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Analyzing the Interplay of Financial Inclusion, Income Inequality, and Carbon Dioxide Emissions: Evidence from Pakistan

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ABSTRACT

The current study uses annual time-series data from Pakistan from 1998 to 2022 to investigate the complex link between financial addition, economic inequality, and carbon emissions. The Auto-regressive Distributed Lag (ARDL) model is used in the study to look at the dynamic correlations between variables including financial addition, income inequality, and carbon emissions. The empirical data indicates that increasing financial inclusion leads to a significant reduction in CO_2 emissions. In contrast, economic inequality, energy consumption, and growth have a positive correlation with CO_2 emissions. These conclusions show the complicated relationship between socioeconomic determinants and environmental effects. Furthermore, the study's implications extend beyond Pakistan, giving valuable information to policymakers dealing with similar difficulties in other developing countries. This work contributes to the global discourse on sustainable growth and climate action by promoting economic addition and addressing financial disparities. It emphasizes the importance of implementing specific policy actions that promote both economic fairness and environmental sustainability. Such approaches have the potential to not only reduce carbon emissions but also encourage inclusive growth, promoting the wider aim of sustainable development in Pakistan and abroad.

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1. Introduction

Globally, the two foremost subjects of study are inequality and climate change. Recently it has been discussed that disparity and economic addiction are responsible for the emission of carbon dioxide (CO_2). In different countries, it may be the main reason for global warming. Inequality has many consequences. Policymakers are more concerned about the level of income, Trends, and wealth equality. Which may lead society to social discontent. Pakistan is among Asia's five fastest emerging economies with a 57% growth rate in 2017 and the fifth most. Based on GDP (Gross domestic production) it ranks the 24th largest country using purchasing power parity (PPP). In terms of Nominal GDP as of 2023, it ranks the 46th largest country with 232 million people. Currently with a growth rate of 6.1% Pakistan ranked 43 in the major economies rest of the world (IMF, 2023). Pakistan recently stands on the list of those countries which is badly affected by global warming and inequalities. Especially after the global pandemic of 2020, the economy of Pakistan facing alarming situations which set back the economy. This research study covers the overall effects of economic addition and income inequality on the emission of carbon dioxide (CO_2). According to the report of the British charity Oxfam, 50% of carbon emissions are contributed by the richest 10% in the world while 10% of carbon emissions are contributed by the 50% of the poorest economies (International, 2015). The more theoretical proof of inequality affecting the emission of carbon dioxide (CO_2) is decorated in the study presented by (Ozturk, Cetin, & Demir, 2022).

