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RESEARCH PAPER

# From Rupees to Responsibility: Assessing the Environmental Impacts of Financial Development in India with a Governance Lens using A VECM Approach

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**ABSTRACT**

**Purpose:** The primary aim of this study is to analyze the impact of financial development and governance in India on environmental quality within the time frame of 1998 to 2021. **Design/methodology:** The present study utilizes Principal Component Analysis (PCA) as a method for constructing an index that encompasses the factors of financial development and governance. Subsequently, the long-run association and direction of causality (short-run and Long-run) among the Environmental Quality(EQ), Financial Development (FD), and Good Governance (GOV) have been explored using Johansen-Juselius (JJ) cointegration test and Granger causality under the VECM framework respectively. **Findings:** The empirical data support long-term cointegration among variables using the Johansen-Juselius (JJ) cointegration test. VECM-based Granger causality analysis shows a unidirectional positive causal link between FD and EQ. However, increasing GOV decreases carbon emissions, which increases EQ. This discovery revolutionizes carbon emissions research. **Practical implication:** The unique notion of green financial development may solve this problem. Green project investment may change outcomes. Good governance can strategically promote financial development and environmental quality through a strong regulatory framework, incentive mechanisms, education, and corruption prevention. In CSR, Indian companies must prioritize environmental responsibility and sustainable practices. Environmental enforcement agency capacity must be increased. Environmental policy benefits from good governance and transparency. **Originality:** The current study contributes to the existing corpus of research by constructing a comprehensive Index of Financial Development and Governance which has not been attempted before. The impact of financial development on environmental quality in India has not been extensively investigated in earlier academic research, particularly in relation to the role of governance.

**HIGHLIGHTS**

- Numerous impediments exist in the accuracy of capturing multi-faceted outlook of financial development.
- The current study assesses the diversity of financial development by creating distinct indices for different components that aid in the study.
- A unidirectional and positive causal link was observed between the FD and EQ through the VECM-based Granger causality analysis.

**Keywords:** financial development, governance, carbon emission, Principal Component Analysis (PCA), VECM model

While there is a general agreement among experts that environmental conditions are influenced by economic growth, the relationship between financial development and economic growth is controversial

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and debated in the literature. For instance, there is a school of thought which suggests that financial development contributes to economic growth (Christopoulos *et al.* 2004; Bist, 2018; Murthy *et al.* 2014) as there will be a better allocation of financial resources (Lenka, 2017; Le *et al.* 2019), with the developed financial markets, institutions and instruments. This leads to higher economic growth and better economic development. However, there is an opposite school of thought (Dullien, 2010) which brings in financial crises from history, and argues that despite deepened, globally integrated and technologically driven financial markets in place, the global economy witnessed a huge dip in the economic growth and it further marred the developmental prospects of the countries hit by financial crises. These crises are largely due to the result of financial markets and their failure to allocate the available financial resources effectively towards productive means.

However, the pertinent point to be noted here is that any financial crisis in any part of the world is caused due to a combination of several factors such as regulatory failures (Khan *et al.* 2022), human greed, behavioural patterns of the investors, domestic economic conditions of the economy facing the crisis, global geo-political developments, domestic political decisions, asset bubbles etc. Thus attributing the dip in the GDP growth rates and setbacks to economic development, completely to the failure of financial markets may not be a logical corollary.

On the other hand, there is ample evidence in the literature on how financial development contributes to economic growth (Guru *et al.* 2019; Murthy and Samantaraya, 2014). However the current study confines itself to the prescription that financial market development attracts larger capital flows, which contributes to economic growth, and results in higher levels of energy consumption, which eventually leads to a detrimental impact on the environment. The present study accepts the view that FD leads to economic growth, but attempts to investigate, in the Indian context as to how it affects the environment. Finding an answer to this question is pertinent, as financial development and economic development link environmental well-being and human health (Xu *et al.* 2022). This study stays more relevant in the wake of rising global concerns to design ways and means to ensure that economic development is not achieved through actions that cause environmental degradation, as climate change and degradation of the environment have become worldwide challenges (Taylor *et al.* 1992; Warner, 2010). Carbon emissions, or greenhouse gas (GHG) emissions, cause most environmental damage (Charfeddine *et al.* 2016). Rising carbon dioxide levels not only cause global warming and climate change, but also threaten environmental stability (Zafar *et al.* 2019). Economic growth (EG) and industrialization have degraded the environment in many countries, including India (SDG, 2018; Dar *et al.* 2019; Dahiya, 2022). India, like other nations, faces natural and man-made disasters due to its diverse geographical, climatic, economic, and social conditions. In addition, high population, urbanization, industrialization, and other factors increase disaster risk.

