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# Financial Development and Carbon Emissions in India: Auto Regressive Distributed Lag (ARDL) Model

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## Abstract

The issue of global warming is an alarming issue for the whole world, and it is widely accepted that it is caused by excessive emissions of the carbon dioxide ($CO_2$). Over the last three decades, many countries and world organizations are trying to identify the factors which are the root cause of carbon emissions. Some recent studies have mentioned that the financial development can be an important factor which is playing a vital role in the carbon emissions. So, in this study, an attempt is made to check the impact of financial development on carbon emissions in India from 1992-2020 by using the ARDL approach. The data for the study is sourced from the world bank database. The proxy of carbon emissions and financial development considered in this study are carbon dioxide emissions (metric tons per capita) and domestic credit to private sector (% of GDP) respectively. The results of the study reveal that there is significant and positive relationship between the financial development and the carbon emissions during the post liberalization period of India.



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## 1. Introduction

Environmental degradation is one of the major issues that is impacting the human health directly and its impact is getting stronger with time. This issue is posing as a possible threat to the existence of human mankind. Global temperature has increased significantly over the last few decades and the carbon emissions are the primary drivers of this rise in the temperature (Yoro & Daramola, 2020). Although, the awareness about the issue has increased among the governments, policy makers and the people, but environmental health of the world is worsening with time as well as the carbon emissions are also increasing continuously over the last many decades, especially in developing economies. According to Global Carbon Report (2021), in 1950 the world emitted only 6 billion tons of $CO_2$ and in 1990 it reached to the 22 billion tons and in 2020

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the just before the pandemic Covid-19 in year 2018 the world was emitting the approximately 37 billion tonnes per year. Due to its seriousness, this issue has gained a lot of attention in the last few decades and continuous efforts are being made to reduce the carbon emissions by the governments. There are numerous studies have been conducted on the factors impacting the carbon emissions, such as economic growth, urbanization, trade openness, industrialization, and energy consumption(Banday, n.d.; Pao & Tsai, 2010; Zaidi et al., 2021; Zakarya et al., 2015). But some recent studies have revealed that the financial development can be an important root cause factor influencing the carbon emissions and ignoring this factor may lead to the larger problems for the climate change in future (Dasgupta et al., 2001; Tamazian&Bhaskara Rao, 2010). The theoretical channel explained behind this argument is that the activities which are responsible for the $CO_2$ emissions get the funds channelized mainly through the financial sector (Sadorsky, 2010).

Paris climate conference 2015 also suggested that to decrease the carbon emissions the green financial initiatives should be taken to fund the low carbon projects. Few central banks have also started discussion on the implications of the monetary policy on environmental degradation and climate change. A little attention has also been devoted to the role of financial markets in environmental degradation (Dasgupta et al., 2001). It has become important because the financial development can have the different effects on the carbon emissions.

In this study, the impact of financial development on $CO_2$ emissions will be checked in India. To check the impact the domestic credit to the private sector (% of GDP) is considered as the proxy of the financial development. The carbon emission proxy will be $CO_2$ emissions (metric tons per capita) as it is the most widely used proxy in the literature. The relationship between the carbon emission and finance will be examined using the Auto Regressive Distributed Lag (ARDL) model.

Further sections of the study are literature review, research methodology, empirical findings, and conclusion and findings respectively.

## 2. Literature review

The finance-$CO_2$ emissions nexus theoretical literature is not very well developed but few possible transmissions are explained between financial development and environmental degradation, reflected by $CO_2$ emissions. Still, the influence of financial development on carbon emissions is inconclusive. As per the theoretical channels, the financial development can increase the carbon emissions, or it can reduce it also.

