) explored the effect of GDP per capita, Renewable and Non-renewable energy sources, Trade openness, Financial Development, and Technological change on carbon emissions in ten Asian countries. Johansen Fisher and Kao cointegration, FMOLS and Dumitrescu-Hurlin test were applied to the panel data act for 1985-2015. Results showed that GDP, Non-renewable energy, and Trade openness positively link with CO2 emission. However, a negative relationship is formed between GDP^2, Financial Development, Renewable sources and Technological changes. This study confirmed the presence.

Anser et al. (2022) explored the relationship between Renewable energy resources and Environmental impact on economic growth in the middle of selected Asian economies that play a significant role in sustainable economic development. He collected panel data sets from eight selected Asian countries and data collected from 1990 to 2018. They use PVCEM for data estimation. It indicates that energy sources such as Biomass, Geothermal, and Wind power positively and significantly impact the environment (Fazal, Gillani, Amjad, & Haider, 2020). Qi et al. (2023) selected data from six Asian countries from 1997-2019 to evaluate the effect of R&D expenditure, Urbanization, Infrastructure Development, and Real income on carbon emission. They use FMOLS, DOLS, and DK estimators. FMOLS indicated that every variable has a significant and positive impact on carbon emission, DOLS showed a significant impact of all variables on CO2 emission, and the last DK estimator indicated a significant and positive impact of Urbanization, Real income, and Population density on CO2 emission. In contrast, R&D expenditures and infrastructure showed insignificant impact.

Y. Sun, Li, Andlib, and Genie (2022) selected the MENA region data from 1991-2019 and investigated the impact of renewable energy consumption on the environment or climate. They used the Bias-corrected method and illustrated that the long-term Environmental Kuznets curve hypothesis is present. They found that rapid urbanization and economic growth were the main cause of CO2 emission. Furthermore, according to an investigation, only moving toward renewable energy sources are the main authentic solution to reduce CO2 emission (Hussain, Nawaz, Ahmad, & Bhatti, 2021; Nawab, Bhatti, & Nawaz, 2021). Farooq, Subhani, Shafiq, and Gillani (2023) explored that the impact of taxes on environment by using data of 10 industry intensive countries. They found that environmental tax rate has a negative impact on environment while corporate statutory tax rate has a positive impact on environment. Shahbaz, Sbia, Hamdi, and Ozturk (2014) investigated the relationship between Economic growth, Urbanization, Electricity

consumption, and Environmental degradation in UAE. They applied an ARDL test to examine a long relationship between the variables. By this, they found a U-shaped relationship between Economics growth and carbon emission. Ultimately, they found that Electricity consumption and Export do not create excessive carbon emissions. Conversely, Economic growth and urbanization are the main sources of CO2 emission.

According to an investigation, only moving toward renewable energy sources is the main authentic solution to reduce CO2 emissions. We go through all the literature in which all these scholars differently relate carbon emissions with various variables such as trade, FDI, and GDP. However, the variables we relate with CO2 emission, none of them use in a way and showed that results and it create its place to fit those excellent work.

3. Data and Method

This chapter consists of data and methodology used to investigate the relationship between dependent variables such as FDI, Electricity power consumption, Trade, Urban population, GDP growth, and Renewable energy sources with Carbon emission in Pakistan. The data estimation shows how these variables are related to carbon emission and whether they have a significant or insignificant impact. Our study is based on time series data, and the data source is World Development Indicator; first will check the stationarity of all variables used in this estimation. And then decide which technique is suitable to run the regression equation. Augmented Dickey fuller unit root test is utilized to check whether the variables are integrated of degree 0 or 1. If all variables are not integrated in the same order, then we use ARDL technique to see the long-run and short-run relationship between variables, and if all variables are coherent in the same order, then the error correction model for all series will be used. On a single equation, ARDL is used, and it will analyze short-run and long-run relations among variables at once. ARDL method is convenient to use when the data sample size is small, said by Narayan (2004). By the joint of F-statistic, the bound test method is constructed, which means to test the long-run relationship between variables.

