# Time to Shift Concerns from Financial Inclusion to Environment Quality: A Case Study of China

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## Abstract

*For a long time, it was considered that a nation can only benefit from economic success. Due to this, all the financial decisions made were in favour of increasing production levels, neglecting that there could be a cost to all this activity. Financial inclusion has the potential to impact the environment in ways. It can lead to increased and eased business activities, which may result in higher production levels and CO2 emissions. Increased levels of CO2 have a greater capacity to hamper growth through economic changes in the form of global warming, financial costs, resource scarcity, and other regulatory and market changes, which are again challenging and risky to resolve. This paper examines the relationship between inclusive finance and environmental quality in China using the ARDL econometric technique. The analysis is based on a time series dataset spanning 55 years, from 1965 to 2020. Upon conducting the Augmented Dickey-Fuller (ADF) test, it is evident that all the variables exhibit a unit root at a significance level of 1%. The research findings indicate that a marginal rise of 1% in financial inclusion, industrialization, population, economic growth, and energy consumption corresponds to a concomitant increase of 1.0%, 2.60%, 40%, 1.45%, and 1.0% in carbon dioxide (CO2) emissions. The findings of this study indicate that the development of accessible financial systems should be prioritized as a strategic approach to address the challenges posed by climate change. It is crucial to minimize the adverse impacts of financial inclusion on environmental quality and foster equitable and sustainable economic growth.*


**Keywords**: CO2 Emissions, GDP Per Capita, Industrialization, Financial Inclusion, Energy Consumption, Population, ARDL, Granger Causality, Unit Root

## Introduction

In recent decades, a significant concern that has perturbed the global community is the escalation of greenhouse gas (GHG) emissions. The primary factor contributing to the increase in greenhouse gas (GHG) emissions is the substantial dependence on fossil fuels as primary energy sources (International Energy Agency, 2017). The exponential growth of development-related endeavours leads to a corresponding escalation in using finite energy resources such as coal, oil, and gas. Conversely, it has substantially and adversely impacted the overall environmental condition. Hence, safeguarding the environment has emerged as a prominent global concern in the contemporary era, garnering substantial attention in various international platforms (Ullah et al., 2020; Usman et al., 2021). The economic development of emerging economies is strongly reliant on the consumption of nonrenewable energy sources, making their contribution vital to attaining these objectives (Qin & Ozturk, 2021).

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Financial inclusion became popular in the early 21st century after Chibba (2009) identified financial exclusion as a significant source of poverty. The World Bank defines *financial inclusion* as easy and affordable access to bank accounts, credit and debit cards, saving schemes, insurance facilities, and transactional services for all people and firms (World Bank, 2018). So, financial inclusion can have long-term consequences on renewable energy usage, which affects countries' environmental performance. There are several researches on the relationship between environmental quality and financial development, such as Farhani and Ozturk (2015), Acheampong (2019), and Li et al. (2022) for emerging economies and China. Because the financial inclusion index is scarce, the literature on inclusive finance and environmental quality is young.

There is theoretical potential for both positive and negative outcomes when considering the impact of financial inclusion on environmental quality. The positive effects of financial inclusion stem from the fact that it invests in clean and green technologies that are more accessible and less expensive by making financial products and services available and affordable to a wide range of people and organizations, including the business community. By making more advanced ecological practices more accessible, affordable, and implemented, an inclusive financial structure can improve environmental quality, as stated by the Institute of Policy Analysis (2017). People in low-income countries often need more financial inclusion to invest in green technologies (IPA, 2017). According to Baloch et al. (2021), solar microgrid adoption is hampered by financial exclusion and limits such as a lack of access to finance, limited financial support from governments, and a lack of banking services. These few instances lend credence to the idea that more accessible and cheaper financial services might boost the adoption of renewable energy sources and green technology, enhancing environmental quality by decreasing reliance on carbon-intensive power generation.

On the other hand, the availability and convenience of access to financial services might spur manufacturing and industrial activities, leading to an increase in CO2 emissions and a subsequent contribution to global warming (Tamazian et al., 2009). More people being financially included means more people can afford to buy cars, microwaves, refrigerators, air conditioners, dishwashers, and washing machines, all of which use much energy. The rising energy demand and, consequently, CO2 emissions from their use is a significant concern. An open financial system, as proposed by Frankel and Romer (1999), is thought to stimulate economic growth, increasing energy demand and carbon dioxide emissions.

