# EFFECT OF THE FINANCIAL DEVELOPMENT ON CARBON EMISSION: AN EMPIRICAL INVESTIGATION FROM A GLOBAL PERSPECTIVE

Wijerathna W.A.I.D.[1] and Dharmarathna D.G.[2]

[1,2]Department of Accountancy and Finance, Faculty of Management Studies, Sabaragamuwa University of Sri Lanka, Belihuloya 70140, Sri Lanka

*imeshikawijerathne2@gmail.com[1], dunu@mgt.sab.ac.lk[2]*

## ABSTRACT

This study analyses the effect of financial development on Carbon ($CO_2$) emissions globally. The World Bank classification of income levels and geographical regions, including 144 countries for the 1980-2019 period, were considered. Newly introduced broad-based financial development indexes of the International Monetary Fund (IMF), i.e., financial development index, financial market index, and financial institutions index and metric tons per capita of $CO_2$ emission extracted from World Development Indicators (WDI) used to measure the financial development and $CO_2$ emission respectively. Panel cointegration tests were employed flowed by the panel unit root tests to reveal the long-run relationship of the variables, and Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators were employed to investigate the long-run impact. The significant positive long-run relationship of the financial development on $CO_2$ emission is confirmed globally. In addition, financial institutions showed higher significant long-run coefficients relative to the financial market index. The financial institutions index showed a significant impact on emissions, and it is a key cause for the positively significant impact of the aggregate financial development index. Hence, transferring to green products, services, and technologies while lowering carbon footprints is crucial in financial institutions. In addition, the adoption of digital platforms to facilitate the customers would be much worthier as it widely caused the improvement of Ecological Footprints (EFP) by lowering the actual interactions by providing a virtual interface. The information necessities of the environmentalists, economists, and regulatory agencies were facilitated through the findings to enable robust strategic decision-making processes and financial, economic, and environmental policy coherence.

**Keywords**: ***Carbon emission, IMF financial development indexes, FMOLS, DOLS***

## 1. INTRODUCTION

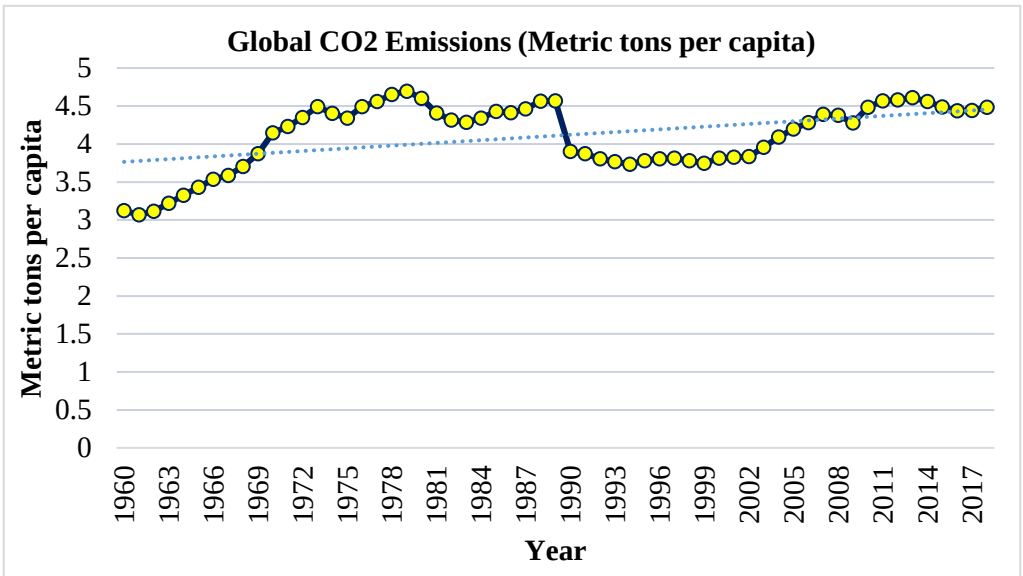
### *1.1. Background*

Researchers have emphasized the increasing speed of environmental pollution globally with the globalization and unification of the world. Further, $CO_2$ emission is one of the critical contributors to environmental pollution. In addition, when setting economic growth targets, most countries are eager to have efficient achievements,

then the effectiveness and sustainability are considered lower. When financial developments are frequent in a particular country, usually those are moving to have new investments and developing the current productions to ascertain economic growth targets. Compared to developed nations, the availability of financial resources and technological advancement is lower in developing countries; hence, developed nations are facilitating the other country categories through Foreign Direct Investments and trade partnerships and agreements.

Moreover, rules and regulations applicable to environmental considerations are tough in advanced economies although the emerging markets do not comprise relatively strict environmental laws. Thus, financially stable economies are focusing on the financial deficit countries to establish new plants and factories where the environmental impact is higher. Then they could lower the $CO_2$ emissions and environmental pollution in their countries. Although $CO_2$ is an essential factor in confirming the habitable temperature on the earth, emission imbalances directly lead to adverse ecological changes. Hence, identifying the financial development effect on $CO_2$ emission is critical unless the financially developed economy would possess an ecologically poor nation. In addition, financial development did not have a specific and standard measurement before the introduction of broad-based Financial Development (FD) indexes by the International Monetary Fund (IMF) 2016. Hence, the researcher focused on incorporating those novel indexes to nourish the literature repositories and fill the scientific knowledge vacuums. Investigating the $CO_2$ emissions affected by financial development from a global perspective and expanding the study into regional investigations and examination of the World Bank income panels is much worthier in the contemporary world today.