In the literature, some scholars purposed that the financial development increases the carbon emissions. According to Dasgupta et al. (2001) financial development increases the financing channels and reduces the financing costs of the firms to make investments in the new projects and it may increase the energy consumption as well as carbon emissions. Tamazian et al. (2009) also finds that the financial sector development leads to environmental degradation. Frankel & Romer (1999) argued that financial developments can lead to the increased inflow of FDIs and can result in economic growth and increased $CO_2$ emissions. Sadorsky (2010) found that better and efficient financial intermediations seem to promote the consumer's loan activities to buy products like, automobiles, air conditioners, refrigerators, which increases the carbon emissions. Al-Mulali et al. (2015) also investigated the financial and carbon emission in 23 EU countries using panel-pooled FMLOS model and found that financial development can be an important factor in increased $CO_2$ emissions in the long-run. Lu (2018) also examined the finance-$CO_2$ emission nexus in selected Asian countries (1993-2013) and found that financial development cause carbon emissions. Cetin et al. (2018) checked the relationship between the finance and the $CO_2$ emissions using the ARDL and vector error correction model in Turkey over the period of 53 years and found that financial development causes Carbon emissions to rise in the long run.

On the other hand, some scholars also argue that financial development helps in the reduction in the carbon emissions. In this direction, Tamanzian and Rao (2010) used generalised methods of moments (GMM) estimation to check the relationship between the financial development and carbon emissions in 24 transition economies. And they found that financial developments reduce Carbon emissions in these economies. Shabaz et al. (2016) studies the finance – $CO_2$ emission relation using the ARDL bounds testing approach in south Africa over the period of 1965-2008. And they found that financial development and financial reforms reduce the carbon emission. Omri et al. (2015) also studied the finance- carbon relation using the simultaneous-equation panel data model in MENA countries over the period of 1990-2011. And they found that financial development can increase the innovation and the increased innovation can lead to the reduction in the carbon emission. Saidi and Mbarek (2017) also checked the influence of finance on carbon emission using the GMM model in 19 emerging countries over the period of 23 years (1990-2013). And they found the negative impact on carbon emissions.

Few studies also conclude that the financial development doesn't have any impact on the carbon emissions. Dogan and Turkekul (2016) studied this relation in USA by using the ARDL approach over the period of 50 years (1960-2010) and they found that it could influence the output, but it doesn't have any effect on the carbon emissions.

## 3. Research Methodology

In this study, the relationship between the financial development and $CO_2$ emissions is investigated over the period of 29 years (1992-2020) in India. The Indian economy is considered in this study because of its developing nature. As the carbon emissions in the developed economies are already decreasing or consistent (Azevedo et al., 2018). But as per world development indicators (2020), carbon emissions in many developing economies are rising over the last few decades. And due to the need of the growth for these developing economies, they are finding it very difficult to reduce their carbon emissions. So, it is very urgent and important to find the root cause for the continuous carbon emissions in these countries. And financial development can be a probable important root cause factor for the carbon emissions. The data for the study will be sourced from World Development Indicators (2021). The proxy of carbonemissions and financial development will be $CO_2$ emissions (metric tons per capita) and the domestic credit to the private sector (% of GDP) respectively. The control variable used in the study is FDI inflow (% of GDP). Based on the variables, following regression model is established:

**3.1 Model Specification:**

$$CE_{it} = \beta_0 CE_{it-1} + \beta_1 FD_{it} + \beta_2 Control_{it} + \varepsilon_{it} \quad (1)$$

Where, CE denotes $CO_2$ emission, FD reflects financial development, Control denotes control variables and $\varepsilon_{it}$ represents the error term. $\beta_0$, $\beta_1$ and $\beta_2$ represents the corresponding coefficients and i and t reflects the country and the time respectively.

Augmented-Dickey-Fuller (ADF) test is applied to check the stationarity of the variables and based on the results of ADF test the ARDL bounds test for the cointegration is confirmed for the further analysis. The ARDL approach is preferred over other regression techniques as it has many advantages as compared to other approaches (Nkoro&Uko, 2016). The short-run and long-run coefficients are also obtained using the ARDL model only. At the end, some diagnostics tests are applied to confirm the authenticity of the results. In diagnostics tests, CUSUM and CUSUMSQ test is used to check the stability of the model. Serial correlation, heteroskedasticity and normality of the model is checked using the LM test, Breusch-Pagan and Jarque-Bera tests respectively.