The consumption as well as labor dynamics that could be influenced by disparities in income are included by explaining the relationship between household income and the emission of carbon dioxide (CO_2). For each $1 increase in income, poor people emit greater amounts of greenhouse gases than those with higher incomes. As a result, Reallocation of income takes place from the wealthy to the poor. It will lead to an increase in the emission of carbon dioxide (CO_2). When the poor upgrade to the middle class, due to the redistribution of income their income increases. As a result, their propensity to consume also increases. They use more carbon-intensive products which may clear the ground for environmental changes. Such as energy consumption (Aghaei & Lin Lawell, 2022; Ahmad et al., 2016; Esen & Bayrak, 2017; Filippidis, Tzouvanas, & Chatziantoniou, 2021). Recent studies have discussed that income is affected by environmental pollution. The discrepancy in the environment is pretentious by both income inequality and income level (Muryani, Esquivias, Sethi, & Iswanti, 2021). To drive economic development the most important factor is inclusive finance. Financial services are becoming more and more crucial to society and economic prosperity in the current day. A developed financial system provides financial access to everyone (Magazzino, 2018). Macroeconomic activities and financial inclusion are always influenced by the banking sector. The impact of poor macroeconomic activities increases the banking risk. Parties who borrow money from banks and non-bank financial services risk more to default. Bank and financial services closely correspond to the provision of capital in an economy (Ayadi, Arbak, Naceur, & De Groen, 2015; Bhanumurthy & Kumawat, 2020). Sustainability and growth are affected by income inequality. As the level of inequality increases it increases macroeconomic instability, which may further cause financial crises. Income inequality is the main cause of high crime rates. Crimes like misuse of resources, corruption, and nepotism, are all caused by income inequality. The outcome of this problem is social and political instability (Acemoğlu & Robinson, 2016; Flachaire, García-Peñalosa, & Konte, 2014; Gardezi & Rafique, 2023). A substantial corpus of research on the factors influencing economic addition and income disparity is available. After examining the results of the study as well as the other current studies, findings show that especially in developing countries the most investigated variable is economic growth which is closely involved in income inequality (Aghaei & Lin Lawell, 2022; Dong, Tang, & Wei, 2018; Saleem, Ahmad, & Dad, 2020). In the empirical investigation of the 1990s era, financial development escalated worldwide. The first and foremost effect of it is to boost income inequality (Abakumova & Primierova, 2018; Ali, Sardar, & Latif, 2023; De Haan & Sturm, 2017; Deininger & Squire, 1997; Sidek, 2021). Financial inclusion enlarged the share of the financial sector and brought down the share of the working class. This may eventually aggregate the level of income inequality. Empirical findings show income inequality is achieved with financial inclusion (Erlando, Riyanto, & Masakazu, 2020; Seng, 2021). Many other studies propound that financial inclusion, income inequality, and CO_2 emission have an accessing impact on economic development (Ahmad et al., 2016; Khan & Ullah, 2019; B. Muhammad & M.K. Khan, 2021; Wen et al., 2021). The income distribution of any country is the most important fact which is measured by the Gini coefficient country by country. In Pakistan, 42% of the nation's income is reported by the wealthiest 10% of households. The bottom 50%, on the other hand, reported 13% of their nation's income. This clearly shows that the wealthiest people in Pakistan earn three times more than the poorest households. In the Global ranking of inequality, Pakistan stands 108 and ranked 67.8 in the world economic inequality index (Index, 2022).

The graphical evidence of the Evolution of income inequality and emission of CO2 is given below.

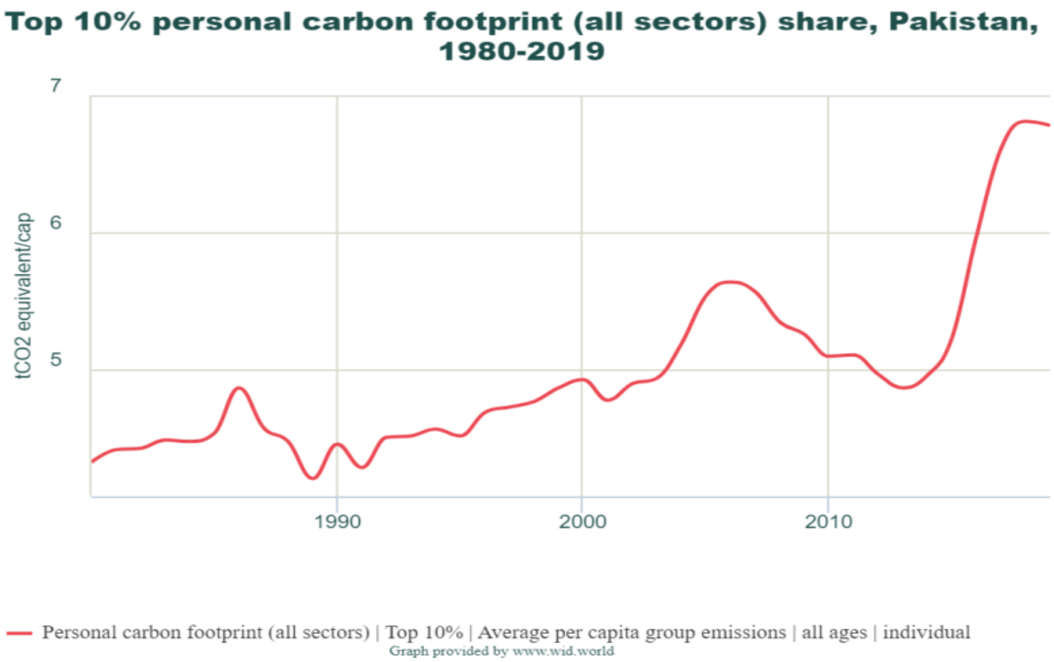


Figure 1: Evolution of income inequality and emission of CO2
Data sourced by Index (2022).