China has the world's most significant CO2 emissions and is the fastest-growing rising economy. When compared to other countries, China has the highest energy demand. As a result, China is under increasing international pressure to replace its polluting, nonrenewable energy infrastructure with renewable, clean energy. China's energy needs can be met through renewable energy sources, reducing the country's carbon footprint (Lei et al., 2021). Renewable energy sources were highlighted as an SDG to prevent further damage to the planet. Increases in the proportion of renewable energy sources in a country's total energy mix have benefited green infrastructure and growth, environmental quality, and quality of life (Zhao et al., 2021). Environmental deprivation caused by global warming, massive waste, and effluents, especially in rivers, canals, and wetlands, may lead to environmental disasters in the future, especially in developing countries, and is a significant concern for agriculture and human health. Water availability, crop patterns, forests, biodiversity, livestock, coastal zones, Etc. have all been directly impacted by the climate change forces in Pakistan. With a GDP growth rate of 5.24% and a per capita income of around $12150 (Goc, 2023), China is one of the emerging countries contributing to environmental degradation issues and emitting roughly 27% of global CO2. Due to ineffective environmental rules and standards, China has become a potential hotspot for pollution as its population and energy consumption continue to grow alarmingly. Over ninety-eight per cent of China's energy consumption comes from nonrenewable sources (Sheikh,

2010).
Against this background, we want to analyze how inclusive finance affects China's ecological output. The first study focuses explicitly on the influence of inclusive finance on CO2 emissions in the Chinese economy. In addition, while aggregation bias plagued prior research' use of panel data analysis, our use of time series analysis was unaffected by this issue. In addition, unlike others that have been done before, this study has considered both short- and long-term projections. For this purpose, we have relied on the ARDL model, a strategy that works well with a limited sample size.
The rest of the paper is organized: Theory and empirical findings from prior research will be reviewed in Section II. Sections III–V describe objective, technique, and empirical outcomes. Section VI covers results and conclusions.

## Literature Review

### The Relationship between Inclusive Finance and Environmental Degradation

Financial inclusion is argued to reduce poverty and help the poor by fostering economic growth (Beck et al., 2007; Makina & Walle, 2019; Li et al., 2021). Two theories explain how financial inclusion affects the environment. Financial inclusion theoretically helps diverse sectors of economies flourish by raising capital (Rehman et al., 2021). Energy usage and environmental deterioration increase as economic activities encourage corporations to produce more. Zaidi and Zhao (2021) suggest that inclusive financial services allow clients to finance high-energy consumer products like vehicles, coolers, and air conditioners, increasing energy consumption and environmental risk. Memduh Eren et al. (2022) found that financial development in Turkey harms the environment. Fareed et al. (2022) find that financial inclusion worsens Eurozone environmental degradation while innovation mitigates these effects. Zaidi et al. (2021) conclude that growing energy use in OECD nations caused environmental difficulties and CO2 emissions from 2004 to 2017. Shahbaz et al. (2020) confirm that financial development harms environmental quality in eight emerging nations. Financial development boosts CO2 emissions, worsening the UAE's environment. Adebayo et al. (2022) and Ganda (2021) may also support the idea that financial globalization-induced FDI will cause technology spillover. However, other considerations support financial inclusion's environmental benefits. Sustainable energy technology financing is crucial for environmental quality (Ganda, 2021). Making funds easily accessible with lower rates and more achievable financial requirements for various society groups to finance productive activities and initiate renewable energy research and development helps protect the environment and combat environmental degradation. Recent empirical studies by Rahman et al. (2022), Zafar et al. (2022), and Du et al. (2022) show that financial inclusion improves environmental quality in high-income countries.

**Table 1 Summary of Literature Review**

| Author(s) | Year | Variables | Data/ Sample | Methodology/ Framework | Findings |
|---|---|---|---|---|---|
| Le et al. | 2020 | Financial inclusion, CO2 emission | 31 Asian countries, 2004-2014 | Panel data analysis | Positive relationship |
| Sidi and Embarik | 2017 | Financial development, CO2 emission | 19 emerging nations, 1990-2013 | Dynamic panel framework settings | Unfavorable impact of financial development |
| Charfeddine and Kahia | 2019 | Financial development, | -MENA,1980-2015 | Experimental studies | Favorable role of |