The functional form of function is:

$$CO_2 = f(ELPPC, FDI, GDPCONLCU, GDPCONLCUSQ, TR, UPOP, REC) \quad (1)$$

Where;

CO2	Carbon Dioxide emission
ELPPC	Electricity power consumption
FDI	Foreign direct investment (net inflow)
GDPCONLCU	Gross domestic product with constant local currency unit
GDPCONLCUSQ	Gross domestic product with constant local currency unit square
TR	Trade
UPOP	Urban Population
REC	Renewable Energy Consumption

The ARDL bound testing technique has two analysis steps, and we can check two things. In 1st step, we can check the long-run relation among variables in the equation. The ARDL eq. is

$$CO_2 = \alpha_1 + \sum_{g=1}^{\alpha_1} \alpha_{2g}\Delta CO_2 + \sum_{h=0}^{b_1} \alpha_{3h}\,\Delta\mathrm{LnELPPC}_{t-1} + \sum_{i=0}^{c_1} \alpha_{4i}\Delta\mathrm{LNFDI}_{t-1} + \sum_{j=0}^{d_1} \alpha_{5j}\Delta\mathrm{LnGDPCONLCU}_{t-1} + \sum_{k=0}^{e_1} \alpha_{6k}\Delta\mathrm{LnGDPCONLCUSQ}_{t-1} + \sum_{m=0}^{f_1} \alpha_{7m}\Delta\mathrm{LnTR}_{t-1} + \sum_{n=0}^{g_1} \alpha_{8n}\Delta\mathrm{LnUPOP}_{t-1} + \sum_{p=0}^{h_1} \alpha_{9p}\Delta\mathrm{LnREC}_{t-1} + \beta_1 CO_{t-1} + \beta_2 LnELPPC_{t-1} + \beta_3 LnFDI_{t-1} + \beta_4 LnGDPCONLCU_{t-1} + \beta_5 LnGDPCONLCUSQ_{t-1} + \beta_6 LnTR_{t-1} + \beta_7 LnUPOP_{t-1} + \beta_8 LnREC_{t-1} + \varepsilon_{1t} \quad (2)$$

Δ is a 1st difference and ε_{1t} is an error term model. This model will analyze the effect of EPC, FDI, GDP and GDP^2, Trade, Urban population and REC on CO2 emission.

This study uses the period from 1990 to 2022. Energy related data and all other data are available on The World Bank. Moreover, the data collected is from WDI. The variable

data are available there, but some year data is not available, so the average formula is used to get the values of that year.

4. Result and Discussion

In order to estimate the EKZ hypothesis in Pakistan from the time period of 1990 to 20022, first of all, we have to convert all series in a log to become the stationarity in values because the CO2 emission series, GDP constant local currency data series and its square data series, urban population series and Foreign direct investment net inflow data series are more extensive as compared to other dependent variables. Then we apply the ADF unit root test stationary or non-stationary variables. This will also evaluate which of the test will apply further ARDL or VAR technique.

Table 1
Descriptive Statistics

	LNCO2	LNELPPC	LNFDI	LNGDPCONLCU	LNGDPCONLCUSQ	LNTR	LNUPOP	LNREC
Mean	11.696	5.909	20.813	29.718	61.422	3.446	17.890	3.883
Median	11.794	5.982	20.919	29.737	61.522	3.476	17.924	3.870
Maximum	12.200	6.063	22.444	31.653	62.594	3.651	18.277	4.062
Minimum	10.986	5.556	19.318	27.475	60.131	3.207	17.379	3.740
Std. Dev.	0.361	0.139	0.882	1.2866	0.758	0.132	0.274	0.089
Skewness	-0.351	-0.768	-0.026	-0.129	-0.046	-0.192	-0.322	0.256
Kurtosis	2.022	2.537	2.041	1.747	1.724	1.773	1.865	2.149
Jarque-Bera	1.991	3.538	1.269	2.251	2.249	2.271	2.343	1.356
Probability	0.370	0.170	0.530	0.325	0.325	0.321	0.309	0.508
Sum	385.960	194.989	686.844	980.700	2026.919	113.713	590.376	128.138
Sum Sq. Dev.	4.166	0.619	24.869	52.973	18.405	0.560	2.406	0.252

The table provided shows descriptive statistics for various variables. LnCO2 represents the natural logarithm of CO2 emission, LN ELPPC LNFDI, LNGDPCONLCU, LNGDPCONLCUSQ, LNTR, LNUPOP, and LNREC represent Natural logarithm of energy use per capita Natural logarithm of foreign direct investment, Natural logarithm of GDP constant 2010 US$, Squared natural logarithm of GDP constant 2010 US$, Natural logarithm of trade, Natural logarithm of population, and Natural logarithm of renewable energy consumption respectively. For each variable, the table provided descriptive statistics such as mean (average value of variables across all observations), median (the middle value of the variable when the observations are arranged in ascending order), maximum (highest observed value for variables), minimum (minimum observed value for variables), Std. dev. (measure the variability of the variable's value around the mean), Skewness (measures the asymmetry of the variable's distribution), Kurtosis (measures the flatness of the variable's distribution), Jarque-Bera (measures the significance of the Variable's distribution from a normal distribution), probability (suggests the p-value is significantly fifer from other), sum (sum of all variables) and at last sum sq. dev. (sum of squared deviations from the mean, related to the variance of variable).