### *1.2. Research Problem*




Source: Databank, The World Bank

**Figure 1: Global $CO_2$ Emissions (Metric tons per capita)**

Recent research on environmental pollution revealed the significance of Carbon emission in pollution levels (Ziaei, 2015; Ozturk, 2017). Further, financial development is a recurrent theme in the research field of its substantial impact on $CO_2$ emission. The Environment Kuznets Curve (EKC) with an inverted U-shape assured the negative relationship between economic growth and environmental quality. Hence the first part of the curve should be flattened as much as possible to avoid an adverse impact on environmental degradation. In addition, when considering the global $CO_2$ emission gradually increased $CO_2$ emission reflected during the period from 1960 to 1988 while a significant downfall was recorded in 1990 as shown in Figure 1.

Moreover, $CO_2$ emissions started to increase again, and in reaching 2018, it has been reported as 4.5 metric tons per capita. From an overall view, $CO_2$ emissions increased considerably. $CO_2$ emissions are inversely related to environmental sustainability, and it is absolute. Further, financial development has been identified as a significant measure of economic growth (Khezri et al., 2021) and it is a recurrent theme among multidisciplinary researchers who are researching environmental sustainability. Thus, there is a significant need to investigate the impact of FD on $CO_2$ emissions to provide insights into lower environmental pollution.

In a decade where the pollution haven hypothesis testing is critical, scientific investigation of financial development impact on the $CO_2$ emission, which is considered one of the highest environmental pollutant substances, is vital to enhance the sustainability and quality of the environment while achieving economic development targets. Hence there is a significant vacuum in the scientific knowledge of the financial development impact of $CO_2$ emissions. Thus, the study aimed at analyzing the impact of financial development on $CO_2$ emission from a global perspective.

### *1.3. Significance of the Study*

Generally, environmental consideration is more significant in the current scenario compared to the prior periods due to the adverse climatic changes and frequent natural catastrophes globally caused by $CO_2$ emission. Hence, there is a dilemma on whether the FD significantly impacted $CO_2$ emission. In addition, broad-based newly introduced FD indexes by the IMF in 2016 were developed based on financial markets and institutions (Svirydzenka, 2016). However, most of the researchers focused on private credit to GDP and the stock market capitalization under their studies with the accessibility and measurability of financial development in a quantitative manner (Adebayo et al., 2021; Sahay et al., 2015). Thus, the researcher has identified significant research gaps in the considered area. Considering all these defects in the existing empirical shreds of evidence, in this study, the researcher incorporated the novel FD indexes of IMF to provide an in-depth understanding. Policymakers, regulatory authorities, environmental agencies, and investors must have updated information regarding $CO_2$ emissions and the impact of financial development on it. Financial development without environmental consideration is useless during a period where severe unprecedented events are often. As per the extent of the researcher's knowledge of the studying field, there are a few works of

literature concerning the financial development effect on $CO_2$ emission as an empirical investigation that provides an overall impact using FD indexes.

## 2. LITERATURE REVIEW

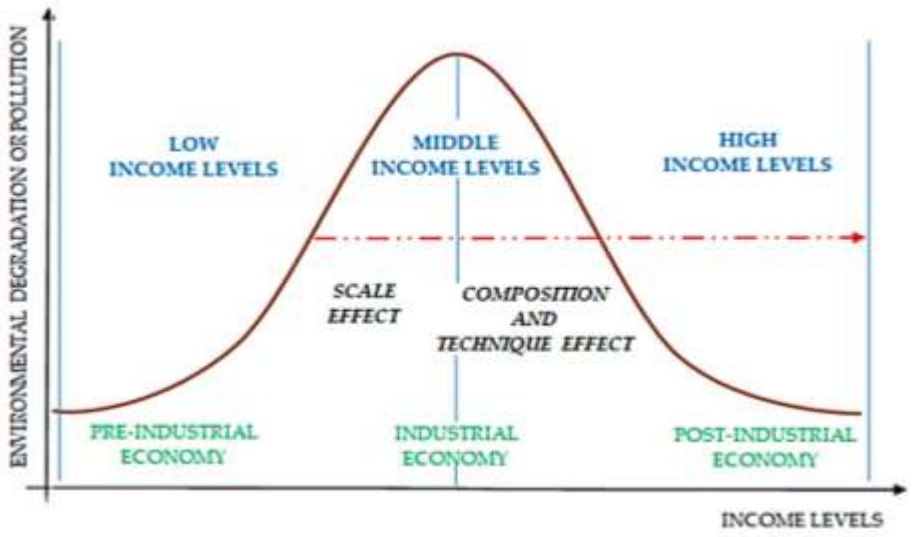
### *2.1. Theoretical Review*

The branch of theoretical review emphasized the significance of examining environmental sustainability, degradation, and pollution, specifically in today's contemporary world where catastrophes and unprecedented events are more frequent and severe than ever before using the existing theories and concepts related to the effect of financial development on the carbon emission. As financial development is recognized and proven as a significant measure of economic growth ( Adebayo et al., 2021; Ahmed et al., 2020; Khan et al., 2022; Wang et al., 2019), hereinafter the literature review provides an overview of the selected research field using the following theories and concepts while highlighting the empirical evidence.