India is one of the fastest-growing economies in the world, maintaining impressive gross domestic product (GDP) growth during the last thirty years, with an average annual growth rate of 5.4%. Not only did this economic growth lead to more energy consumption, it also increased the degree of air pollution, which ultimately led to environmental degradation. During the COVID-19, the economic growth of India slowed down, due to the shutdown of various manufacturing lines. At the same time, a significant reduction in carbon dioxide emissions was observed. This supports the fact that industrialization and economic growth cause an increase in greenhouse gas emissions and thus environmental degradation. Experts argue that a well-developed financial system will go a long way in sustaining economic growth through a healthy growth of the manufacturing sector without any environmental degradation by providing necessary funds for green technology and environmental projects (Xu *et al.* 2022). However, critics argue that rapid financial expansion may increase resource pressures and environmental degradation (Chen *et al.* 2017; Shahbaz, 2018). There is also a sense that the financial system plays its role more successfully when the governance mechanism is brought into the equation to act as the moderator of this whole affair (North *et al.* 1990). Governance helps in the effective implementation of regulations and the successful adoption of environmentally conscious

policies. Inadequate governance, on the other hand, has the potential to inflict adverse environmental effects that are linked with financial development even worse (Adegbite *et al.* 2020; Shahbaz *et al.* 2020). This research study focuses on India and aims to provide empirical insights into the complex interplay of variables such as financial development, governance and environmental degradation that affect sustainable development, so as to better understand the repercussions of these variables and their impact on India's sustainable development. Sustainable development demands a deep understanding of these complicated topics' interplay. This research adds to the discussion by investigating how financial development on environmental quality through governance.

This study uses PCA to create an index for financial development and governance, which is the study's most significant contribution. Finally, the Johansen cointegration model and VECM are used to analyze the complex relationship between financial development, environmental quality, and governance in India in both the short and long terms. The aim is to contribute to academic discussions and policymaking. The empirical results of VECM indicate that there exists a long-run relationship among the variables. Additionally, there is a unidirectional negative causal link between FD and EQ. Increased FD reduces carbon emissions, which increases EQ. However, increasing GOV decreases carbon emissions, which increases EQ These statistics can help policymakers and stakeholders to balance economic growth and environmental protection.

The study is structured as follows. Section 2 briefly reviews the literature and discusses the theoretical framework. The data involved in the study and the methods used are detailed in section 3. Detailed analysis and interpretation of the empirical data are provided in section 4. Finally, Section 5 summarizes the paper and also discusses its policy implications.

## LITERATURE REVIEW

The main focus of this study is to analyze the impact of financial development (FD) and governance (GOV) on environmental quality (EQ) within the context of India. The literature review was structured into three different sections. The initial section provides a description of the connections between the FD and EQ. The latter (second and third) sections delve into the relationship between GOV and EQ, and the interplay of EQ, FD, and GOV, respectively.

### The relationship between FD and EQ

Many theoretical frameworks and facts affect the intricate relationship between FD and EQ. Many theories examine economic growth, financial development, and environmental sustainability trade-offs and synergies. Multiple viewpoints and philosophies highlight this connection. The Environmental Kuznets Curve (EKC) shows an inverted-U connection between per capita income and environmental deterioration. In early economic growth, growing incomes may promote industrialization and resource usage, causing environmental damage. As a society becomes wealthier, it invests in cleaner technology and environmental legislation, minimizing environmental deterioration (Grossman *et al.* 1995). Financial system improvements may aid environmental sustainability. Capital markets and banks sponsor green technologies and environmental initiatives. Beck *et al.* (2004), Wang *et al.* (2023), and Razzaq *et al.* (2021) claim financial system complexity enhances environmental resource allocation. The resource curse and Dutch disease describe the environmental dangers of resource extraction-driven financial growth. Variables may cause environmental damage, economic volatility, and social inequity. Resource exports may impair diversity and sustainable development (Sachs *et al.* 1997). Strong financial markets help environmental control. Market-based mechanisms like carbon trading systems may reduce pollution by encouraging enterprises to adopt green practices. Financial institutions may affect firm behaviour and promote sustainability by considering ESG aspects while investing (Busch *et al.* 2017). Enhancing financial services for excluded groups reduces poverty and improves the environment. Financial access promotes sustainable practices and technologies, improving resource efficiency and the environment (Demirguc *et al.* 2012).