The research paper is also catalogued as follows; the next section contains literature reviews of existing knowledge from the rest of the world. The other portion exhibits the empirical data and findings, and the final piece summarizes the results and makes policy recommendations. Many research studies paint a clear image of the root reasons for economic addition, economic inequality, and CO2 emissions. Hopefully, this study will close a gap in the literature.

2. Literature Review

Chinoda and Mashamba (2021) analyzed the impact of financial inclusion, income inequality, GDP (gross domestic output), and energy use on carbon emissions. They used the method of Kuznets curve for three countries Pakistan, Bangladesh, and India. Using the Longitudinal data of time spanning from 1980-2014 and FMOLS methodology is used. Findings show that (CO2) emissions are significantly affected by financial development. Furthermore, In Pakistan and India CO2 emission is reduced by income inequality at the same time the result is the opposite for Bangladesh. The study introduced policy-making suggestions that may lead to the achievement of high efficiency of economic development.

Andersson (2023) researched the relationship between income inequality and carbon emissions and concluded that greater income inequality leads to higher CO2 emissions. This study emphasizes the important link between inequality and CO2 emissions. Cross-sectional panel data from 42 mounting countries was used in 1984 & 2016. Figures obtained from WDI, SWDI, and ICRG Unit root test, panel co-integration, and long-run estimate approaches were used. CO2 is the dependent variable, and income inequality, GDP, energy consumption, and the import ratio are employed as independent factors to evaluate the research findings. The finding demonstrates strong detrimental effects on CO_2.

Mdingi and Ho (2023) examined the correlation between CO_2 emissions, income inequality, and financial inclusion. Study induced data of Türkiye from the year 1980-2021. Data sourced by the World Bank and Infusing the methods of Unit root test, Co-integration, FMOLS, LM test, and DOLS & CCR. The dependent variable (income inequality) and dependent variables (FI, Education, Inflation, and Urban population) are used to find the relation between them. The study concluded that income inequality is a complex problem. Raising the incomes of all low-income groups will help to reduce income disparity. Furthermore, improving education will result in a more equitable allocation of income.

Tay, Tai, and Tan (2022) completed the study to explore the impact of financial inclusion on economic growth, by including the non-parametric quantitative data of 48 Asian countries in the year 2020. The DEA (data envelopment analysis) method is used in the research. Economic inclusion is used because the dependent variable and trade openness, market industrial structure, insurance, and environmental governance are used as the independent variables. Data sourced by the OECD and World Bank. The result tells us that to minimize the effect of environmental damage economic development must be necessary. Infrastructure development hurts credit as well as green economic development.

Immurana, Iddrisu, Boachie, and Dalaba (2021) used time series data from 1960 to 2020 to study the impact of financial inclusion on the population. The ARDL (Auto-regression distributed lag model) technique is used. The dependent variable is urban population growth, whereas the independent variables are financial inclusion, GDP, and industrialization. The data came from the World Bank. According to the report, governments should make financial services more accessible to people living in locations where there are few financial institutions.

Purwanto, Sinaga, and Sidik (2021) examine the connection between inflation and energy use. The data included in this study is taken from sub-Sahara Africa between the years 2005-2020. The source of data is based on the GICP and WID. The methodology used in this research is GMM estimation. The findings of this research show financial development maintains its positive effects on per capita income. Access to financial development has an unfavorable effect on CO_2 emission which may be inevitable. A finding of research shows alleviation of financial increase, income inequality, and CO_2 emission. financial development having antagonistic effects on CO_2 emission.

Ju et al. (2023) examine the reduction strategies of CO_2 emissions that make economic development fast. Using the evidence from India from the past 35 years' data to find how CO_2 emission is affected by development and how to reduce the negative impacts of the given phenomenon. GAMS is the programming tool used in the study. The study looked at dependent and independent variables that could impact economic development and minimize carbon dioxide and CO_2 emissions. The research revealed that maintaining capital inflows and welfare levels is necessary to reduce CO_2 emissions.