#### *2.1.1. Environment Kuznets Curve*

Researchers identified the prior adverse effects of economic growth and later favorable impacts of economic growth on environmental sustainability as the EKC, which takes an inverted U-shape for the time being (Raymond, 2004). As the ever-largest market failure of humankind, higher $CO_2$ emissions are reducing the environmental quality in the first phase of the EKC, although the economies tried to lower and move towards green concepts after reaching a peak in emissions. Suppose it is possible to adopt technologies and methodologies where the emission levels do not exceed the required standard levels. In that case, no more specific efforts have to be incorporated in the later phase of EKC in lowering emission volumes. Enhancing developments in economic and financial sectors is directly associated with the EKC curve's shape in the contemporary world (Sun, 2013). The environmentalists also made significant efforts to investigate the level and depth of the impact of particular factors on the environment. As the EKC shows that the development of the economy initially leads to environmental pollution, while after a certain level of achieving economic growth, the economy begins to enhance the relationship with the environment while supporting to improve the environmental quality (Raymond, 2004).

Concerning the definition of EKC itself, pollution haven is a common feature of a developing country since they seek investments from other countries. Although there are enough resources, they do not have plenty of investments inside the countries. According to Figure 2, pollution haven takes place in the first phase of the EKC, and after reaching the second phase, countries tighten their regulations on the environment and reduce environmental degradation.




Source: (Ouédraogo et al., 2021)

**Figure 2: Environmental Kuznets Curve**

### *2.1.2. Pollution Haven Effect and Pollution Haven Hypothesis*

Pollution Haven is a recurrent topic for researchers in the decade, although it has been a process that runs to the emergence of developed countries in the world (Salehnia et al., 2020). When the world is becoming a global village where the physical boundaries are disregarded while the virtual world is the place where people are seeking to do so to make their lives better and easier and maximize their wealth; the focus is on having sustainable development and a sustainable environment is only a concept which is far away from the practice. When considering the Pollution Haven Effect (PHE), net exports of dirty goods from highly regulated countries should reduce as a more limited and strict regulation highly requires a specialization of the economy in the production of much cleaner products or cleaner goods, not the dirty products. On the other hand, Pollution Haven Hypothesis (PHH) explains that trade liberalization will transfer the polluting industries from countries with comparatively strict regulations to countries with relatively weak environmental regulations (Salehnia et al., 2020). It can be defined in other words as the pollution haven hypothesis claims that liberalization of international trade disproportionally influences trading in polluting goods. At the same time, it causes relocation of the polluting industries and factories with weak environmental regulations.

### *2.1.3. Environment Governance Theory*

Environmental laws are old as the evolution of the human being as the inseparable relationship between nature and earthlings. Environment Governance Theory (EGT) stands for the environmental protection vested in the robust regime (Partelow et al., 2020). Similarly, a strong government is considered an essential element in lowering environmental degradation and improving environmental sustainability (Ahmed et al., 2020). National policy integration and collaboration through formal procedures directly influenced environmental consideration. Similarly, identifying the phases

and places where the environmental concern has to be ensured and implementing workable environmental regulations was the utmost important role of the EGT. Polycentricity and solid governance, which made sufficient consideration of the environment, is a critical factor in protecting the environment (Partelow et al., 2020). Thus, the improved and amended policies aligning with the changing nature of environmental pollution and protection are identified as crucial factors ensuring environmental sustainability.

### *2.1.4. Broad-based Index of Financial Development*

Generally, researchers used a wide range of proxies to measure financial development, which significantly caused the development of a financial development index to resolve the issue of having different measures. Further, using a single indicator to investigate financial development was criticized as the vast diversity among the countries worldwide and the evolution of financial systems in the dynamic world; there should be a reliable and robust measure of financial development (Sahay et al., 2015). Hence, to compare different contexts and provide a reliable outcome to reveal the impact of financial development. Thereupon, IMF considered this matter critically and introduced a broad range of indicators based on the depth, access, and efficiency of financial institutions and financial markets aligning with Table 1 and developed aggregate financial development index (Sahay et al., 2015; Svirydzenka, 2016).

**Table 1: Indicators of Financial Development Index**

| Index | Indicators |
|---|---|
| **Financial Development (FD) Index** | |
| **FI** | Financial Institutions/ FI Index |
| **FM** | Financial Markets/ FM Index |
| **Financial Institutions (FI) Index** | |
| **FID** | *Financial Institutions Depth* |
| **FID1** | Private sector credit to GDP |
| **FID2** | Pension fund assets to GDP |
| **FID3** | Mutual fund assets to GDP |
| **FID4** | Insurance premiums (life + non-life) to GDP |
| **FIA** | *Financial Institutions Access* |
| **FIA1** | Bank branches per 100,000 adults |
| **FIA2** | ATMs per 100,000 adults |
| **FIE** | *Financial Institutions Efficiency* |
| **FIE1** | Net interest margin |
| **FIE2** | Lending-deposits spread |
| **FIE3** | Non-interest income to total income |
| **FIE4** | Overhead costs to total assets |
| **FIE5** | Return on assets |
| **FIE6** | Return on equity |
| **Financial Markets (FM) Index** | |
| **FMD** | *Financial Markets Depth* |
| **FMD1** | Stock market capitalization to GDP |
| **FMD2** | Stocks traded to GDP |
| **FMD3** | International debt securities of government to GDP |
| **FMD4** | Total debt securities of the financial corporation to GDP |
| **FMD5** | Total debt securities of nonfinancial corporations to GDP |

| | |
|---|---|
| **FMA** | *Financial Markets Access* |
| **FMA1** | Percent of market capitalization outside of the top 10 largest companies |
| **FMA2** | Total number of issuers of debt (domestic and external, finance and non-finance corporations) |
| **FME** | *Financial Markets Efficiency* |
| **FME1** | Stock market turnover ratio (value traded/ stock market capitalization) |

Source: IMF Staff Estimates

### *2.2. Empirical Review*

When considering the literature repository available, financial development was the latest independent variable in the environment function in the research field (Adebayo et al., 2021) due to the rapid increments recorded in the financial development along with the emission volumes. Furthermore, many studies were conducted on $CO_2$ emissions, economic growth, and financial development. However, the researchers focused on the financial development indicators of the IMF in the latent period when most of the prior literature made the findings based on different types of financial development proxies. $CO_2$ emission is considered the largest failure of human beings in the recent studies carried out in global and different contextual perspectives (Khezri et al., 2021; Sahay et al., 2015; Zhao et al., 2021).