| | | | | | |
|---|---|---|---|---|---|
| | | Climate change | | | financial development |
| Raghotla and Chatidi | 2020 | Financial system, $CO_2$ emission | -Brazil Nations,1998-2016 | - Panel data analysis | Financial development worsens $CO_2$ emission |
| Gök | 2020 | Financial prosperity, energy-efficient products, $CO_2$ emission | -27 Sep 2019 | -Meta-Regression Analysis (Primary Studies) FAT-PET | Financial prosperity raises $CO_2$ emission |
| AlMulali et al. | 2015 | -Financial development, trade openness, urbanization, $CO_2$ emission | -Europe, 1990-2013 | -Panel Data Analysis | A positive relationship between financial inclusion and $CO_2$ emission |
| Pata | 2018 | - Financial development, $CO_2$ emission | -Turkey,1974-2013 | -Environmental Kuznet Curve | Positive relationship between financial inclusion and $CO_2$ emission |
| Renzhi and Baek | 2020 | Financial inclusion, $CO_2$ emission | 103 nations | Environmental Kuznets Curve (EKC) paradigm | Inverted U-shaped relationship |
| Zafar et al. | 2020 | Industrialization, $CO_2$ emission | Asia ,1991-2017 | -Panel data Analysis | Long-term link |
| Sun et al. | 2020 | Trade openness, economic growth, $CO_2$ emission | Sub-Saharan African countries | -Environmental Kuznets Curve | Long-term association |
| Le et al. | 2016 | Trade openness, economic growth, $CO_2$ emission | -1990-2013 | -Panel data Analysis | Long-term association |
| Anser et al. | 2020 | Urbanization, $CO_2$ emission | SAARC countries, 1994-2013 | -Panel data Analysis | U-shaped relationship |

There is ongoing debate and conflicting data on inclusive finance's theoretical and empirical implications on environmental quality, as shown by the literature above review. However, there are two limitations to the current state of this research. It is the first study that focuses explicitly on the influence of inclusive finance on $CO_2$ emissions in the Chinese economy. In addition, while aggregation bias plagued prior research' use of panel data analysis, our use of time series analysis was unaffected by this issue. In addition, unlike others that have been done before, this study has considered both short- and long-term projections. We have used the ARDL model for this, a method dealing with a limited data set.

### Study Objective

The primary objective of this study is to analyze the long and short-term relationship between inclusive finance and CO2 emission using co-integration (ARDL- Approach).

### Description of Variables

The following table gives the description and operationalization of each variable.

**Table 2 Description of variables**

| Variables | Symbol | Description |
|---|---|---|
| Industrialization | Log( IND) | It is measured as industry (including construction), value added (% of GDP) |
| Population Growth | Log(POPG) | It is measured in Population growth (annual %) |
| Economic Growth | Log(GDP) | It is measured in GDP per capita. |
| Energy Consumption | Log(ENG) | It is measured in coal, oil, petroleum, and natural products) % of total energy consumption. |
| Carbon Emission | log(CO2) | It is calculated as CO2 in metric tons per capita |

### Model

The "STIRPAT" model put forth by Dietz and Rosa (1997) served as the basis for the study's analytic and theoretical framework. This study's model is based on previous research and proven economic connections.

$$\ln Co_{2_{i,t}} = \beta_0 + \beta_1 lnFII_{i,t} + \beta_2 lnGDP_{i,t} + \beta_3 lnENG_{i,t} + \beta_4 lnPOP_{i,t} + \beta_5 lnIND_{i,t} + e_{i,t}$$

Where Co2i,t stands for the log of CO2 emissions and $\boldsymbol{FI_{i,t}}$ represents the financial inclusion

### Construction of Financial Inclusion Index

In this study, the measurement of financial inclusion encompasses various indicators, including the number of bank branches per 100,000 adults, the number of ATMs per 100,000 adults, the proportion of outstanding deposits with commercial banks relative to GDP, the proportion of outstanding loans with commercial banks relative to GDP, and the percentage of domestic credit provided by banks to the private sector relative to GDP. China and PCA have collected this construct to develop a unified and relevant construct to serve as an Index. The financial inclusion index has been developed for China to make it more straightforward. It is worth mentioning that for China, the Bartlett sphericity test yielded a chi-square value of 362.522 with 10 degrees of freedom, resulting in a p-value of less than 0.000.

**Table 3 Bartlett test of sphericity**

| | |
|---|---|
| Chi-squ | 362.522 |
| Df | 10 |
| p-value | 0.000 |
| H0: No correlation between variables | |

The set of variables that was previously indicated is now referred to as being excellent for factorial analysis. The Bartlett sphericity test determines whether the hypothesis that the correlation matrix is an identity matrix is valid, indicating that variables are unrelated and thus unsuitable for structure discovery. Less than 0.05 significance level results indicate that factor analysis may benefit data. Similarly, the KMO test assesses whether constructs are acceptable for factor analysis. The statistic displays the potential shared variance among the variables as a percentage. The better the data is for factor analysis, the lower the proportion. The KMO rule of thumb has values between 0 and 1.