Hailemariam, Dzhumashev, and Shahbaz (2020) examine the correspondence between CO_2 emission and income discrepancies. The research includes previous empirical studies. Using the balance panel data of annual observation of five emerging economies. Including the data from the years 2000-2014. Using the methodology of the Hausman test. Wealth inequality was used as the independent variable and carbon dioxide CO_2 emission and population as the dependent variables. The findings highlight the advantages of income disparity, population, and GDP, as well as the drawbacks of financial development.

Demir, Pesqué-Cela, Altunbas, and Murinde (2022) investigated the impact of financial inclusion and economic inequality on CO_2 emissions. This study used facts from 34 Sub-Saharan

African nations collected between 2004 & 2014. Three main indicators were used in the study (Inequality indicators, Atkinson index and Palma ratio, Gini coefficient). Data sourced by WDI (World Development Indicator). The study reveals a link between carbon dioxide emissions and economic disparity. The empirical findings of the study were acquired by using the GMM Specification methodology. The findings indicate that economic disparities have a positive impact on carbon emissions.

Ota (2017) studied the link between inequality and environmental change. The study examines the variations in CO2 emissions per capita because of wealth disparity in Latin American nations, using data from 1970 to 2013. The experiential findings will be estimated using the GMM (generalized method of moments) approach. The independent variables are GDP per capita and the Gini coefficient, and CO2 is the dependent variable. WDI and SWIID gather information. According to the study, income disparity has a direct influence on CO2 emissions, although the direction of this environmental shift varies depending on wealth. According to the findings, there is a quadratic link in developing countries between environmental change, inequality, and GDP per capita.

3. Data and Methodology

3.1. Description of Data

This study investigated the relationship between financial inclusion economic inequality and CO2 emissions in Pakistan using time series data from 1998 to 2022. The World Development Indicators (WDI) provided the information that is displayed here. Indicators of financial inclusion in a nation include the number of commercial bank branches, automated teller machines (ATMs), deposit and loan accounts per 1,000 people, outstanding deposits as a percentage of GDP and outstanding loans. Metric tonnes are used to estimate carbon dioxide emissions per person.

Additionally, the data on GDP per capita, energy consumption, and total natural resources is included in the study due to the influence of the other variables taking part in the research study. All the data of this variable were gathered from WDI. Data is full and substantiated except for some missing values of income inequality and energy consumption. Interpolation is used in which missing values are substituted with the other values that were acquired. Interpolating is a way to determine unknown values that lie between data paths. It allows the inclusion of all observations that facilitated to construction of the results more symmetrical.

The study utilizes different indicators to measure the impact of variables included in the research. To examine the influence of financial inclusion and inequality of income on carbon emission. The study includes relevant co-variants that influence the regression model. Using the different indicators of financial inclusion to ensure that the findings are compatible and wholesome. Other studies show the same results by using these variables (Gardezi & Chaudhry, 2022; Gardezi & Rafique, 2023; Malik, bin Md Isa, bin Jais, Rehman, & Khan, 2022; Tay et al., 2022; Tram, Lai, & Nguyen, 2023; Wan, Wang, Wang, & Zhang, 2022). All the measures come from the World Bank. In addition, as control variables study included energy consumption, total natural resources, and economic growth.

3.2. Methodology

In the existing empirical work, results are calculated by removing the heteroscedasticity problem that exists in the data. All the series of data was converted to logarithmic form. To determine how the explanatory variable influenced the experimental variable. The study used the ARDL method (Jordan & Philips, 2018). To determine whether each variable in the study is stationary or non-stationary, the unit root test is performed. If any of the variables are non-stationary, the regression results may vary. All the variables must be stationary so that we can apply ARDL simulation. The variables are stationary at I(0) and I(I).To determine the association between the variables included in the empirical analysis, the Phillips-person unit root test and the enhanced Dickey-Fuller test were used sequentially (Dickey & Fuller, 1979; Phillips & Perron, 1988).

3.2.1. Econometric Model

To examine the results of the research, the Study set down the following equation in functional form:

$$CO2_t = F(FI_t, INQ_t, GDP_t, EC_t, TNR_t) \quad (1)$$

CO2 emissions is a dependent variable, FI_t (financial inclusion) and INQ_t (income inequality) are independent variables. GDP_t (Gross domestic production), EC_t (energy consumption) and TNR_t (total natural resources) are control variables.
The following empirical equation brings forward:

$$CO2_t = \beta_1 + \beta_2 FI_t + \beta_3 INQ_t + \beta_4 GDP_t + \beta_5 EC_t + \beta_6 TNR_t + \mu_t \quad (2)$$

In above equation: Constant is denoted by β1 and β2, β3, β4, β5 and β6 denoted as coefficients of independent variables, and the error term is denoted as μ_t.