### The relationship between GOV and EQ

Governance and environmental quality drive sustainable growth. Good governance and policy may

change laws, enforcement, and public engagement, influencing the environment. Many theoretical methods explain this relationship. Institutionalism stresses how formal and informal norms, customs, and structures affect human behaviour. Good governance—transparent decision-making, rule of law, and effective regulations—can improve environmental management. Organizations that encourage sustainable resource use and pollution reduction enhance environmental quality (North *et al.* 1990). The principal-agent theory examines how agents represent persons and principals. This approach emphasizes the challenges of balancing government, regulator, and stakeholder interests in environmental law enforcement. Good governance is needed to handle information asymmetry, agency difficulties, and environmental legislation (Jensen *et al.* 2019). Forests, fisheries, and rivers are managed by the common-pool resource theory. Community-based resource management and collaborative action prevent natural resource overexploitation and degradation. Community participation, unambiguous property rights, and participatory decision-making can preserve resource utilization (Ostrom *et al.* 1990). Air and water pollution are transboundary environmental issues that require international coordination and oversight. Transboundary environmental governance uses treaties, agreements, and diplomacy to solve environmental issues and foster cooperation (Keohane *et al.* 2010). Governance should be transparent, accountable, participatory, and responsive. Good environmental management governance improves decision-making by eliminating corruption, gathering appropriate information, and engaging the public. Environmental policy design and execution depend on this component, according to UNDP (1997). Environmental federalism examines how national and local governments regulate the environment. Decentralization lets communities tailor environmental policies, enhancing resource and ecosystem management (Oates, 1972). The above theoretical frameworks stress governance's impact on environmental outcomes and sustainability. Empirical investigation in many situations is crucial to understanding the complicated relationship between governance and environmental quality.

**The relationship between EQ, FD, and GOV**

The complex relationship between environmental quality, financial development, and governance shapes sustainable development. This paper discusses the relationship's theory and includes key scholarly sources. UN SDGs provide a comprehensive framework for analyzing environmental, economic, and governance interdependencies. SDGs 8 and 12 promote economic growth and environmental sustainability through responsible resource use and consumption (UN, 2015; UNDP, 2018; Nations, U. 2015; Orlitzky *et al.* 2016). Economic, social, and environmental sustainability comprise the triple bottom line. Elkington (1997) says sustainable development requires balancing economic growth, social justice, and environmental conservation (Le & Ozturk, 2020). Ecological factors and financial systems are integrated into inclusive green finance to promote sustainable growth. Financial development and governance structures help direct resources to environmentally sustainable investments (UN Environment Inquiry, 2014; Svartzman *et al.* 2019). Environmental governance and financial regulation are linked. Effective governance is needed to match financial legislation with the goal of encouraging sustainable investments and discouraging environmentally harmful activities. Barrett *et al.* (2014) suggest incorporating environmental risk assessments into finance laws to promote sustainability. Many studies havestudied the link between corporate environmental and financial success. Effective governance and financial development may help firms adopt environmentally responsible practices, improving financial outcomes (Hart *et al.* 1996; Eccles *et al.* 2014).

These theoretical frameworks highlight the intricate relationships between environmental quality, financial development, and governance, emphasizing the need for a holistic approach to sustainable development. Empirical study in numerous contexts is essential for understanding these interactions' complexities and effects.

A large corpus of recent empirical and intellectual research suggests that ethical finance systems and good governance can improve environmental results. Financial development, measured by market depth, intermediary efficiency, and loan accessibility, affects a nation's environmental

performance. Dasgupta and Hamilton (2021) (Zadek *et al.* 2015) found that strong financial systems support sustained investments. They can efficiently fund green projects, fostering green technology innovation. This investment in green projects helps protect the environment. In formulating environmental rules and regulations, good governance is crucial. Jorgenson and Burns (2018) and Bénassy-Quéré *et al.* (2019) are among several studies that emphasize the necessity of open and accountable governance structures during environmental legislation implementation. Poor governance can create regulatory gaps, worsening environmental damage.

The above literature strongly suggests that supporting financial growth and adopting governance improvements leads to economic prosperity and environmental betterment. This discourse will examine concrete cases and policy implications to highlight the transformational power of well-regulated financial systems and efficient governance in addressing the global environmental crisis.

## DATA AND METHODOLOGY

### Data Description

Financial development and governance are multifaceted and intricate concepts. A collection of indices has been utilized in this article to summarize the general condition of financial institutions and markets. These indices encompass various factors including accessibility, depth, efficiency, and stability. This approach deviates from the traditional method of evaluating financial development by relying on a single indicator as a substitute. PCA is tasked with developing distinct indices for "Governance" and "Financial development" in this study. The proxy for environmental quality is carbon emission. After the index has been constructed, this study employs time series analysis to examine the influence of these indices on environmental quality from 1998 to 2021. The data pertaining to the variable were collected from reputable sources such as; (i) World Bank's World Development Indicator, (ii) Global Financial Development Database, and (iii) World Governance Indicator. The specifics are outlined in Table 1.