**Table 4 KMO Test**

| Variables | China |
|---|---|
| Bank branches per 100,000 adults | 0.64 |
| ATMs per 100,000 adults | 0.54 |
| Outstanding deposits with commercial banks % of GDP | 0.90 |
| Outstanding Loans with commercial banks % of GDP | 0.58 |
| Domestic credit to private sector by banks % of GDP | 0.80 |
| KMO overall Values | 0.80 |

The sample needed to be increased; corrective action is required if the KMO overall values are less than 0.6. When choosing values between 0.5 and 0.6, utilise the best judgment because some authors set this value at 0.5. According to (Dauriat et al., 2011; Rea & Rea, 2016), KMO scores close to 0 show this is the case even when there are significant partial correlations compared to the sum of correlations.

If we look at the KMO, overall values against each country are sufficient for factor analysis. In the same way, China has an overall KMO score of 0.80, which is above the threshold score of 0.60. The second half of the battle to construct an index is identifying the factors and explaining the variance through Eigenvalue. After extracting the components using the equation below, each country has developed an index. The Factors selection is based upon Eigenvalue criteria stated above all factors to be considered in developing an index (Webb & Lan, 2006). There are five factors for financial inclusion in each country. By considering these indicators, factor analysis applies with the Promax rotation method to operationalize this model.

Index=a1X1+a2X2+a3X3+……+apXp…… (I)

**Table 5 Factor Analysis**

| **Component** | **Eigenvalue** | **Difference** | **Proportion** | **Cumulative** |
|---|---|---|---|---|
| Component1 | 4.100 | 3.510 | 0.850 | 0.850 |
| Component 2 | 0.682 | 0.605 | 0.128 | 0.967 |
| Component 3 | 0.065 | 0.030 | 0.013 | 0.981 |
| Component 4 | 0.025 | 0.021 | 0.006 | 0.987 |
| Component 5 | 0.003 | . | 0.001 | 1.000 |

The above table represents the factor analysis for CHINA. Component-1 explains the maximum of financial inclusion. Thus, Bank branches per 100,000 adults will be considered a significant factor in the construction of the index for China. It has an Eigenvalue of 4.100 and the maximum variation is explaining 0.850. These components are selected based on Eigenvalue criteria (Patil et al., 2008).

**Table 6 Construction of Financial Inclusion Index**

| Symbol | Description |
|---|---|
| FII(1) | It is determined by the ratio of commercial bank branches per 100,000 adults. |
| FII (2) | It's calculated on the number of ATMs for every 100,000 people. |
| FII (3) | It was figured out by dividing the total amount of savings in banks by GDP. |
| FII (4) | It was calculated by dividing the total loans with banks by GDP. |
| FII (5) | It is measured as domestic credit with banks divided by GDP |

## Data

This study used secondary data and covered the period from 1965 to 2020. Time series analysis will be performed. This study comprises financial inclusion, GDP, energy consumption, Population growth, and industrialization as independent variables. The dependent variable of this study includes CO2 emission. The data of variables are taken from WDI and GFDD. This study develops a financial inclusion index that comprises five proxies.

## Methodology

First, the Augmented Duckey Fuller test (ADF) was used to determine the order of integration to determine the long-term and short-term relationships among the factors. Pesaran et al. (2001) wrote about using the ARDL method to determine if the factors are co-integrated. If co-integration exists in the model (2), an Error Correction Term (ECT) would be added to determine the short-run behavior.

## Estimation Results

### Descriptive Statistics

**Table 7 Results of Descriptive Statistics**

| Descriptive Statistics | LNCO2 | LNFII | LNENG | LNGDP | LNIND | LNPOP |
|---|---|---|---|---|---|---|
| Mean | 1.145 | 0.022 | 1.017 | 1.246 | 2.218 | 0.714 |
| Median | 0.854 | 0.181 | 0.770 | 1.566 | 3.200 | 1.058 |
| Maximum | 3.181 | 1.870 | 2.412 | 2.200 | 3.761 | 1.630 |
| Minimum | -0.700 | -2.102 | -0.608 | -2.478 | 2.527 | -0.334 |
| Std. Dev. | 1.045 | 1.207 | 0.754 | 1.206 | 0.134 | 0.321 |
| Observations | 55 | 55 | 55 | 55 | 55 | 55 |