3.2.2. Auto-regressive distributed lag bounds test.

The bound test is used to investigate the long-run relationship between variables. In this work, the ARDL bound test is used to base on hypothesis, assess long run relationship among variables of the empirical model.

$$\Delta \mathrm{C02PCt} = \varphi + \varphi_1 \mathrm{FI}_{t-1} + \varphi_2 \mathrm{INQ}_{t-1} + \varphi_3 \mathrm{GDP}_{t-1} + \varphi_4 \mathrm{EC}_{t-1} + \varphi_5 TNR_{t-1} + \sum_{i=1}^{q} \beta_1 \Delta FI_{t-i} + \sum_{i=1}^{q} \beta_2 \Delta INQ_{t-i} + \sum_{i=1}^{q} \beta_3 \Delta GDP_{t-i} + \sum_{i=1}^{q} \beta_4 \Delta EC_{t-i} + \sum_{i=1}^{q} \beta_5 \Delta TNR_{t-1} + \varepsilon t \quad (3)$$

Above equation Δ shows the first difference, CO2PC represents the emission of CO2 per capita, FI is financial inclusion, INQ is income inequality, GDP is the gross domestic production, EC is energy consumption TNR is total natural resources, and (t-i) represent the optional Lag based on information. The variables φ and β are used to analyze the long-term relationship between them. The short-run equation for the following is shown below:

$$\Delta \mathrm{C02PGt} = a + \sum_{i=1}^{q} \lambda_1 \Delta \mathrm{FI}_{t-1} + \sum_{i=1}^{q} \lambda_2 \Delta \mathrm{INQ}_{t-1} + \sum_{i=1}^{q} \lambda_3 \Delta \mathrm{GDP}_{t-1} + \sum_{i=1}^{q} \lambda_4 \Delta \mathrm{EC}_{t-1} + \sum_{i=1}^{q} \lambda_5 \Delta TNR_{t-1} + \omega\, ECM_{t-1} \quad (4)$$

In the above equation the parameters with summation sign represent the short-run parameters and ω the coefficient of ECM shows the time adjustment of the long-run equilibrium. ECM should be negative and significant for long-run equilibrium.

4. Results and Discussions

This section includes a comprehensive discussion of the results of descriptive statistics, correlation analysis, dynamic results of the ARDL model, different diagnostic tests, and the CUSUM and CUSUM square tests.

Table 1 provides a complete descriptive study of six variables: CO2 emissions, GDP, LEC, LTNR, LINQ, and LFI. The statistical properties of each variable give information about its distribution and general trends. For example, mean and median values provide central tendency measurements by reflecting the typical values for each variable. The highest and lowest values show the range of variance in the dataset, with GDP having the biggest range of the variables. Standard deviation values represent the spread of data points around the mean, with higher values indicating greater variability, as seen in LFI. Skewness and kurtosis indicate the shape of the distributions, with LINQ and LFI deviating greatly from symmetry and peaks, respectively. If the likelihood of Jarque-Berra is < 0.05, it means that the data distribution is not normal, hence we reject the null hypothesis. If the probability value is larger than 0.05, we accept the null hypothesis and conclude that the data distribution is normal. The Jarque-Berra test results in the table above show that the probability value for all independent variables is greater than 0.05, indicating that the data distribution is normal and the model stable.