Wang et al., (2019) empirically proved financial development as a controlling factor of $CO_2$ emissions through the fundamental effect of the policies on enhancing environmental sustainability from a global perspective. Moreover, panel cointegration, FMOLS, and VECM techniques were employed to investigate the impact of financial development, economic growth, and energy consumption on $CO_2$ emissions for three decades up to 2010 globally. The panel data set was categorized into three sub-panels based on income levels, and the researcher proved the categorial differences in the analysis. Bidirectional causality was represented in the high-income panel when the low and middle-income categories showed a unidirectional causality (Sahay et al., 2015). Hence the categorial differences in the emission levels can be identified. Throughout the last half-century, researchers have been focusing their keen eyes on investigating the impact of trade intensity on environmental sustainability. At the same time, the development of foreign currency inflows and outflows was frequent. Explosive $CO_2$ emissions were analyzed as a dependent of trading (Zhao et al., 2021). The encouraging nationwide trading partnerships led to considerable environmental degradation relative to the world economy in the initial stages. Transferring pollution intensified industries were highly encouraged through the strong financial inflows and outflows facilitated by financial development (Adebayo et al., 2021). Hence, the global scenario confirmed the naturally ordered relationship of the financial development indicators in the higher $CO_2$ emission volumes.

Furthermore, researchers used a wide range of proxies to measure financial development, which significantly caused a financial development index to resolve the issue of having different measures such as stock market capitalization to GDP, private debt to GDP, etc. Further, using a single indicator to investigate financial development was criticized as the vast diversity among the countries worldwide and the evolution of 11 financial systems in the dynamic world; there should be a reliable

and robust measure of financial development (Sahay et al., 2015). Financial development has been identified as the highest economic growth contributor in recurrent global economic growth and it is widely used by researchers as a measure of economic growth (Khan et al., 2022). Hence, to compare different contexts and provide a reliable outcome to reveal the impact of financial development. Thereupon, IMF considered this matter critically and introduced a broad range of indicators based on the depth, access, and efficiency of financial institutions and financial markets and developed an aggregate financial development index (Sahay et al., 2015; Svirydzenka, 2016).

Based on the literature, the researcher developed hypotheses.

$H_1$: Financial Development Index significantly impacts $CO_2$ emission.

$H_2$: Financial Institutions Index significantly impacts $CO_2$ emission.

$H_3$: Financial Markets Index significantly impacts $CO_2$ emission.

### *2.3. Literature Gap*

As environmental consideration is crucial in recent decades, CO2 emission has been a heated debate among scientific researchers globally. When decomposing widely considered themes related to environmental degradation and pollution, economic development, energy consumption, and FDI were the highly researched areas by researchers from 1960 to 2010. From a different perspective, during the current decade, most of the analysts moved forward to investigate the impact of financial development rather than the investigations vested upon the priorly mentioned traditional variables. In addition, researchers focused their efforts on investigating the financial development effect on emissions as a proxy of economic growth and environmental pollution (Adebayo et al., 2021; Khan et al., 2022; Khezri et al., 2021; Zhao et al., 2021). They used different proxies to measure the financial development, i.e., private credit to GDP and stock market capitalization to GDP. It made it complex to encounter the comparisons. In addition, the researcher identified the literature gaps based on the employed methodology and considered data while focusing on the novelty of the research area. There is a significant scientific knowledge vacuum in applying the FD indexes although well-established indexes are developed. There is a real need to understand the emitters and the actual impact of the financial development in terms of $CO_2$ emissions to incorporate the tradeoffs of foreign currency inflows and pollution have project schemes by the policymakers and implementers of the policies. Thus, the bridging of the existing implication gap is specifically aimed by the researcher to lower $CO_2$ emissions to ensure environmental sustainability that leads to a green world tomorrow (Khezri et al., 2021). Empirical evidence supported the methodological gap due to the dynamic need of having varying methods to provide different and novel insights into the research field. In addition, panel estimation methods, i.e., OLS, adopted were usually criticized by contemporary investigators due to the ignorance of measuring the long-run relationships and the correlation (Anwar et al., 2021; Dogan & Seker, 2016; Svirydzenka, 2016). Therefore, the researcher incorporated FMOLS to address endogeneity issues and serial correlation while enhancing the robustness of the

estimates. DOLS was used to eradicate the problem of endogeneity and serial correlation.