Table 2
ADF test stationarity

Variables	Parameter	Prob.	Trend/intercept	Inference
CO2	-3.03	0.05	intercept	1st difference
ELPPC	-4.64	0.008	intercept	1st difference
FDI	-3.83	0.006	intercept	1st difference
GDPCONLCU	-2.82	0.06	intercept	1st difference
GDPCONLCUSQ	-2.98	0.05	intercept	1st difference
TR	-5.79	0.000	intercept	1st difference
UPOP	-3.03	0.05	intercept	1st difference
REC	-2.50	0.01	none	level

The outcomes show REC is stationary at level, i.e., series is integrated of I(0), and all other series are stationary at 1st difference, i.e., series are integrated of I(1). ELPPC has

a parameter of -4.64 and a 0.0008 probability value which estimate that it is statistically significant. FDI has the same results, and GDPCONLCU has a -2.82 parameter value, but its p-value is 0.06. GDPCONLCUSQ, TR, UPOP series becomes stationary at 1st difference. On the other hand, the REC series is stationary at the level (none) without the need for differencing, as the parameter estimate is statistically significant. Moreover, the ADF unit root test result justified using the ARDL method.

We used a bound test to find whether long-run relation exists in the middle of variables. The F-test for co-integrated provided clear proof of the long-run relationship between carbon emission, FDI (net inflow), Trade, Urban Population, Electricity power consumption, Renewable electricity consumption, GDP contact local currency unit and its square.

Table 3
Result of Bound test for co-integration

Test Statistic	**Value**	**k**
F-statistic	10.81006	7
	Critical Value Bounds	
Significance	**I0 Bound**	**I1 Bound**
10%	2.03	3.13
5%	2.32	3.5
2.5%	2.6	3.84
1%	2.96	4.26

The F-statistic value is given in the 2nd column, and lower and upper bound values are given in columns 2nd and 3rd, respectively. The F-statistic value is 10.81006, more significant than the lower bound value of 2.96 at a 1% level that leads to rejecting the null hypothesis, and we concluded the existence of long-run between variables.

Table 4
Short run Results

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LNCO2(-1))	-0.161370	0.130723	-1.234443	0.2483
D(LNELPPC)	0.032771	0.091535	0.358014	0.7286
D(LNFDI)	0.042764	0.008349	5.122179	0.0006
D(LNGDPCONLCU)	0.038393	0.047913	0.801319	0.4436
D(LNGDPCONLCU(-1))	-0.166101	0.073057	-2.273592	0.0491
D(LNGDPCONLCUSQ)	-0.096886	0.072515	-1.336081	0.2143
D(LNGDPCONLCUSQ(-1))	0.466287	0.092004	5.068102	0.0007
D(LNTR)	-0.183232	0.051221	-3.577293	0.0060
D(LNTR(-1))	-0.126820	0.037982	-3.338993	0.0087
D(LNUPOP)	0.160503	0.389505	0.412070	0.6899
D(LNUPOP(-1))	-5.635116	1.147519	-4.910695	0.0008
D(LNREC)	-1.337679	0.144594	-9.251292	0.0000
D(LNREC(-1))	0.624858	0.289938	2.155146	0.0595
CointEq(-1)	-1.267801	0.216951	-5.843715	0.0002

The table presents the coefficient, standard error, t-statics, and p-values for the variables in the regression model. In this regression model, several variables show a statistically significant relationship with CO2 emission, such as LNFDI, the increase in one unit of D(LNFDI) makes 0.042 units increase in CO2. Conversely, some variables show a statistically insignificant relationship with the dependent variable, i.e., Carbon emission. For instance, D(LNELPPC) has a 0.038 co-efficient value and 0.72 p-values, indicating an insignificant impact.

The outcomes show that by changing 1 unit in electricity, the carbon emission decreases by -0.059 units. In contrast, the negative sign shows the antagonistic relation between carbon emission and electricity power consumption, and the probability of 0.58 shoe an insignificant effect on CO2 emission. This insignificant relation is also supported by Abbas, Kousar, and Pervaiz (2021). The result reveals that the carbon emission rises by a

change of 1 unit of FDI with 0.057 units. At the same time, the positive sign shows a positive relation between the dependent variable FDI and the independent variable CO2 emission, and the probability of 0.000 shows a significant effect on carbon emission. In the long run, the positive relation between FDI and CO2 emissions shows that the change in 1 unit of GDPCONLCU 0.395 units of carbon emission increased, while the positive sign shows a direct relationship between these variables.