Table 1
Descriptive Analysis

	CO2	GDP	LEC	LTNR	LINQ	LFI
Mean	0.632167	2.005525	6.054490	0.570328	1.373850	0.562662
Median	0.642399	2.231883	6.053110	0.618425	1.308333	1.082089
Maximum	0.703003	5.447802	6.134701	1.061660	2.014903	1.696129
Minimum	0.554245	-2.970295	5.999613	-0.035284	1.098612	-2.958312
Std. Dev.	0.042491	2.125258	0.032428	0.333654	0.240743	1.277866
Skewness	-0.304644	-0.175088	0.441770	-0.295989	1.102432	-1.057658
Kurtosis	2.008197	2.531091	2.860705	1.740925	3.599875	3.407173
Jarque-Berra	1.411361	0.356770	0.833381	2.016362	5.438827	4.833700
Probability	0.493773	0.836620	0.659225	0.364882	0.065913	0.089202

Table 2
Correlation Analysis

	CO2	GDP	LEC	LTNR	LINQ	LFI
CO2	1					
GDP	0.0515	1				
LEC	0.227	0.2134	1			
LTNR	0.2860	0.046	0.4795	1		
LINQ	-0.5300	0.0306	-0.5197	-0.4191	1	
LFI	0.8261	-0.1495	0.2329	0.579	-0.6111	1

Table 2 demonstrates that there is a correlation between CO2 and the factors considered in this study report. The correlation coefficient of GDP and CO2 is 0.0515, which shows that GDP and CO2 emissions have a positive relationship. An increase or decrease in GDP changes the level of CO2 emission. An increase in GDP will also increase CO2 emission and vice versa. Energy use and CO2 emission have a positive correlation. The correlation coefficient between energy consumption and CO2 is 0.227, implying that as energy use increases, so will carbon emissions. There is a positive association between energy usage and CO2 level. Total natural resources and CO2 have a positive correlation. The correlation coefficient of Total natural and CO2 is 0.2860, increase and decrease in the value of total natural resources will affect the level of carbon emission respectively. Income inequality has a negative relationship with CO2 emissions. The correlation coefficient of Income inequality and emissions of CO2 is -0.5300. The negative correlation suggests that reducing wealth disparity increases CO2 emissions, and vice versa. Financial inclusion and CO2 emissions are positively correlated. The correlation coefficient between financial inclusion and CO2 is 0.8261, implying that greater financial inclusion will reduce CO2 emissions.

Table 3
Unit Root Test

	Augmented Ducky-fuller (ADF)		Phillips Perron (PP)	
Variable	**Level**	**First Difference**	**Level**	**First Difference**
FI	1.00	0.045	1.00	0.045
INQ	0.6558	0.0253	0.664	0.0253
GDP	0.021	0.000	0.021	0.000
EC	0.435	0.0327	0.365	0.0120
TNR	0.3795	0.0056	0.3116	0.0056

Note: Probability values are given in the table

Before applying the estimation technique, this study checks the unit root test for the stationarity of the variables. For instance, if any of the series is not I(2) in other respects the results will be estimated wrong. Table 3 represents two different unit root tests ADF and PP. These tests were used to ensure that each series' unit root was correct. The result indicates that the series is not stationary at all at I(2). Table 3 shows varied behavior, with some factors being significant at the level and others being significant at the first difference. It is important to highlight that ARDL simulations are employed only when some variables are stationary at the level and others are stationary at the first difference.

Table 4
ARDL Bond Test

Value of F Bond test	Lower Bond 1(0)	Upper Bond 1(1)
7.544	2.08	3
	2.39	3.38
	2.7	3.73
	3.06	4.15

Table 4 presents the consequences of the bound test, which concluded long-run connection between dependent & independent variables exists. The f-bond test value is 7.544. The given value is higher than values of lower and higher bounds. It shows that a long-run relationship between indicators exists.

Table 5
Dynamic Results of the ARDL Model

Variables	Coefficients	Std. Errors	t-Statistics	Probs
C	-1.010638	1.079765	-0.935980	0.3651
LFI	-0.055871	0.009207	6.068054	0.0000
Δ(LFI)	-0.027	0.015	-1.771	0.099
LINQ	0.001537	0.030507	0.050383	0.9605
Δ(LINQ)	0.010	0.039	0.256	0.801
LEC	0.270674	0.175414	1.543063	0.1451
Δ(LEC)	0.870	0.303	2.865	0.01
LTNR	-0.096255	0.023173	-4.153754	0.0010
Δ(LTNR)	-0.103	0.020	-4.955	0.003
GDP	0.006195	0.002387	2.595290	0.0212
Δ(LGDP)	0.167	0.092	-1.818	0.092
Coint Eq (-1)*	-0.671	0.1202	-8.785	0.000

Table 5 displays the long- and short-term results of the ARDL model. The coefficient of financial inclusion shows a clear negative relationship between financial inclusion and CO2 emissions. A one-unit increase in financial inclusion will cut CO2 emissions by 0.05% in the long run & 0.02% in the short term. This relationship is the outcome of advancements in the financial sector. The development of the financial industry will result in changes in technology as well as improvements in banking and business. Some earlier investigations Le, Le, and Taghizadeh-Hesary (2020); Mehmood (2022) support our findings.