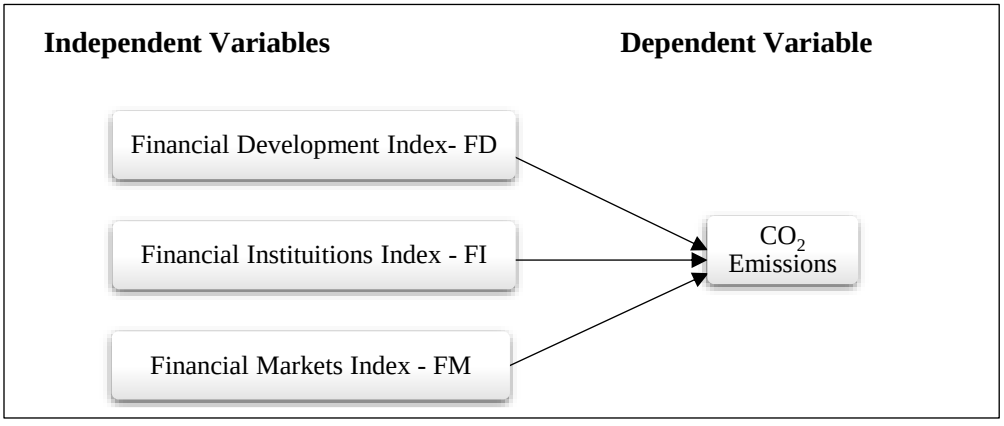
## 3. METHODOLOGY

The researchers adopted a quantitative research approach in the study. With the novelty of incorporating the FD indexes introduced by IMF in 2016 in the investigation of $CO_2$ emission, the study takes the form of an experimental research design. The study encountered the 183 countries listed by the IMF in introducing the latest broad-based index to measure financial development (Sahay et al., 2015; Svirydzenka, 2016) as the population of the study, and the whole world has been identified as the research context. Covering the whole population of 183 countries, the researcher incorporated 144 countries in the sample based on FD indexes and $CO_2$ emissions covering all the seven regions in the world i.e., East Asia & Pacific (EAP), Europe & Central Asia (ECA), Latin 4 America & Caribbean (LAC), Middle East & North Africa (MENA), North America (NA), South Asia (SA), and Sub-Saharan Africa (SSA) as shown in Table 2. As all 183 countries do not have the completed data for the considered period, 39 countries have been removed from the analysis to enhance the accuracy of the findings. Further, researchers incorporated a period from 1980-2019 based on the data availability of the IMF FD indexes.

**Table 2: Number of countries from respective geographical regions incorporated in the study**

| Serial No. | Region | No. of Countries Incorporated |
|---|---|---|
| 1 | East Asia & Pacific (EAP) | 18 |
| 2 | Europe & Central Asia (ECA) | 25 |
| 3 | Latin America & Caribbean (LAC) | 35 |
| 4 | Middle East & North Africa (MENA) | 17 |
| 5 | North America (NA) | 2 |
| 6 | South Asia (SA) | 7 |
| 7 | Sub-Saharan Africa (SSA) | 40 |
| **Total number of countries incorporated in the study** | | 144 |

### *3.1. Conceptualization of variable*




Source: Survey (2022)

**Figure 3: Conceptual Framework**

Further, referring to the research questions and objectives of the study, the researcher developed the conceptual framework as represented by Figure 3 aligning with the empirical evidence.

### *3.2. Operationalization of variables*

**Table 3: Measurement of variables**

| Variable | Definition | Proxy | Source of Data Retrieving |
|---|---|---|---|
| Dependent variable | | | |
| $CO_2$ | $CO_2$ emission is the summation of the consumption of all types of fuels, i.e., solid, liquid, gas, and the total burning of fossil fuels (Ahmed et al., 2020; Wang et al., 2019). | Metric tons per capita | DataBank, World Development Indicators, World Bank. (DataBank, 2022) |
| Independent variables | | | |
| FD | Financial development is the overall index representing both financial institutions and financial markets sub-indicators. The financial system's depth, access, and efficiency in terms of financial markets and institutions is FD (Svirydzenka, 2016). | Financial Development Index | Financial Development Indexes, IMF Strategy, Policy, and Review Department, International Monetary Fund. (Financial Development Indexes, 2022) |
| FI | Depth, access, and efficiency of financial institutions, i.e., Banks, Insurers, Mutual Funds, and Pension Funds (Sahay et al., 2015; Svirydzenka, 2016). | Financial Institutions Index | |
| FM | Depth, access, and, efficiency of financial markets, i.e., Stock Markets and, Bond Markets (Svirydzenka, 2016). | Financial Markets Index | |

Source: Survey (2022)

Table 3 represents the operationalization and retrieval sources of data along with the developed conceptual framework.

### *3.3. Data Estimation and Representation*

The researchers, incorporated panel unit root tests to identify the unit root of the data series incorporated in the analysis Levin, Lin & Chu (LLC), Im, Pesaran and Shin W-stat (IPS), ADF Fisher Chi-Square (ADF) and, PP Fisher Chi-Square (PPF) unit root tests employed by the researcher. First-generation panel unit root tests including LLC (Levin et al., 2002), IPS (Im et al., 2003), ADF, and, PPF unit root tests are based on the assumption of identical panel unit root processes where $H_0$:$\rho<1$ and $H_A$:$\rho>1$ in $\triangle y_{i,t} = \alpha_i + \rho y_{i,t} + \sum_{k=1}^{n} \emptyset \triangle y_{i,t-1} + \delta_{i,t} + \theta_t$in all the cross-sections they have identified.

Further, in this study, Pedroni (Engle-Granger based) Cointegration Test, and Kao Residual Cointegration Test were used as the residual-based cointegrations tests while incorporating the combined Johansen test, namely, Johansen Fisher Panel Cointegration to reveal the cointegration of the model. Thereafter, the researchers incorporated the FMOLS and DOLS models as cointegrating regressors.