## 4. Result and Discussion

In this section of the study, the empirical outcomes of the unit root test, ARDL bounds test for the co-integration, long run and short run coefficients and diagnostic tests results are presented and discussed.

### 4.1 Unit root test

Stationarity series is when its structure of mean and variance do not change over the period. Stationarity of time series is pre-requisite for performing the co-integration analysis. It is important to test the stationarity of data series before the implementation of any other statistical methods as the results of stationarity helps to decide the further techniques for the study. If the data is not stationarity, then it can also lead to spurious results. In this study, Augmented-Dickey-Fuller (ADF) test is applied to check the stationarity of the data series and the results of the same are presented below in table 1.

**Table No. 1: Unit root results (ADF Test)**

| Variable | Level | 1st Difference |
|---|---|---|
| CO2 | 0.9974 | 0.0021 |
| DCP | 0.8507 | 0.0000 |
| FDI | 0.2642 | 0.0001 |
| Authors' Computation with EViews 12. | | |

The unit root results are presented in the table 1 and as mentioned earlier the ADF test is applied to check the stationarity of the series. The results of ADF test reveal that all the variables are non-stationarity at level. But, after differencing the series once, all the variables were integrated of order 1 that is I (1). At first difference the null hypothesis of presence of unit root is rejected.

### 4.2 Cointegration test

In the next step, the existence of cointegration between the variables is examined using the ARDL bounds cointegration approach.

| **Table No. 2: ARDL Bounds Co-integration Test Results** | | | |
|---|---|---|---|
| Significance | Lower Bound I (0) | Upper Bound I (1) | F-Statistic |
| 10% | 2.63 | 3.35 | 6.92 |
| 5% | 3.1 | 3.87 | |
| 2.5% | 3.55 | 4.38 | |
| 1% | 4.13 | 5 | |
| Authors' Computation with EViews 12. | | | |

In Table No. 2 the results of the ARDL bounds cointegration test results are presented. The calculated F-Statistics is 6.92 which is larger than the upper bounds I (1) at the 5% level of significance. If the F-Statistic value is greater than I (1) then it indicates co-integration between the variables. So here, the null hypothesis of no cointegration between the variables is rejected which means that there is co-integration between the financial development and the carbon emissions in India. Next, the long-run and short coefficients of the model are estimated using the ARDL model.

**4.3 Long-run and Short-run coefficients**

| **Table No. 3: Long-Run estimates based on AIC-ARDL (3,3) for the Study Period** | | |
|---|---|---|
| Variable | Coefficient | P- Value |
| DCP | 0.034117 | 0.0002 |
| FDI | 0.063710 | 0.6341 |
| C | 0.087386 | 0.5829 |
| Authors' Computation with EViews 12. | | |

In Table 3 the long run coefficients are presented. Based on the results, it is evident that financial development is having significant and positive impact on the carbon emissions in the long run as the obtained p-value is 0.0002 which is less than the 0.05. The coefficient value of financial development is 0.034 which states that 1% change in financial development leads to 0.34% change in the carbon emissions. The Foreign Direct Investment (FDI) inflow does not have any significant relationship with the carbon emissions. Next the short-run coefficients are obtained using the ARDL model only.

| **Table No. 4: Error Correction Representation of Model, (ARDL 3,3) for the Study Period** | | |
|---|---|---|
| Variable | Coefficient | p-value |
| D(CO2(-1)) | -0.260 | 0.1682 |
| D(DCP) | 0.007 | 0.0721 |
| D(DCP(-1) | -0.011 | 0.0103 |
| D(DCP(-2)) | -0.007 | 0.1160 |
| D(FDI) | -0.001 | 0.8732 |
| D(FDI(-1)) | 0.013 | 0.3245 |
| D(FDI(-2)) | -0.019 | 0.1153 |
| ECM (-1) | -0.191849 | 0.0000 |