The coefficient of income inequality demonstrates that income inequality has a strong positive relationship with CO2 emissions. If the income gap widens by one unit, CO2 emissions will grow 0.001% in the long run and 0.010% in short term. The relationship exists because when the level of income disparity drops, an individual's income grows. Increased income forces the individual to adjust his consumption habits. They might increase their consumption of goods and services. Thus, the use of carbon-intensive items grows. Individuals spend more and more as their income increases. The discussion concluded that as the consumption of carbon-intensive items increases, so does the risk of environmental damage. Other research results are likewise related to our findings (Gardezi & Chaudhry, 2022; Ozturk et al., 2022; Wan et al., 2022; Yang, Ali, Hashmi, & Shabir, 2020; Zhang & Zhao, 2014).

Increased income forces individuals to change their consumption habits. They may boost their consumption of goods and services. As a result, the consumption of carbon-intensive items increases. Individuals spend more as their income rises. The discussion concluded that as the consumption of carbon-intensive things rises, so does the risk of environmental degradation. Other study outcomes are also relevant to our findings (Aras & Van, 2022; Guo, Uhde, & Wen, 2023; Pejović, Karadžić, Dragašević, & Backović, 2021; Pita, Winyuchakrit, & Limmeechokchai, 2020; Shafiei & Salim, 2014; Tao & Wu, 2021).

Similarly, the Total Natural Resources coefficient shows a strong negative link between total natural resources and CO2 emissions. If one unit of total natural resources is raised, CO2 emissions will be reduced by -0.096% run and -0.103% in the short run. The correlation is due to increased consumption of natural resources, which raises CO2 emissions. Excessive use of natural resources can cause environmental damage and increase carbon emissions. Some previous studies connected with our findings (Danielsen et al., 2022; Gardezi & Chaudhry, 2022; Hassan, Xia, Huang, Khan, & Iqbal, 2019; Majeed, Wang, Zhang, & Kirikkaleli, 2021; B. Muhammad & S. Khan, 2021; Pearce & Turner, 1989; Purnomo, Srifitriani, Shichiyakh, Laxmi, & Shankar, 2020; Xue et al., 2021).

The GDP coefficient indicates a strong positive relationship between GDP and CO2 emissions. When GDP rises by one unit, CO2 emissions increase by 0.006% in the long run and 0.167% in the short term. GDP and CO2 emissions are positively related because modern technologies allow for faster expansion in output through more intensive energy use, which increases capacity. Furthermore, excessive usage of energy increases CO2 emissions. Some past investigations are linked to our findings (Acheampong, Boateng, Amponsah, & Dzator, 2021; Farooq, 2022; Farooq, Gardezi, & Safdar, 2020; Hamid et al., 2021; B. Muhammad & M.K. Khan, 2021; Wen et al., 2021).

Table 6
Variance Inflation Factors (ARDL Method)

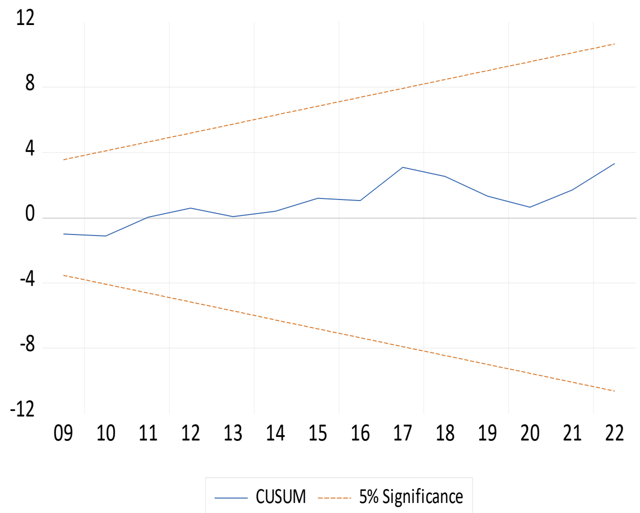
Variable	Coefficient Variance	UN-centered VIF	Centered VIF
GDP	5.33E-06	2.125825	1.102834
LEC	0.037658	65819.16	1.812537
LTNR	0.000373	7.693640	1.902676
LINQ	0.000811	75.12559	2.151157
LFI	3.07E-05	2.759432	2.295787
C	1.416719	67548.44	NA