This model incorporates the residual symmetric, and one-sided long-run covariances and $\lambda$ coefficient of the FMOLS estimator can be defined as equation (1),

$$\lambda_{NT}^{*} = N^{-1}\sum_{i=1}^{N}[\sum_{t=1}^{T}(Z_{it}-\bar{Z}_{\iota})^{2}]^{-1}\left[\sum_{t=1}^{T}(Z_{it}-\bar{Z}_{i})m_{it}^{*}-T\hat{\gamma}_{i}\right] \rightarrow \quad (1)$$

Moreover, equation (2) represents the $\beta$ coefficient for the FMOLS model, and it is identified as the coefficient of the slope;

$$\hat{\beta} = N^{-1}\sum_{i=1}^{N}(\sum_{t=1}^{T}(y_{it}-\bar{y})^{2})^{-1}(\sum_{t=1}^{T}(y_{it}-\bar{y}))Z_{it}^{*}-T\hat{\eta}_{i} \rightarrow \quad (2)$$

Where,

$$Z_{it}^{*} = (z_{it}-\bar{Z})-\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta y_{it}$$

$$\hat{\eta}_{i} \equiv \hat{\Gamma}_{21i}+\hat{\Omega}_{21i}^{0}-\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i}+\hat{\Omega}_{21i}^{0}\right)$$

$\hat{L}_{i}$= Lower triangle decomposition of $\hat{\Omega}_{i}$

$\hat{\Omega}_{i}$= Long-run Covariance

With the association of long run covariances, modified data can be defined as represented by equation (3) and the estimated bias correction term as equation (4);

$$y_{t}^{+} = y_{t}-\hat{\omega}_{12}\hat{\Omega}_{22}{}^{-1}u_{2} \rightarrow \quad (3)$$

$$\hat{\lambda}_{12}^{+} = \hat{\lambda}_{12}-\hat{\omega}_{12}\hat{\Omega}_{22}{}^{-1}\hat{\Lambda}_{22} \rightarrow \quad (4)$$

Hence the FMOLS estimator can be defined as equation (5), where the $Z_{t} = (X_{t}', D_{t}')'$ and this is identified as the ultimate construction of long run covariances, i.e., $\hat{\Lambda}$ and $\hat{\Omega}$.

$$\hat{\theta} = \begin{bmatrix}\beta \\ \hat{\gamma}_{1}\end{bmatrix} = (\sum_{t=1}^{T}Z_{t}Z_{t}')^{-1}\left(\sum_{t=2}^{T}Z_{t}y_{t}^{+}-T\begin{bmatrix}\lambda_{12}^{+\prime} \\ 0\end{bmatrix}\right) \rightarrow \quad (5)$$

Where,

$Z_{t}$ = Construction of long-run covariance

$\hat{\lambda}_{12}^{+}$ = Bias correction term

*3.3.1. Dynamic Ordinary Least Squares (DOLS)*

In this estimation method, cointegrations are augmented with lags and leads of$\Delta X_{t}$ and that directed the error term of the cointegrating equation to be orthogonal for the entire period of the stochastic regressor innovations. DOLS estimator can be defined as the equation (6);

$$v_{t} = X_{t}'\beta + D_{1t}'\gamma_{1}+\sum_{j=-q}^{r}\Delta X_{t+j}\delta + v_{1t} \rightarrow \quad (6)$$

## 4. RESULTS AND DISCUSSION

As per the recurrent issues in the studying field, ignorance of serial correlations has been identified as a critical factor (Ahmed et al., 2020; Anwar et al., 2021; Jiang & Ma, 2019). FMOLS methods were incorporated in the studies as the method usually takes the cross-sectional heterogeneity, serial correlation, and endogeneity issues (Sahay et al., 2015; Dogan & Seker, 2016). Hence, the researcher employed the FMOLS as the static model when the DOLS models encountered the dynamic model's necessity as the estimation method. Considering all these factors researcher employed, FMOLS and DOLS as the main estimators.

**Table 4: Unit Root Tests**

| Panel Unit Root Test | | | | |
|---|---|---|---|---|
| | Assumes common unit root process | Assumes individual unit root process | | |
| **Variable** | **LLC** | **IPS** | **ADF** | **PPF** |
| **Dependent Variable** | | | | |
| **$CO_2$** | $-32.06_{(.00)}^{D*}$ | $-41.79_{(.00)}^{D*}$ | $2147.83_{(.00)}^{D*}$ | $449.39_{(.00)}^{D*}$ |
| **Independent Variables** | | | | |
| **FD** | $-6.12_{(.00)}^{D*}$ | $-39.03_{(.00)}^{D*}$ | $1974_{(.00)}^{D*}$ | $349.84_{(.00)}^{D*}$ |
| **FI** | $-5.23_{(.00)}^{D*}$ | $-38.22_{(.00)}^{D*}$ | $350.59_{(.01)}^{D*}$ | $425.08_{(.00)}^{*}$ |
| **FM** | $-3.51_{(.00)}^{D*}$ | $-36.92_{(.00)}^{D*}$ | $1796.04_{(.00)}^{D*}$ | $3118.60_{(.00)}^{D*}$ |

*Note: $^{D}$ represents the first difference, and * represents a 0.01 significance level*
*Probability values represented in the parentheses*

Source: Outputs of analysis (2022)

The researcher incorporated Levin, Lin & Chu (LLC), Im, Pesaran, and Shin W-stat (IPS), ADF Fisher Chi-Square (ADF) and, PP Fisher Chi-Square (PPF) panel unit root tests to ensure the stationarity of the data series included in the investigation. The employed unit root tests output shown in Table 4 is used to confirm the long-run stationarity of the data series.