Table 7 exhibits that the average mean value of CO2 is 1.145, and the standard deviation is 1.045, almost close to the mean value. It indicates carbon dioxide emission in the air, but the variation could be much higher. Financial inclusion, represented as FII, has a mean value of 0.022 or 22% in China. It means there is still a need for more financial inclusion in China. However, the standard deviation is relatively high, around 1.207. In other words, high variation indicates that China is in the process of adopting financial inclusion. The mean results of ENG indicate that the mean energy consumption is higher in China. At the same time, the SD value indicates a low risk of energy consumption in China. The mean economic growth is 1.246, which is considered reasonable in the China region. However, it has a higher SD of 1.307, which indicates a significant variation in economic growth.

Similarly, industrialization has, on average, 2.218 in the China region. It has an SD of 0.134, which is low. In China, population growth is 0.825, with a slight SD of 0.321. It means population growth is satisfactory for China.

### Unit Root Test

Table 8 depicts the unit root test results at the level and a difference. A unit root test is utilised to establish whether or not time-series variables are stationary. In other words, it was hypothesized that a time series variable processes a unit root. The null hypothesis states the presence of a unit root, while the alternative hypothesis, depending on the test employed, is stationarity, trend stationarity, or explosive root (Phillips & Perron, 1988). The ADF test was used to determine the degree of integration of the variables. As shown in Table 1, the unit root test results show that CO2 and economic growth are stationary at the same level. In contrast, financial inclusion, energy consumption, population, and industrialization are stationary at different significance levels.

The model's overall results show a mixed integration of factors. Applying panel ARDL co-integration to examine the short- and long-term relationships between variables is best done under these circumstances (Bahmani-Oskooee & Ng, 2002; Baharumshah et al., 2009).

**Table 8 Results of (ADF) unit root test**

| Variables | 'V at level | PV at differ |
|---|---|---|
| $CO_2$ | 0.0000 | 0.0000 |
| FI | 0.9520 | 0.0000 |
| GDP | 0.0000 | 0.0000 |
| ENG | 0.8808 | 0.0005 |
| POP | 0.8050 | 0.0185 |
| IND | 0.5922 | 0.000 |

**Cointegration Test**

This study examines the influence of inclusive finance on carbon dioxide emissions in China in the context of industrialization, economic growth, population, and energy consumption. Furthermore, for lag order selection, the following criteria are used: LR, FPE, AIC, SC, and HQ. The VAR results are shown in Table. A maximum of 5 lag duration is chosen for the model in this study based on LR, FPE, and AIC. However, for additional modelling, the Schwarz information criteria with lag duration one were applied (Ludden et al., 1994). Minimum lag selection always saves critical information in the data from loss (Doucouliagos & Stanley, 2009; Ozcicek & Douglas Mcmillin, 1999). The stationary test findings empirically showed a heterogeneous integration of factors. Panel, ARDL model Bound testing is used for further analysis to determine the presence of cointegration among variables.

**Table 9 VAR Order Selection Criteria**

Endogenous variables: LNPOP LNIND LNFII LNGDP LNENG LNCO2

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -1160.6 | NA | 1.81e-05 | 14.61999 | 14.79297 | 14.69023 |
| 1 | 982.6473 | 4018.587 | 1.15e-16 | -11.15809 | -9.428306* | -10.4557 |
| 2 | 1119.437 | 241.0922 | 5.80e-17 | -11.85546 | -8.56887 | -10.52089* |
| 3 | 1205.943 | 142.7340 | 5.54e-17 | -11.92428 | -7.08088 | -9.95755 |
| 4 | 1335.465 | 199.1412 | 3.15e-17 | -12.53082 | -6.13061 | -9.93192 |
| 5 | 1437.350 | 145.1863 | 2.62e-17 | -12.79188 | -4.83487 | -9.56081 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The bound test is used to determine whether or not there are long-term links among the variables. We must execute this test before executing the ARDL model. The general guideline for the bound test is that cointegration is present if the estimated value of the bound test (F-Statistics) is greater than the upper and lower bound values. The test is inconclusive if the F-statistics value is between these two bounds. There is no cointegration if the F-statistics value is lower than the lower bound values (Pesaran et al., 2001). Table below in this paper shows the ARDL results, which reject the null hypothesis that there is no cointegration for an alternative.