Table 6 shows that the values of VIF indicators are less than 10 and some of the indicators have VIF value <5 which shows the model is free from the problem of multicollinearity.

Table 7
Different Diagnostic Tests

Diagnostic tests statistics	P-Value	Results
Heteroscedasticity	0.8995	No problem with Heteroscedasticity
Serial correlation/Autocorrelation	0.2775	No problem with serial-correlation/Autocorrelation
Normality test	0.774	Data is normally distributed

Table 7 shows that the P-value of the tests is insignificant, so we are rejecting the Null hypothesis, that there is a problem with hero/auto. So that there is no problem of autocorrelation in data. The probability value of the normality test (0.774849) is insignificant it shows that the distribution of the data is normal.



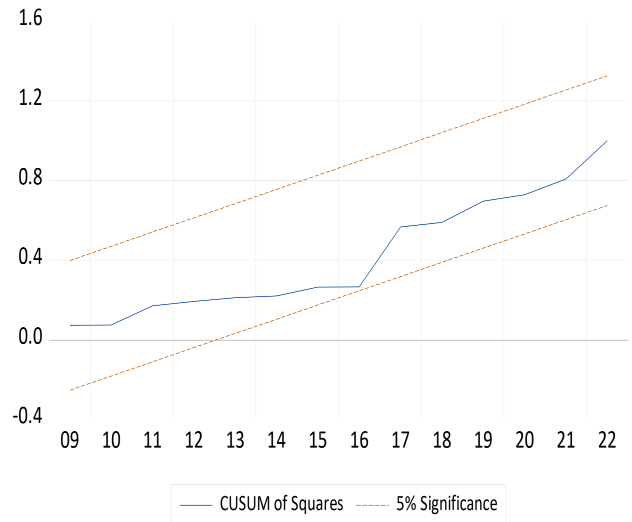


Figure 3: CUSUM and CUSUM Square Test

CUSUM and CUSUMS of squares also show that the values of estimated parameters are stable as they have not gone outside the critical lines. Thus, the plotted deviations and plotted square of deviations show model is stable.

5. Conclusion and policy recommendation

Using time series data, this study investigated the effects of financial inclusion and economic inequality on CO2 emissions in Pakistan. The findings of this study show that Financial Inclusion and Total Natural Resources have a negative correlation with CO2 emissions. This demonstrates that while expansion in the financial services industry reduces CO2 emissions, excessive usage of Total Natural Resources raises CO2 emissions. The more abundant natural resources, the more inefficient CO2 emissions become. The other variables considered in this study demonstrated a positive correlation with CO2 emissions. According to a study, rising income disparity, GDP, & energy use will guide higher CO2.

When planning, developing, and designing carbon emission policies to decrease the level of CO2 emission, the region should consider numerous policies that are efficient in activating inclusive economic development. It is important to encourage policymakers to focus on the pathways that may raise economic growth without an increase in CO2 emission. Make such policies that counter the emission of CO2 to decrease and increase economic growth positively. This generally points towards the use of technology and competent use of possessions as well as educating individuals about the harm of environmental degradation. Knowing the routes that are important as they will provide new perspectives to the policymakers, governments, and international bodies to allocate the resources more efficiently will reduce the factors that threaten Humanity as well as the environment. Therefore, further research can illuminate the different avenues.

Author's Contribution:
Muhammad Ali Gardezi: Conceptualization, software working, econometric modeling, methodology, and reference verification.
Bakhtawar Zafar: Writing introduction, literature review, and discussions of results.
Aurang Zaib: Conceptualization, proofreading and reference verification.
Ayesha Rasheed: Helps in writeup.

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