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# Role of Inclusive Digital Finance on Environmental Decentralization: A Mediated Moderated Mechanism

[1]Huma Ali & [2]Anam Mubashir
[1]Institute of Banking and Finance, Bahauddin Zakariya University, Multan, Pakistan.
[2]MS, Business Administration, Institute of Banking and Finance, Bahauddin Zakariya University, Multan, Pakistan.

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## ABSTRACT

This research investigates how inclusive digital finance affects corporate green technological innovation, environmental decentralization, and how green transformational leadership moderates these relationships. As finance becomes more digitalized, especially in an inclusive manner, it encourages corporations to adopt sustainable practices, such as green technology integration, and to further decentralize their adaptive environmental strategies. This research applies the Resource-Based View (RBV) theory to explore the role of digital finance in promoting organizational green innovations, and the Ability-Motivation-Opportunity (AMO) leadership framework regarding the innovation mediating role of leadership. This study seeks to its address empirical research gaps regarding the role of inclusive digital finance in fostering environmentally sustainable corporate practices from an environmental and financial inclusivity perspective. This research focuses on the inclusive digital finance and its effects on the corporate ecosystem green innovation and the decentralization of the environment, particularly on green transformational leadership. The anticipated results would inform policy and practice in digital finance as a driver for sustainable corporate green innovations.



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## 1.0 Introduction

The journey of digital finance history began with the innovations of ATMs and online banking, progressed with the innovations of mobile banking and digital payment systems, and ended with the crossing of the payment systems. In Pakistan, innovations of Jazz Cash and Easypaisa helped to financially include the unbanked population through cashless mobile transactions and savings. The digital cash and online loans, provided with bank-level encryption and thorough data analysis, helped to include the unbanked and underbanked to the formal financial system by extending loans to those lacking traditional credit scores. This research focuses on the inclusive digital finance and its effects on the corporate ecosystem green innovation and the decentralization of the environment, particularly on green transformational leadership. This research aims to fill the gap in the literature pertaining to the effects of digital finance on the environment and the corporate pillar of sustainability.

The financial inclusion aims to fulfill the unbanked and underbanked population's diverse and varying needs. Its relevance to sustainable development remains underemphasized. Current literature focuses on the impacts on unbanked and underbanked populations when new, additional, complimentary or subsidized services are provided, and the effects that these services cause. The unaddressed gaps in the literature substantially.

## 2.0 Literature Review

### 2.1 Digital Inclusive Finance

DIF employs advanced digital innovations to enhance the allocation of financial resources. According to Tang, Wu, and Zhu (2020), DIF closes the information divide between investors and firms, thus supporting financially neglected groups, especially small businesses and retail investors. Wan, Zhou, and Xiao (2020) assert that DIF expands the range of available corporate financing, thereby easing financial limitations. While Zhao and Zhong (2021) claim that DIF employs AI and big data to enhance the financial risk control and reallocation efficiencies. World Bank (2020) reports that DIF means the provision of digital tech to the economically and financially excluded to offer low-cost financial services. The disruptive banking innovations and entrepreneurship that DIF promotes economically benefits the formal banking sector, thus, stimulating economic growth (Zhang et al., 2019; Lee at al., 2021).

### 2.2 Corporate Green Technology Innovation

Innovation is when resources are used minimally and product and process innovations are risk-free, and environmentally damaging methods are used less and less (Singh et al., 2020). Post Green Reforms Finance and removal of financial green barriers and utilization optimization of lending resource use enhance Green Innovation (Jia, J.S. & He, X.Y., 2023). Green Technology Innovations also lessen (Braun, E. & Wield, D., 2007; Kaveh, A. & O'Connor, N.G., 2022) the impact to the surroundings by consuming less energy and raw materials. “Regulation of environmental protection hinders innovation, and over protection of the environment encourages innovation” U-shaped pattern is claimed by Porter and Behera (Porter, M.E., 1991; Behera, P. & Sethi, N., 2022). Here, DIF extends Green Innovation by developing human capital through R high & D investments that fill the financial gap (Zhao, X. & Zhong, S., 2021; Jiang, D.C. & Pan, X.W.,

2022).