**Table 5: Correlation Analysis**

| Variables | Correlation Coefficient |
|---|---|
| FD | $0.68_{(.00)}^{*}$ |
| FI | $0.67_{(.00)}^{*}$ |
| FM | $0.60_{(.00)}^{*}$ |
| Observations | 5577 |

Dependent Variable: $CO_2$
Note: *represents 0.01 significance level and probability value represented in the parentheses

Source: Outputs of analysis (2022)

Correlation Analysis was employed to reveal the association between $CO_2$ and financial development including all three Financial Development Index, Financial Institutional Index, and Financial Market Index, and the results are shown in Table 5.

Three cointegration tests were employed to ensure the long-run relationship of variables and cointegration test results are shown in Table 6.

**Table 6: Cointegration Tests**

| **Pedroni Residual Cointegration Test** | | |
|---|---|---|
| **Model** | 1a | 1b |
| **Within Dimensions** | | |
| **Panel v-Stat** | 17.69(.00) | 13.54(.00) |
| **Panel rho-Stat** | -24.72(.00) | -17.15(.00) |
| **Panel PP-Stat** | -29.73(.00) | -28.51(.00) |
| **Panel ADF-Stat** | -31.98(.00) | -30.09(.00) |
| ***Weighted Stat*** | | |
| **Panel v-Stat** | -0.91(.82) | -1.68(.95) |
| **Panel rho-Stat** | -2.52(.01) | -1.13(.13) |
| **Panel PP-Stat** | -3.74(.00) | -3.72(.00) |
| **Panel ADF-Stat** | -3.25(.00) | -4.02(.00) |
| **Between Dimensions** | | |
| **Group rho-Stat** | -2.75(.00) | -0.42(.34) |
| **Group PP-Stat** | -4.35(.00) | -4.81(.00) |
| **Group ADF-Stat** | -4.39(.00) | -6.04(.00) |
| **Kao Residual Cointegration Test** | | |
| **ADF** | -6.25(.00) | -6.38(.00) |
| **Johansen Fisher Panel Cointegration Test** | | |
| **Fisher Stat from trace test** | | |
| **None** | 623(.00) | 665.7(.00) |
| **At most 1** | 483(.00) | 297.8(.05) |
| **At most 2** | | 398.4(.00) |
| **Fisher Stat from max-eigen test** | | |
| **None** | 531(.00) | 570.7(.00) |
| **At most 1** | 483(.00) | 228.6(.92) |
| **At most 2** | | 398.4(.00) |

**Note: *, **, and, *** represent 0.01, 0.05, and. 0.1 significance levels and probability values represented in the parentheses**

Source: Outputs of analysis (2022)

Cointegration Regression is the main analysis technique incorporated in this study and Table 7 represents the outputs of the cointegrating regressions used to test the hypotheses.

**Table 7: Cointegrating Regression Model Summary**

**Global Perspective**
**Long-run Coefficients**

| Model | FMOLS | | | | DOLS | | | |
|---|---|---|---|---|---|---|---|---|
| | FD | FI | FM | $R^2$ | FD | FI | FM | $R^2$ |
| 1a | 0.80 (.00)* | | | 0.95 | 0.82 (.00)* | | | 0.96 |
| 1b | | 1.02 (.00)* | -0.07 (.50) | 0.96 | | 0.98 (.00)* | 0.02 (.82) | 0.97 |

Note: *, **, and, *** represent 0.01, 0.05, and. 0.1 significance levels
Probability values represented in the parentheses

Source: Outputs of analysis (2022)

As per the correlation analysis outputs shown in Table 3, FD, FM, and FI showed a statistically significant positive relationship with $CO_2$ emission globally. $CO_2$, FD, FI, and FM variables were tested in level series and first difference. In the PPF test, only FI was stationary in the level series, while all the other variables were stationary in the first difference. Aligning with Table 2, the researcher ensured the long-run stationarity at a 99% confidence level.

Aligning with the outputs of the cointegration tests shown in Table 4, the Pedroni, Kao, and Johansen Fisher cointegration tests confirmed the cointegration of models at a 0.01 significance level as most statistics comprised a probability value below 0.01 alpha. Thus, the researcher concluded that the FD, FM, and FI indexes impact $CO_2$ emissions in the long run globally at a 99% confidence level.

Cointegrating Regressions including FMOLS and DOLS estimators ensured the significance of financial development in emissions as shown in Table 5. According to the represented outputs, the FD index and FI index significantly impact $CO_2$ emission globally, and in contrast, the FM index insignificantly affects emissions. As the significance values are above the probability values of the coefficients of the FMOLS and DOLS models incorporated researcher revealed the substantial positive impact of the indexes at a 99% confidence level. According to the FMOLS models, a unit change in FD and FI affects a 0.8 and 1.02 change in $CO_2$ emission. Therefore, the developed $H_1$, $H_2$, and $H_3$ hypotheses were accepted at a 99% confidence level. Further, the DOLS model confirmed the 0.82 and 0.98 significant positive increment in the emission due to the increased unit of FD and FI indexes worldwide. The revealed significant impact of FD on $CO_2$ emission in the long run from a global perspective (Adebayo et al., 2021) reassured the researcher through this study. Moreover, developed models with higher $R^2$ not less than 0.95 values ensured the higher explanatory powers of the models globally. Based on the cointegration regressions, final fitted models were developed as in (9) and (10) by FMOLS and (11) and (12) by DOLS estimation outputs based on the (7) and (8) basic models.