Table 5
Estimation of the long-run coefficient

Variables	Coefficient	Std. Error	t-Statistic	Prob.
LNELPPC	-0.059291	0.105872	-0.560027	0.5891
LNFDI	0.057357	0.007848	7.308580	0.0000
LNGDPCONLCU	0.391078	0.051840	7.543897	0.0000
LNGDPCONLCUSQ	-0.395097	0.058171	-6.792032	0.0001
LNTR	-0.009417	0.032350	-0.291099	0.7776
LNUPOP	-0.401533	0.171305	-2.343963	0.0437
LNREC	-2.248876	0.135453	-16.602686	0.0000
C	39.586792	4.493956	8.808895	0.0000

Moreover, the probability shows that it significantly affects carbon emissions. Moreover, when the square of GDP changes by 1 unit, it decreases carbon emission with 0.395 units, and the negative sign shows the negative relation among these two variables, while the probability of 0.0001 significantly affects carbon emission. The result shows that the change in 1 unit of trade decreases carbon emissions by 0.009. The negative sign shows the indirect relation between trade and carbon emission because services also do trade, and now sustainable ways are used for trade that decreases the carbon emission ratio in the atmosphere. In contrast, the probability shows insignificant impact on CO2 emission. The negative relationship between trade and carbon emission is supported by M. Ahmad et al. (2022). The result shows that with the change in 1 unit of the urban population, the carbon emission falls to 0.401 units, while the negative sign shows the opposite relationship.

Moreover, the probability of trade shows an insignificant impact on CO2 emission. The people in urban areas take care of pollution and try to make carbon emissions less in the environment and keep the atmosphere clean. W. Sun and Huang (2020) supported that the more people shift to urban areas, the more they take the emission issues seriously and try to make a green economy. The results stated that if 1-unit changes in renewable energy consumption, then the carbon emission fall by 2.248 units, while the negative sign shows the indirect relation among them. The high use of renewable energy results in falls in carbon emissions, and the probability also shows its significant effect. Many studies supported this debate, Zaidi, Danish, Hou, and Mirza (2018) is one of them.

5. Conclusion

This study also explores the trend of CO2 emissions from 1990-2022 in Pakistan's economy. Burning fossil fuels, economic growth, population, trade and investment affect carbon emissions in several ways. The electricity power consumption shows a negative sign that’s mean with the increase in power consumption, the CO2 emission goes down. Consuming electricity during the peak hours when the emission chances of carbon are low reduces the amount of carbon emission in the environment, but it has an insignificant effect. Foreign direct investment has positive signs means that with an increase in investment, carbon emissions will also increase because the investment is only used on business projects which provide profit in return. The technologies used are that old and cannot take care of pollution, but it has a significant effect if we can invest in projects which also help lessen the carbon emission.

The GDP shows a positive sign means it has a direct relation with emissions. When economic growth rises, it means an increase in industrial sector production and use, which creates CO2 emissions. On the other side, GDP^2 shows a negative sign because economic

growth becomes stable after reaching the optimum point. The sector starts moving toward sustainable sources to make the environment sustainable, and that is how the carbon emission reduction starts, and they both significantly impact CO2 emission. The trade shows a negative sign which means it has indirect relation with carbon emission, and it is because the trade system set limit on how much a country can emit carbon emission and above that, they can face problems. This rule is set by the Cap-and-Trade approach. This is how carbon emissions can control by trade, but it has an insignificant impact. The population rises in urban can also decrease carbon emissions because people start preferring a sustainable environment which makes them healthy for this. They can pay extra for a green climate, the recycling system is improving, and the buildings are also boosting the ventilation system, making them extraordinary. In addition to this, they also promote the SDGs, and it has a significant impact on carbon emissions.

At last, renewable energy sources also decreases carbon emission because, on one side, the traditional method of producing electricity emits a considerable amount of Green House Gases when fossil fuels burn. However, on the other side, renewable energy resources such as solar panels absorb the Sun's radiation and produce electricity. This is how they can reduce the ratio of carbon in the atmosphere, which has a significant impact and creates a sustainable environment. In the future, Pakistan will convert Electricity production to Renewable Energy sources. In addition, Pakistan focuses on energy efficiency, especially on industrial sectors and improving technology, which emits less CO2 emission in the environment. Moreover, investment in renewable energy projects should be enhanced in future.

Authors Contribution

Zeesha Tahir: study design, data collection and analysis, methodology, writing original draft

Conflict of Interests/Disclosures

The authors declared no potential conflicts of interest w.r.t the research, authorship and/or publication of this article.

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