**Table 10 Bound Test**

| ARDL Bounds Testing Approach | | |
|---|---|---|
| Critical Value | F-Statistics=1.20<br>Upper Bound | Lower Bound |
| 95% | 4.01 | 2.86 |
| 90% | 3.52 | 2.45 |

After establishing the co-integration of variables, the ARDL model can be established. Pesaran and Shin (1999) and Pesaran et al (2001) presented it. The dependent variable in the ARDL model is a function of its previous values as well as the current and previous values of the other independent variables. The investigation employs the autoregressive distributed (ARDL) model, whose general form is as follows:

$$y_t = \beta_0 + \beta_1 y_{t-1} \ldots + \beta_k y_{t-k} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} \ldots + \alpha_q x_{t-q} + \varepsilon_t$$

$$y_t = \text{Dependent Variable, CO2 Emission}, \beta_0 = \text{Coefficient Value},\ y_{t-1} = \text{Lagged Value ( CO2 Emission)},\ \alpha_0 = \text{Coefficient value (Explanatory Variable)}, x_{t-1} = \text{Lagged Value (Explanatory Variable)}$$

**Table 11 (ARDL) Long Run Coefficients**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| DLNPOP | 0.400205 | 0.145655 | 1.823835 | 0.0640 |
| LNGDP | 0.014593 | 0.005269 | 1.769725 | 0.0630 |
| LNFII | 0.01082 | 0.005610 | 0.853782 | 0.0400 |
| LNIND | 0.026056 | 0.016859 | 1.204645 | 0.0290 |
| LNENG | -0.010003 | 0.088005 | -1.046105 | 0.0281 |
| C | -0.06523 | 0.072618 | -0.898266 | 0.3705 |

Additionally, (Hussain et al., 2021) used the ARDL model to analyze the effect of inclusive financing on CO2 emissions. Similarly, (Le et al., 2020) hypothesize that improved financial inclusion should be incorporated into regional climate change adaptation strategies, particularly to address the side effects of higher CO2 emissions. Table 2 shows long-term ARDL findings. Long-term data suggest financial inclusion has a 5% positive influence on CO2 emissions in China. One per cent shift in financial inclusion will impact CO2 emissions by 1.08%. The data demonstrate that financial inclusion increases CO2 emissions in China. The investigation found that Chinese citizens with better access to finance could afford more big-ticket items like cars, refrigerators, air-conditioners, and TVs, which increase the region's use of fossil fuels and CO2 emissions. These findings match (Agbenyo et al., 2019; Hussain, 2021; Le, 2020). Positive CO2 emissions result in population expansion of up to 10%. Thus, one per cent population growth increases CO2 emissions by 40%. Economic growth is significant up to 10% of the time and helps reduce CO2 emissions. If there is a 1% boost in economic behaviour, CO2 emissions will rise by 1.45%. The findings imply that rising carbon emissions in the China region are a function of economic expansion. It suggests that rising economic activity in China is primarily responsible for rising carbon emissions. Carbon emissions have significantly increased over the past few decades due to China's shift from a low-income nation to an emerging economy. China is responsible for about 27% of global carbon dioxide emissions. In the coming decades, the economy is anticipated to continue to rise due to industrialization and globalization, which will significantly impact the viability of the nations' environments.

However, energy use negatively influences CO2 emissions and is significant up to 5%. It means that a one per cent fall in energy use will increase CO2 emissions by about 1.0%.

Furthermore, industrial growth also affects CO2 emissions in the same manner as economic activity and has an effect of up to 5%. If an industry grows by 1%, CO2 emissions will increase by about 2.60%. The findings show that CO2 emissions increase due to industrialization, which uses many fossil fuels to make things. As the number of factories grows, so does the number of energy-burning plants, which hurts the environment. Also, heavy businesses pollute the environment by putting out pollutants in the environment that could be dangerous. Zhou et al. (2013), Al-Mulali & Ozturk (2015), Wang et al. (2018), and Liu et al. (2018) all agree with this result.