$$CO2_{it} = \beta_0 + \beta_1 FD_{it} + \varepsilon_{it} \quad (7)$$

$$CO2_{it} = \beta_0 + \beta_1 FI_{it} + \beta_2 FM_{it} + \varepsilon_{it} \quad (8)$$

$$CO2_{it} = 0.80 FD_{it} + \varepsilon_{it} \quad (9)$$

$$CO2_{it} = 1.02 FI_{it} + \varepsilon_{it} \quad (10)$$

$$CO2_{it} = 0.82 FD_{it} + \varepsilon_{it} \quad (11)$$

$$CO2_{it} = 0.98 FI_{it} + \varepsilon_{it} \quad (12)$$

Where,

$CO_2$ = Carbon emission

*FD* = Financial Development Index

*FI* = Financial Institution Index

*FM* = Financial Market Index

When considering the significance of the FI index, access to financial institutions can be identified as a critical factor that impacts emissions as the number of branches, and ATMs established worldwide to facilitate the customers (Sahay et al., 2015; Dogan & Seker, 2016; Nazir et al., 2018). Although the interaction of the financial markets in terms of branches and ATMs is lower in every economy, the FI had been identified as the substantial determinant of the increasing effect of the aggregate FD index on $CO_2$ emission globally. Similarly, under this study, the "race to the bottom" scenario (i.e., financial development reduces environmental sustainability by enhancing $CO_2$ emission) can be identified through the increasing relationships, although it is not the only influencing factor and it is an essential factor. Therefore, to widen the existing scientific knowledge repository, the researcher highlighted that incorporating all nine dimensions of broad-based newly introduced FD indexes of the IMF would nurture the decision-making units further.

## 5. CONCLUSION

The researcher investigates the impact of financial development on $CO_2$ emission globally using a sample of 144 countries. A period of 40 years from 1980 to 2019 is considered in the study. Aligning with the cointegration tests employed, including Pedroni, Kao, and Johansen Fisher cointegration tests, cointegration of financial development and $CO_2$ emission was confirmed for all the models developed for the global, income panels and regional sub-samples except the NA region, which showed no cointegration. Hence, the researcher assured the long-run relationship between the FD indexes and $CO_2$ emission.

Aligning with the cointegration tests employed, including Pedroni, Kao, and Johansen Fisher cointegration tests, long-run cointegration of financial development and $CO_2$ emission was confirmed. Hence, the researcher assured the long-run relationship between the FD indexes and $CO_2$ emission globally. In addition, the researcher assured the increasing relationship between financial development on $CO_2$ emission globally when the FD and FI indexes comprised significant positive coefficients except for FM as it was insignificant globally using the cointegrating regressions, i.e., FMOLS and DOLS estimators. Thus, the researcher ensured the significance of financial institutions than financial markets in lowering $CO_2$ emissions by encouraging green finance, eco-friendly operations, and restructuring the firms to reduce their Carbon footprints. Also, the findings of this study are complied with the previous research findings.

As the significance of the financial development in the $CO_2$ emission in the long run, necessary policy amendments and changes must be incorporated unless the dynamic world where there are frequent and severe catastrophes and natural disasters would collapse the whole financial system. Further, it will challenge the survival of human beings. When considering the substantial effect of FD as an overall index and FI index relative to the FM index in all three samples analyzed by the researcher, focusing on more greenly products, services, and business processes while adopting eco-friendly policies and practices to lower the Carbon footprints to improve EFP is much worthier and adverse effects of financial development must be carefully encountered unless the whole world would be in high risk with the increasing $CO_2$ emission.

Additionally, the policy coherence among the environmental and financial policies must be revised based on the current scenario, and the impact of FD on emissions as the contemporary world is more competitive than in the last decades. Even though the policy amendments would not be enough to lower the emission through FD impact as the implementation should be supervised and well regulated, the tightened environmental regulations worldwide aligning with the contextual differences can be used as a specific tool to lower the adverse effects of financial inflows and outflows usually facilitated with the financial developments in the partnering countries. According to the positive significance of the overall FD index on $CO_2$ emission, where the substantial role played by the FI index, continuance promotion of the eco-friendly financial system, financial policies, and green products and services is critical (Khan et al., 2022). Further, the adoption of virtual platforms and digital financing to lower carbon footprints was identified as a recurrent solution to lower the FD effect on $CO_2$ emissions (Zhao et al., 2021).

In contrast, technology transferring appears to be relocating pollution incentive projects in developing and least developed economies. Hence the financing of the projects through financial institutions must be granted after evaluating the long-term plan and effect of the respective project from several perspectives, especially on the environment, and practicing those would lower the degradation nature. Moreover, when considering the countries in the same geographical boundaries, high emitters directly impact the neighboring nation although they were free from the pollutants. To overcome these types of issues researcher recommends the promotion of regional agreements on $CO_2$ emission and financial development targets as the cause would be aroused from one country, but the outcome would not be limited to the country and affects the survival of all the earthlings. With the research gaps in studying the field based on the nexus between financial development and $CO_2$ emission, future studies on the same theme are highly appreciated. Further, financial development is a critical factor in the contemporary world today due to the hyper-competition intensified by globalization. Hence, setting FD goals in the most possible manner where the environmental consideration is also substantial must be facilitated with the information on how to align the financial and environmental policy coherences. In addition, as the findings are based on the quantitative approach and if those are tested through a qualitative approach is much worthier to recognize the deviations visible in the practical scenario.

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