In short run diagnostics, ecm shows how much of the disequilibrium is being corrected, that it, the extent to which any disequilibrium in the previous period is being adjusted in current point. A positive value of ecm coefficient value shows divergence, while a negative value denotes convergence, It the value of ecm is 1 than the 100% adjustment takes place and it it is 0 than no adjustment takes place in the current period. Here, the value of error correction coefficient value is -0.19 and p-value is 0.00 which suggests that there is moderate speed of convergence. The results also reveal that financial development at lag 1 have a significant impact on the carbon emissions. But still the direction of causality is not known. So, to know the direction of causality, Granger causality test is applied and the result of the same are presented below in table 5.

**4.4 Granger Causality Test**

| **Table No. 5: Granger Causality Test Results of CO2 and Financial Development of China.** | | | |
|---|---|---|---|
| Null Hypothesis | F-statistic | P-value | Casual Relation |
| DCP does not Granger Causes CO2 | 7.66970 | 0.0032 | DCP Causes CO2 |
| CO2 does not Granger Cause DCP | 1.52706 | 0.2403 | No Causality |
| Authors' Computation with EViews 12. | | | |

The granger causality test shows the direction of causality among the variables. If the p-value is less than 0.05 than the null hypothesis (does not granger cause) is rejected and on the other hand if the p-value is more than 0.05 than the null hypothesis is accepted. Here, the p-value in case of DCP does not granger cause CO2 is 0.0032 which is less than 0.05, So in this case the null hypothesis is rejected which means that the financial development causes the carbon emissions. And on the other hand, the CO2 does not granger causes p-value is 0.2403, which rejects the null hypothesis. So, in this study, unidirectional relationship is found between the financial development and CO2 emissions that is financial development causes carbon emissions in India. Next to authenticate our results some diagnostic tests are applied. The results of the same are presented in table 6.

**4.5 Diagnostic tests**

**Table No. 6: Diagnostic Tests**

| Countries | P-value |
|---|---|
| Heteroscedasticity (Breusch-Pagan-Godfrey Test) | 0.2276 |
| Serial Correlation (LM Test) | 0.08 |
| Normality (Jargue - Bera Test) | 0.22 (0.89) |
| CUSUM & CUSUM Sq. | Lies within Lines |
| Authors' Computation with EViews 12. | |

The robustness of the results is investigated with the help of diagnostic and stability tests. The ARDL models passes the diagnostic test and stability test. Heteroscedasticity, serial correlation, and normality tests are performed against diagnostic tests and CUSUM & CUSUMSQ test are applied against stability test. And the results of these diagnostic tests shows that model does not suffer from any misspecification. The CUSUM and CUSUM SQ test results also show that the model does not suffer from any structural instability over the study period.

## 5. Conclusion, Findings and Policy Implications

In this study, an attempt is made to investigate the relationship between the financial development and carbon emissions in India over the period of 28 years from 1992 to 2020. The index was constructed by using the PCA approach. The proxy of carbon emissions and financial development considered in this study are carbon dioxide emissions (metric tons per capita) and domestic credit to private sector (% of GDP) respectivelyThe ARDL model is applied to investigate the relationship. And the findings of the study reveals that the financial development of India and the carbon emissions in India have a cointegrating relationship over the study period. And the relation is between the financial development and carbon emissions is unidirectional where financial development of India causes the carbon emissions in India. So, based on the results it can be said that the financial development is very vital factor causing the carbon emissions in India. To reduce the effect of financial development on carbon emissions it is very important to frame the environment friendly policy in the financial sector and most importantly the financial sector regulatory bodies need to check the credit seeking projects. If the credit seeking projects are found to be anti-environment than such kind of loan applications need to be rejected. The financial sector also needs to follow carbon reducing practices.

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