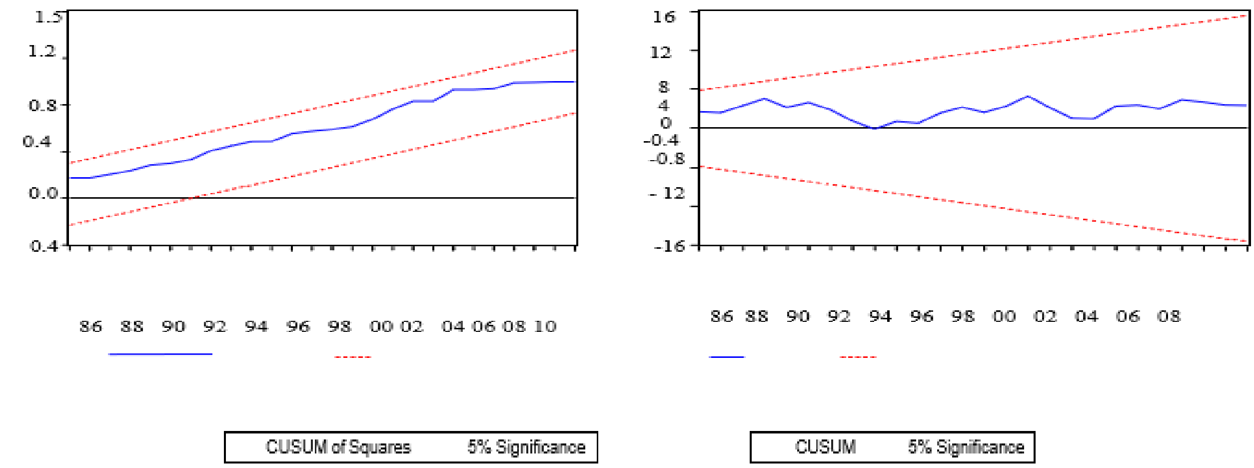
**Table 12 Results of Short Run Dynamics**

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -5.370001 | 0.123515 | -4.138261 | 0.0000 |
| DLCO2(-1) | -0.131333 | 0.005812 | -1.062417 | 0.0371 |
| DLFII(-1) | 0.101117 | 0.004213 | 1.801107 | 0.0048 |
| DLGDP(-2) | 0.035648 | 0.078630 | 2.365502 | 0.0250 |
| DPOP(-1) | 8.600000 | 2.233561 | 2.890005 | 0.0060 |
| DEC(-3) | 0.004458 | 0.004011 | 1.388341 | 0.1768 |
| DLIND(-1) | -0.242657 | 0.088735 | -2.734615 | 0.007 |
| ECT(-1) | -0.834600 | 0.128260 | -4.167644 | 0.0000 |
| R-squ | 0.716202 | Mean dept var | | 0.021620 |
| Adj R-squ | 0.661625 | S.D dept var | | 0.033742 |
| S.E. of reg | 0.019634 | Akaike info criterion | | -4.744623 |
| Sum squared resid | 0.010023 | Schwarz criterion | | -4.470807 |
| Log-likelihood | 83.69174 | F-stat | | 12.01178 |
| D-Watson stat | 2.280887 | Pro (F-stat) | | 0.000001 |

Table 12 of the Error Term Correction model results show that financial inclusion strongly influences CO2 emissions in the China region, with an impact of up to 5%. Moreover, it is instructive that a 10% increase in CO2 emissions corresponds to a 1% increase in financial inclusion. Results agree with those reported by other researchers (Agbenyo et al., 2019; Hussain et al., 2021; Le et al., 2020). CO2 emissions per capita in Pakistan increased with GDP per capita, population growth, and energy usage. CO2 emissions per person increase by 3.56%, 8.60%, and 0.44% for every 1% increase in GDP per person, population growth, and energy use, respectively. Since the sign of the Error Correction Term coefficient is negative and statistically significant, it follows that the short-run to long-run annual error in China's CO2 per capita would be corrected by 83.4%.

The stability of short-run and long-run parameters was analyzed using the Cumulative Sum (CUSUM) and Cumulative Sum of Square tests. Figure 2 demonstrates that the parameters are stable because they fall inside the allowable range (at the 5% significance level).

**Figure 1 Cumulative Sum and Cumulative Sum of Square**




## Discussion

This study investigates the effect of financial inclusion on CO2 emissions. The findings support the hypothesis that financial involvement, which makes it easier for people and businesses to access financial services, pushes corporations to increase output and supply customers with energy-intensive technological equipment. The findings imply that rising carbon emissions in the China region are a function of economic expansion. It suggests that rising economic activity in China is primarily responsible for rising carbon emissions. Carbon emissions have significantly increased over the past few decades due to China's shift from a low-income nation to an emerging economy. China is responsible for about 27% of global carbon dioxide emissions. In the coming decades, the economy is anticipated to continue to rise due to industrialization and globalization, which will significantly impact the viability of the nations' environments. It demonstrates how closely economic activity development is linked to increased CO2 emissions in China.