**Table 1:** Details of variables

| Category | Indicator | Data Source |
|---|---|---|
| **Financial Development** | | |
| Access | ATMs per 100,000 adults | GFD, WB |
| | Bank Branches per 100,000 adults | GFD, WB |
| | Value Traded excluding top 10 traded companies to total value traded | GFD, WB |
| | Market Capitalization excluding top 10 companies to total market capitalization | GFD, WB |
| Efficiency | Net Interest Margin | GFD, WB |
| | Overhead costs to total assets | GFD, WB |
| | SM turnover ratio | GFD, WB |
| | Bank Non-interest income to total income | GFD, WB |
| | Return on equity | GFD, WB |
| Depth | Life insurance premium volume to GDP | GFD, WB |
| | Private Credit by deposit money banks to GDP | GFD, WB |
| | Mutual Fund Assets to GDP | GFD, WB |
| | SM total value tradedto GDP | GFD, WB |
| | SM capitalization to GDP | GFD, WB |
| Stability | Bank Z-score | GFD, WB |
| | Bank capital to total assets | GFD, WB |
| | Bank Credit to Bank deposits | GFD, WB |
| | Stock price volatility | GFD, WB |
| Governance | Control of corruption | WGI, WB |
| | Government effectiveness | WGI, WB |
| | Regulatory quality | WGI, WB |
| | Rule of law | WGI, WB |
| | Voice and Accountability | WGI, WB |
| | Political Stability and Absence of violence | WGI, WB |
| Environmental Quality | Carbon emissions (metric tons per capita) | WDI, WB |

***Source:*** **World Bank Database.*

### Empirical Methodology

### Principal Component Analysis

PCA creates financial development and governance indices. Prior research lacks a complete investigation index. This statistical method is used in financial development and governance metrics (Zhou *et al.* 2007; XIE 2019; OECD, 2008). PCA finds and extracts

key components, reducing data dimensionality (Dunteman, 1989). Composite indexes are essential, multiple variables make measuring financial development and governance difficult, so dimension-reduction analysis is needed. PCA reduces dataset dimensionality by creating uncorrelated principal components. This variable reduction simplifies data representation while retaining key information. Jolliffe (2002) says merging correlated indicators into uncorrelated variables improves data interpretation. Financial development and governance indices are often multicollinear due to their close relationship. PCA solves this by creating uncorrelated principal components (Sarstedt *et al.* 2019; Wold & Geladi 1987). Some indicators are weighted more when creating an index. PCA calculates principal component weights to represent data accurately (Tabachnick *et al.* 2013). PCA reduces data representation to its basics. According to Everitt *et al.* (2011) and Shlens (2014), these elements simplify understanding and convey key points.

The construction of the indices involved several steps. The initial phase consisted of selecting the variables from various components. Subsequently, the raw data was normalized, and the PCA weights were utilized to perform arithmetic aggregation, resulting in the derivation of the relevant indices.

## Components of Financial Development

### Access

Financial access, often referred to as financial inclusion, pertains to the capacity of individuals to get and utilize a diverse array of financial services and products. It facilitates the inclusion of individuals, irrespective of their socioeconomic status, into the formal economy, allowing them to engage in activities such as saving, investing, and safeguarding themselves from financial uncertainties. The access component in the paper includes four variables namely ATMs per 100,000 adults, Bank Branches per 100,000 adults, Value traded excluding top 10 trading companies to total value traded, and Market capitalization excluding top 10 companies to total market capitalization (Lenka, 2017; Camara, 2014; Le *et al.* 2019).

The inclusion of financial access components is of paramount importance in the calculation of a financial development index, as these components encompass all facets of a robust financial system.

### Efficiency

Financial efficiency is a company's ability to maximize earnings while minimizing inefficiencies and costs. The indicator measures how well a company manages its assets and liabilities to meet financial goals. The efficiency components used in this paper include five variables Net interest margin, overhead costs to total assets, stock market (stock market) turnover ratio, Bank non-interest income to total income, and return on equity (ROI) (Le *et al.* 2019).

Therefore, financial efficiency involves optimizing financial performance through asset management, cost control, and investment returns. The inclusion of financial efficiency components within a financial development index is of paramount importance, as these components encapsulate all facets of a robust and effective financial system.

### Depth

Financial depth also called financial development or financial intermediation is the extent and efficacy of an economy's financial systems. The indicator measures the ease and complexity of financial services and organizations that transmit cash from savers and investors to borrowers and businesses. The depth components used in this paper include five variables Life insurance premium volume to GDP, private credit by deposit money banks to GDP, mutual fund assets to GDP, SM total value trade to GDP, and SM capitalization to GDP (Lenka, 2015).

The aforementioned financial depth components encompass several facets of a comprehensively established financial system, rendering them indispensable to the establishment of a financial development index.

### Stability

Financial stability is referred to as the state in which the financial system, including banks, financial institutions, markets, and the broader economy, operates smoothly and efficiently, free from significant disruptions or crises. The components of financial stability include four variables Bank Z-score, bank capital to total assets, bank credit to bank deposits, and stock price volatility (Le *et al.* 2019).