**2.3 Environmental Decentralization**

With environmental decentralization, the environment is managed by local authorities who respond to local ecological issues which lie within the boundaries of local authorities and fosters the development of innovative green technologies (Hao et al., 2020). It fosters the development of green growth at the local level and encourages the advancement of innovative green technologies by offering legal and financial assistance (Que et al., 2018; Manello, 2017). Nonetheless, it could have negative regional spillover consequences (D'Amato et al., 2018). Environment-related regulations on decentralization can promote GI by motivating red-green entrepreneurship which is consistent with the Porter hypothesis (Porter, M.E., 1991; Linde, 1995).

**2.4 Green Transformational Leadership**

Green transformational leadership (GTL) inspires employees to achieve environmentally sustainable goals through vision, inspiration, and intellectual stimulation (Kusi, M., Zhao, F., & Sukamani, D., 2021). GTL promotes creativity and innovation, enhancing environmental performance (Robertson, J.L. & Barling, J., 2013; Singh et al., 2020). Its dimensions—vision, inspirational motivation, supportive leadership, and intellectual stimulation—foster employee engagement in green initiatives (Bass, B.M., 1985; Hameed et al., 2022).

**2.5 Impact of Digital Inclusive Finance on Green Technology Innovation**

DIF enhances corporate green technology innovation by alleviating financial constraints and improving analytic capabilities surrounding information (Jiang, D.C. & Pan, X.W., 2022; Guo, P.Y. & Yin, Z.C., 2022). It also fosters green innovation within new energy firms and advances the initiatives surrounding environmentally sustainable consumption (Jiang, J.X. & Tang, Y.C., 2022; Feng, S.L. & Zhang, R., 2022). DIF reduces information asymmetry, thus improving risk evaluation and resource allocation (Wan, J.Y., Zhou, Q., & Xiao, Y., 2020).

**2.6 Digital Inclusive Finance and Environmental Decentralization**

In Zhou et al. (2019), DIF is described as promoting the decentralization of financial services. This is tied to the use of DIF in the improvement of different financial service cost and the allocation of resources towards the development of environmental innovations in green technologies. DIF encourages the improvement of the financial capabilities of local authorities which directly impacts their ability to control and manage pollution, this results in the uplifting of green innovations 'race to the top' (Levinson, 2003; Feng et al., 2020).

**2.7 Corporate Green Technology Innovation and Environmental Decentralization**

As indicated by Manello (2017), environmental decentralization encourages green technology innovation by motivating local governmental bodies to endorse green activities. It adds new environmental components to the political performance appraisal system which fosters originality while possibly creating region spillover effects. (Xiang, X. & Liu, C., 2022; D'Amato et al., 2018). Concerning the influence of DIF on green technology innovation, the current literature tends to overlook the firm's operations as well as the green economy's growth (Rui, X., Yao, D., & Zhou, M., 2023). Also, the green technology leadership (GTL) attributes regarding environmental sustainability merits further investigation (Huawei, T., & Siddik, A.B., 2023).

The present study addresses this gap by analyzing the principal constructs of interest, namely, DIF, green technology innovation, environmental decentralization, and GTL, and their interrelationships. This justifies the basis for the creation of a conceptual model to address the research problem.

## 3.0 Methodology

This research is anchored on a causal research design framework on the interaction of digital inclusive finance (DIF), corporate green technology innovation (GTI), environmental decentralization (ED), and green transformational leadership (GTL) within the banking industry of Pakistan. The causal explanation, as articulated by Trochim and Creswell (2018) and Donnelly (2001), works to clarify the branches' influence and the nature and direction of the impact each of them has on one another. The current study has a positivist underpinning of research philosophy and, as noted by Zefeti (2015), defends objectivity through quantification and empirical testing. Also, the research is deductively framed as it tests existing theories and previous research findings through quantitative methodologies. This is also the case with Haris et al. (2024) when analyzing the relationship between the liquidity and credit risks of a bank and their profitability. The author used primary data collected through the administration of structured questionnaires to officer-level bankers in Multan. Informed consent was obtained in regard to the study's purpose and was then kept confidential to guarantee ethical and reliable answers. Unlike the time series data predominant in prior financial studies, this research utilizes cross-sectional data to clarify direct and indirect causal relationships. This data was collected at a single point in time.

The specific demographic focused on in this study were decision-enabling role employees regarding digital inclusive finance (DIF) and Green Technology Innovation (GTI) frameworks from public and private Banks in Multan, Pakistan. Out of 300 distributed surveys, 250 returned surveys were considered a reasonable representation for this study (Trochim & Creswell, 2018). Given time and budget constraints, convenience sampling, from Allied Bank, Habib Bank, United Bank, MCB Bank, Bank Al-Falah, Askari Bank, National Bank of Pakistan and JS Bank, was used for this study. This aligns with Haris et al. (2024, in press) study, which researched financial risks using primary data collection for DIF and GTI across 20 commercial banks in Pakistan.