In the coming decades, industrialization processes are expected to contribute to stable economic growth due to increased economic activity, which will harm a nation's ability to sustain its environment. The data show that using fossil fuels in industrial production increases CO2 emissions. The number of energy combustion facilities develops with industrial development at the expense of environmental standards. Heavy industries also release potentially harmful pollutants into the atmosphere. The results of short-term dynamics show that CO2 emissions per capita in Pakistan increased with GDP per capita, population growth, and energy usage. Since the sign of the Error Correction Term coefficient is negative and statistically significant, it follows that the short-run to long-run annual error in China's CO2 per capita would be corrected by 83.4%.

The stability of short-run and long-run parameters was analyzed using the Cumulative Sum (CUSUM) and Cumulative Sum of Square tests, demonstrating that the parameters are stable because they fall inside the allowable range (at the 5% significance level).

## Conclusion

This study investigates the effect of inclusive finance on environmental quality. The findings support the hypothesis that financial involvement, which makes it easier for people and businesses to access financial services, pushes corporations to increase output and supply customers with energy-intensive technological equipment. The findings suggest that increasing economic growth leads to increased CO2 emissions in the China region. It demonstrates how closely economic activity development is linked to increased CO2 emissions in China. CO2 emissions have increased hugely as China transitioned from undeveloped to developing economies during the last few decades. China accounts for around 27% of global $CO_2$ emissions. It is expected that, in the coming decades, industrialization processes will contribute to stable economic growth due to increased economic activity, which will negatively impact a nation's ability to sustain its environment. The data show that using fossil fuels in industrial production increases $CO_2$ emissions. The number of energy combustion facilities develops with industrial development at the expense of environmental standards. Heavy industries also release potentially harmful pollutants into the atmosphere, which can worsen the quality of the environment and is currently humankind's biggest worry.

Carbon dioxide ($CO_2$) is among the greenhouse gases released in larger quantities due to human activities. These emissions contribute to global warming, which is anticipated to result in heightened occurrences and severity of severe events, including floods, cyclones, heavy rainfall, and droughts. The Error Correction Term coefficient is negative and statistically significant, indicating that approximately 83.4% of the error in $CO_2$ per capita in China is expected to be corrected annually from the short run to the long run. The stability of the error-correcting model's parameters has been observed. Hence, it is recommended that the government formulate a comprehensive policy that prioritizes developing and implementing environmentally friendly alternative energy sources. This approach is crucial in mitigating $CO_2$ emissions and regulating the earth's surface temperature, reducing the likelihood of extreme events in China.

**Recommendations & Policy Implications**

The phenomenon of extensive and disproportionate development has given rise to many difficulties, notably encompassing the destruction of the environment and the exacerbation of climate change. Global warming poses a significant peril to the survival of the human species and has emerged as a prominent apprehension over the last twenty years. In recent times, the issue of financial inclusion has garnered global recognition as a significant aspect of the battle against climate change. Hence, it is imperative to foster enhanced collaboration among China to address and alleviate climate change's consequences effectively. It is imperative to address these policies in order to tackle the issues presented by climate change effectively.

- The government recommends establishing a regional energy security plan, explicitly focusing on cooperative development mechanisms to optimize investment.
- In a similar vein, it is imperative to implement carbon sequestration technologies as a means of mitigating carbon emissions. The process entails the sequestration of carbon dioxide, wherein it is effectively isolated from the surrounding environment and subsequently stored within plant organisms.
- One potential approach is incentivizing the financial sector to prioritize environmental improvement by providing loans supporting investments in low-pollution projects. These projects would aid in safeguarding the environment and facilitate the adoption of sophisticated, cleaner, and more environmentally friendly approaches by enterprises.
- Businesses in underdeveloped nations prioritize financial loans above green technology investments, contributing to climate change due to economic pressure. The conflict between economic growth and environmental sustainability is unavoidable. We propose strategies harmonizing financial inclusion with $CO_2$ reduction to promote sustainable, comprehensive development.

**Future Research**

- This study can be further improved by undertaking extensive variables to find the impacts of financial inclusion on climate change in China and some other top carbon dioxide-producing countries like the US, India, and Russia.

- Future research could examine how governance levels affect the association between financial inclusion and climate change indicators. Research on financial inclusion based on a broader set of fundamental attributes like penetration, availability, and usage of financial systems in each country or region could help policymakers understand the non-linear relationship between financial inclusion and climate change.

**Limitations**

- The study has a limited period. Thus, aggregating data from different countries throughout time would be more effective than using time series.
- Only China is included in this analysis. This study must be applied to all exponentially developing countries.
- This study needs to discuss all gases other than CO2 to understand how gases such as sulfur dioxide and nitrogen oxide affect climate change,

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