The significance of these components pertaining to financial stability in the establishment of a financial development index rests in their capacity to encompass various aspects of a secure financial system.

### Components of governance

Governance is how a group, organization, or society manages and makes choices to accomplish its goals and solve difficulties. It includes decision-making, resource allocation, and power and responsibility distribution norms, structures, and practices. A governance index is a comprehensive tool that combines several variables related to governance, including political stability, rule of law, regulatory quality, corruption, and government performance (Hellman, 2000). This technique is employed to compare and assess the performance of governance in different countries or regions.

### Normalization

The comparability of the true values of the indicator was hindered due to the utilization of data sourced from the World Bank Database, where each variable is characterized by unique units of measurement. Hence, it is customary to normalize the data prior to doing any comparisons. The utilization of the max-min technique is prevalent in various studies as a means to standardize raw data (Svirydzenka, 2016; Goel *et al.* 2020; Redhu & Jain, 2023). The equation representing the process of normalization is denoted as Equation (1), as shown below.

$$X\,normalised = \frac{X_{\max} - X_i}{X_{\max} - X_{\min}} \qquad \ldots(1)$$

In this context, $X_i$ denotes the initial value, whilst $X_{min}$ and $X_{max}$ reflect the minimum and maximum values of the variables, respectively, that have been observed for the country under examination.

### Weighing and Aggregation

The presence of connected features among the variables utilized in constructing indices can frequently result in an abundance of data that may overwhelm decision-makers and potentially lead to a situation where there is an excess of indicators but a lack of meaningful information (Nardo *et al.* 2005, p.25). PCA was employed as a statistical approach to generate indices and decrease the number of variables.

Prior to conducting PCA, it is imperative for researchers to ascertain the representativeness of their samples through the utilization of the Kaiser-Meyer- Olkin (KMO) test, as well as to verify the sphericity of their variables using the Bartlett test (Hair *et al.* 2006). Correlations may be present as a result of a multitude of component elements. Bartlett's test is employed to ascertain whether the correlation matrix of a variable represents an identity matrix ($|D|=0$) or an orthogonal matrix ($|D|=1$) with variables that are uncorrelated. PCA is ineffective in cases where the association between the variables is zero, as individual variables in the dataset contain unique and independent information. The null hypothesis of Bartlett's test posits that the selected variables are not correlated, with a correlation coefficient ($|D|$) equal to 1.

The Bartlett test reveals that the FD proxies, which include financial access, financial efficiency, financial depth, financial stability, and financial development aggregate, exhibit statistical significance (p-value = 0.000). Similarly, the test also indicates significant findings (p-value = 0.000) for the governance variable. The KMO-MSA values for the indicators are as follows: 0.641, 0.545, 0.582, 0.731, and 0.513. Additionally, the KMO-MSA value for governance is 0.526. These values suggest that PCA should be performed for all the components, as indicated in Table 2. Hence, the Bartlett test is deemed unnecessary when employing a component of the index as it solely encompasses a single variable, thereby eliminating the requirement for any multi-variate analysis.

The supplementation of Bartlett's sphericity test with KMO-MSA is necessary due to the dependence of the former's accuracy on the size of the sample. If there exists an adequate amount of variability between variables, which justifies the use of factor analysis, namely the Kaiser-Meyer-Olkin Measure of Sampling Adequacy, (KMO-MSA) test is reported to yield a good result (Kaiser, 1974). PCA can be a valuable tool in situations when the KMO index approaches unity. Conversely, when the KMO index falls below 0.5, it is advisable to refrain from the use of PCA.

**Table 2:** Factorability test

| Statistic | Access | Efficiency | Depth | Stability | Financial development | Governance |
|---|---|---|---|---|---|---|
| Determinantof The correlationmatrix | 0.004 | 0.043 | 0.029 | 0.064 | 0.047 | 0.014 |
| Kaiser - Meyer - Olkin measure of sampling adequacy KMO | 0.641 | 0.545 | 0.582 | 0.731 | 0.513 | 0.526 |
| **Bartlett test of sphericity** | | | | | | |
| Chi-square | 510.995 | 291.883 | 328.653 | 254.532 | 284.707 | 393.640 |
| DF | 6 | 10 | 10 | 6 | 6 | 15 |
| P value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

***Source:*** *Author's calculation.*

Based on the data from Table 2, it can be deduced that PCA can be utilized to examine sub-indices such as financial access, efficiency, depth, and stability. These sub-indices can then be combined to create a comprehensive financial development index. Similarly, a governance index can be constructed using the same approach, as it has been determined to meet the criteria for factorability.

The indicators are classified into four sub-indices calculation of the weighted linear average of the underlying series provides an aggregate. The weights used in this calculation are derived using PCA, which quantifies the contribution of each series to the variance of the subindex. These equations, specifically eqn(2) to eqn(7), illustrate the process of determining the weights and calculating the aggregate.

$$Fa = \sum_{J=1}^{n} w_J fa_J \quad \ldots(2)$$

$$Fe = \sum_{J=1}^{n} w_J fe_J \quad \ldots(3)$$

$$Fd = \sum_{J=1}^{n} w_J fd_J \quad \ldots(4)$$

$$Fs = \sum_{J=1}^{n} w_J fs_J \quad \ldots(5)$$

$$FD = \sum_{J=1}^{n} (w_{fa} fa + w_{fe} fe + w_{fd} fd + w_{fs} fs) \quad \ldots(6)$$

$$GOV = \sum_{J=1}^{n} w_J g_J \quad \ldots(7)$$

Where $w_j$ is weights assigned to each variable, $f_a$ is financial access, $F_e$ is financial efficiency, $F_d$ is financial depth, $F_s$ is financial stability, $F_D$ is financial development and GOV is governance.

## Modelling framework

In order to examine the enduring equilibrium and immediate dynamic connection between environmental quality, FD and governance in India, the current study employs the Johansen cointegration test and VECM for analysis. The VECM is extensively employed in academic research to examine the presence of long-term as well as short-term equilibrium relationships involving co-integrated variables (Groen & Kleibergen 2023; Mayasami & Koh 2000; Mukherjee & Naka 1995). In the present study, if the variables exhibit cointegration, the VECM equation is represented as follows:

$$EQt = \varphi 1 + \sum_{i=1}^{n} \alpha 1i \Delta EQt - 1 + \sum_{j=1}^{n} \beta 1j \Delta FDt - j + \sum_{k=1}^{n} \gamma 1k \Delta GOVt - k + \varepsilon 1 ECTt - 1 + u1t \quad \ldots(8)$$

$$FDt = \varphi 2 + \sum_{i=1}^{n} \alpha 2i \Delta FDt - 1 + \sum_{j=1}^{n} \beta 2j \Delta EQt - j + \sum_{k=1}^{n} \gamma 2k \Delta GOVt - k + \varepsilon 2 ECTt - 1 + u2t \quad \ldots(9)$$

$$GOVt = \varphi 3 + \sum_{i=1}^{n} \alpha 3i \Delta GOVt - 1 + \sum_{j=1}^{n} \beta 3j \Delta EQt - j + \sum_{k=1}^{n} \gamma 3k \Delta FDt - k + \varepsilon 3 ECTt - 1 + u3t \quad \ldots(10)$$

The coefficients of the polynomial are ϕ, $\alpha$, β, and γ. The optimal lag is represented by $n$, and the correction term is denoted as ECTt-1. Consider equation (8) as an illustrative instance, which is the model for conducting a causality test involving the variables EQ, FD, and GOV. In the event that the null hypothesis (H0: $\beta_{ij} = \gamma_{ik} = 0$) is disproven in equation (8), it can be inferred that there exists a short-term Granger causality relationship from FD and GOV to EQ. Coefficient ε1, representing the error correction term, indicates the rate at which the system adjusts toward its equilibrium state. If the null hypothesis (H0:ε1 = 0) is rejected, it can be drawn to a conclusion that there is evidence of long-term Granger causation from the right variable to the left variable.

## Empirical Results and Analysis

### Unit Root Analysis

The current study employs time series analysis which makes it necessary to check the order in which the variables are stationary to steer clear of the phenomena of spurious regression, for this two-unit root test has been integrated i.e. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test. Table 3 illustrates the results for the above.

It is observed from the test applied that all variables under the umbrella of this study are integrated at first difference i.e. $I(1)$ at a 5% level of significance (p-value < 0.05).

### Cointegration Test

Since the variables of the study have successfully passed the unit root test and exhibit characteristics of being a first-order differential stationary sequence, the present study employed the Johansen-Juselius (JJ) co-integration test and Granger causality under the VECM framework to detect the appearance of the long-run association and causality between EQ, FD and GOV. Prior to that by using VAR lag length criteria, Lag 2 is identified as the ideal lag length of the model-based Schwarz criterion (SC).

JJ co-integration test is conducted using both trace statistics and maximal eigenvalue testing methods. Guided by the estimated trace statistic and maximal eigenvalue values reported in Table 4, this study rejects the null of 'no co-integration' and fails to reject the null of at most 1 co-integration vector' among time series variables. The obtained P value (< 0.05) indicates a significant rejection of the null hypothesis at a 5 per cent level of significance, which provides evidence of long-run co-integration among the variables under consideration. However, the null of both at most 1 and at most 2 co-integration relationship among the variables fails to reject as the Trace/Max Eigen statistics (13.32/13.02 and 0.29/0.29) are less than its critical value (14.26 and

**Table 3:** Unit Root Tests

| | At level | | At First Difference | | Order of Integration |
|---|---|---|---|---|---|
| | ADF | PP | ADF | PP | |
| **Variables** | **T-statistics** | **T-statistics** | **T-statistics** | **T-statistics** | |
| EnvironmentalQuality (EQ) | -2.1933 | -2.5954 | -3.2479*** | - 3.0072*** | I (1) |
| Financial development (FD) | -0.5245 | -0.5274 | -2.5237** | - 3.9075*** | I (1) |
| Governance (GOV) | 0.7491 | 0.6568 | -2.6785*** | - 5.8161*** | I (1) |

***Source:*** *Author's calculations.*

***Note:*** *** and *** signifies significance at 5% and 1% level, respectively.*

**Table 4:** Johansen cointegration test

| Null Hypothesis | Trace statistics | 5% criticalvalue | Prob** | Max-Eigen statistics | 5% criticalvalue | Prob** |
|---|---|---|---|---|---|---|
| None | 38.3682 | 29.7971 | 0.0041 | 25.0454 | 21.1316 | 0.0133 |
| At most 1 | 13.3228 | 15.4947 | 0.1035 | 13.0239 | 14.2646 | 0.0778 |
| At most 2 | 0.2990 | 3.8415 | 0.5845 | 0.2990 | 3.8415 | 0.5845 |

***Source:*** *Author's calculation.*

***Note:*** *Trace- Statistic and Max-eigenvalue indicates 1 cointegration eqn.; * denotes the rejection of the null hypothesis at a 5% level of significance.*

3.84/3.84). Hence, it is concluded that there exists a stable long relationship between environmental quality, FD, and good governance in India during the study period.

Similarly, since the presence of co-integration doesn't mirror the direction of causality among variables and the variables of the study are non-stationary in nature, the study employed Engle and Granger's (1987) test to detect the causal relationship among variables.

## Causality Analysis using a VECM

The application of a Granger causality test follows the establishment of a cointegration relationship among variables, with the aim of formulating effective economic policies. The presence of cointegration among the different variables required the application of the VECM architecture as discussed in the previous section. According to Granger (1988), if the variable is integrated at I(1), the VECM is utilized to study the relationship between the series.

**Table 5:** Vector Error Correction Estimates

| **Cointegrating Eq** | **CointEq1** |
|---|---|
| EQ(-1) | 1.0000 |
| FD(-1) | 0.2187 [4.8392] |
| GOV(-1) | -0.8762 [5.7346] |
| C | 113.1215 |

| **Error Correction:** | **D(EQ)** | **D(FD)** | **D(GOV)** |
|---|---|---|---|
| CointEq1 | -0.0084 | 0.2105 | -0.1888 |
| | [-1.4398] | [ 2.7722] | [-3.0706] |
| **D(EQ(-1))** | 0.6276 | -0.8288 | -0.3568 |
| | [ 5.0529] | [-0.5140] | [-0.2732] |
| **D(EQ(-2))** | 0.1065 | -0.0537 | 0.6673 |
| | [ 0.8332] | [-0.0324] | [ 0.4968] |
| D(FD(-1)) | -0.0066 | 0.5697 | 0.0820 |
| | [-0.7514] | [ 4.9787] | [ 0.8852] |
| D(FD(-2)) | -0.0042 | 0.1345 | -0.0613 |
| | [-0.4703] | [ 1.1642] | [-0.6550] |
| D(GOV(-1)) | 0.0067 | 0.0220 | 0.4509 |
| | [0.6390] | [ 0.1621] | [4.1034] |
| D(GOV(-2)) | 0.0109 | -0.0691 | 0.1495 |
| | [0.9449] | [-0.4563] | [1.2376] |
| C | -0.0022 | -0.0057 | 0.0070 |
| | [-1.9659] | [-0.3877] | [ 0.5863] |

***Source:*** *Author's Calculation;* ***Note:****"t-statistics are bracketed"*

Table 5 presents the parameter estimate results for the VECM. The results show that there exists a unidirectional positive causality running from financial development to environmental quality (Value of FD coefficient 0.2187) and a negative causality from governance to environmental quality (value of gov coefficient -0.8762). The direction of causality is indicated by the sign of the coefficient. The error correction coefficient serves as an indicator of the model's ability to swiftly recover from a disturbance and revert back to its equilibrium state in the long term. A statistically significant and negative error correction coefficient for environmental quality (EQ) was observed (-0.008420), indicating the presence of short-term convergence dynamics towards a long-term equilibrium. Finally, the Granger Causality test was utilized to study the established causal relationship among the variables by the implementation of VECM. The examination differentiates the direction of causality into two distinct time frames: the short run as well as the long run. The outcomes of this analysis are presented in Table 6.

**Table 6:** VECM Granger causality test

| **Variable** | **Direction of causality** | | | |
|---|---|---|---|---|
| | **Short-run** | | | **Long-Run** |
| | **D(EQ)** | **D(FD)** | **D(GOV)** | **ECTt-1** |
| D(EQ) | — | 0.4826 | 0.2510 | -0.0084*** |
| | | (0.7856) | (0.8825) | [-1.4398] |
| D(FD) | 1.9357 | — | 0.8047 | 0.2105 |
| | (0.3799) | | (0.6687) | [ 2.7722] |
| D(GOV) | 1.9549 | 0.2082 | — | -0.1888*** |
| | (0.3763) | (0.9011) | | [-3.0706] |

***Source:*** *Author's calculation.*

***Note:*** *The chi-square value is employed in the short-term causality test, with the matching p-value enclosed between brackets. Long-term causality test t-statistics are represented in square brackets. The symbols *, **, and *** denote the statistical significance at 10%, 5%, and 1%.*

The parameter estimation findings for the VECM are presented in Table 5. The error correction coefficient functions as a metric for assessing the model's capacity to efficiently reinstate equilibrium in the long run after a disturbance. The analysis revealed a statistically significant and negative coefficient for error correction in relation to environmental quality (EQ) (-0.008420). This suggests the existence of short-term convergence dynamics towards a long-

term equilibrium. The researchers employed the Granger Causality test to investigate the established causal relationship between the variables using the VECM methodology. The study distinguishes between two unique temporal frames, namely the short run and the long run, to analyze the direction of causality. The results of this investigation are displayed in Table 6.

## CONCLUSION AND POLICY IMPLICATION

Constructing a comprehensive measure of FD that encompasses the diverse undertakings of a financial system poses a significant challenge in the empirical literature. There exist numerous obstacles in accurately capturing the multi-faceted outlook of FD, including issues pertaining to the availability and quality of data, the heterogeneity of financial systems, the absence of consensus, the trade-off between quality and quantity, institutional factors, the presence of informal financial sectors, and regulatory and legal disparities, among others (Qayyum *et al.* 2021; Jian *et al.* 2019). This study aimed to comprehensively assess the diversity of FD by creating distinct indices for each component, including access, efficiency, depth, and stability. These individual indices were subsequently combined to build a final FD index. Another multifaceted variable governance index has been developed to explore the impact of institutional quality on environmental quality by making use of PCA.

As a result, after the formation of the index, the present study aims to examine the impact of FD and governance on environmental quality, using a time series Vector Error Correction Model (VECM) for the time frame starting from 1998 to 2021. Results show a unidirectional negative causal link between FD and EQ. Increased FD increases carbon emissions, which lowers EQ. However, increasing GOV decreases carbon emissions, which increases EQ. The findings of the empirical analysis of the Johansen co-integration test indicate the presence of a sustained co-integration relationship between the variables considered. The findings of the current study hold significant policy implications in the Indian context. The financial sector has been recognized as a contributing factor leading to the deterioration of environmental quality. The adoption of the novel concept of green FD can be employed as a means to address this issue. Promoting widespread investment in ecologically sustainable projects has the potential to significantly impact future outcomes. On the other hand, good governance can strategically contribute to the promotion of FD while upholding environmental quality by the implementation of a robust regulatory framework, incentive mechanisms, integrated planning and management, capacity training, and education, as well as efforts to combat corruption.

It raises questions about balancing FD and environmental protection. It stresses the need for sustainable development to protect the environment and boost economic prosperity. Polluting industries may need tighter environmental restrictions if financial progress harms the environment. Since FD harms the environment, green finance must be promoted. This involves encouraging financial institutions to consider environmental factors while lending and investing in eco-friendly projects.

Therefore, Indian enterprises must take their environmental responsibilities seriously and include sustainable practices into Corporate Social Responsibility programs. This necessitates environmental enforcement agency capacity upgrading, stronger governance and transparency to improve environmental policy. In conclusion, the topic this study investigated is important for balancing FD and environmental preservation. India needs better governance, regulation, sustainable financing, and environmental awareness. These activities propel the nation economically and sustainably.

The empirical model can be enhanced by substituting the FD index with the index of green FD. Furthermore, it is possible to construct a more complete FD index that encompasses a broad range of aspects pertaining to FD. The current model may be enhanced by integrating other variables, such as energy consumption and economic growth, into the co-integration relationship.

## ABBREVIATIONS

PCA : Principal Component Analysis

VECM : Vector Error Correction Form

GHG : Green House Gas

FD : Financial development

GOV : Governance

EQ : Environmental Quality

SM : Stock market

ROE : Return on equity

CSR : Corporate Social Responsibility

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