As for primary data collection, a structured closed-ended questionnaire based on the works of Aisaiti et al. (2018); Chege & Wang (2020); Cruz & Manata (2020) was developed. The 63-question instrument was distributed among the bankers of Multan to collect their insights on DIF, GTI, environmental decentralization (ED), and green transformational leadership (GTL). This is different from Haris et al. (2024), who is more concerned with the dynamics of the banking sector and used secondary data from bank financial statements. The demographic data collected and the inter-variable relationships were assessed using a 5-point Likert scale (strongly disagree to strongly agree). The sample size was calculated using the rule of 5 respondents for each questionnaire item (63 items × 5 = 315), and due to distribution logistics the number of distributed questionnaires was set to 300, of which 250 were returned. This is to ensure an adequate cushion for the anticipated response rate while ensuring real representation, similar to the practical approach to sampling in Haris et al. (2024).

In order to guarantee the satisfaction of the requirements of the definitions of each construct, the Reliable and Validated Scales from the Previous Studies are Used. Regarding Digital inclusive finance (DIF), the specifiaed Scales of Aisaiti et al. (2018) were used, which Digital Platforms are Escoped, and the Accessibility and sustainable innovations are highlighted (Tang et al., 2020; Zhao & Zhong, 2021). Assessments of Corporate green technology Innovation (GTI) were Elicited from Chege and Wang (2020), Jia and He (2023), and Wang et al. (2022) concerning innovations of environmentally friendly products and processes, efficiency with regard to Resources, Adaption of Technologies. Environmental Decentralization (ED) used Scales of Cruz and Manata (2020) which measure the local Goverments authority and policy independence concerning environmentally related issues (Hao et al., 2020; D'Amato et al., 2018). Dimensions of GTL were based on definitions from Chong and Wang (2023), Özgül and Zehir (2023), and Sobaih et al. (2022) which were vision, inspirational motivation, intellectual stimulation, and supportive leadership. These GTL Definitions were enhanced with Rafferty and Griffin (2004) and House (1998). All Scales used a five-point Likert scale to tune the responses to the satisfaction of a pre-defined requirement.

Data was organized, cleaned, and analyzed using Microsoft Excel and SPSS software. The analysis entailed the use of descriptive statistics to summarize the respondent's profile and the use of reliability tests for confirmation of internal consistency, and the application of inferential statistical methods, namely regression and mediation/moderation analyses, to assess the proposed relationships. Unlike regression-based time-series modeling (OLS, GMM) described in Haris et al. (2024), this research follows a cross-sectional approach and uses survey-based quantitative methods. It examines the effect of DIF on GTI and GTI on ED, with GTL as a moderating variable. Insights on how digital financial inclusion fosters innovation and decentralizes empowered environmental governance are derived from 250 responses. These responses were analyzed and targeted for officer-level personnel. The actionable strategies for the banking sector in Pakistan are clear from the study's finding on the digital finance convergence with sustainable finance innovation and coupled with radical vision and leadership to decouple the banking sector from environmental unsustainable socio-economic practice.

## 4.0 Findings and Results

### 4.1. Descriptive Statistics

Descriptive statistics summarize respondent demographics (gender, age, qualifications, experience, and current position tenure) in a single table, with graphical representations for clarity.

**Table 4.1**

| Demographic | Category | Frequency | Percent | Valid % | Cumulative % |
|---|---|---|---|---|---|
| Gender | Male | 132 | 52.8 | 52.8 | 52.8 |
| | Female | 118 | 47.2 | 47.2 | 100.0 |
| Age | 25–34 years | 84 | 33.6 | 33.6 | 33.6 |
| | 35–44 years | 100 | 40.0 | 40.0 | 73.6 |
| | 45–54 years | 44 | 17.6 | 17.6 | 91.2 |
| | 55+ years | 22 | 8.8 | 8.8 | 100.0 |
| Qualification | Bachelor's | 41 | 16.4 | 16.4 | 16.4 |
| | Master's | 112 | 44.8 | 44.8 | 61.2 |

| | | | | | |
|---|---|---|---|---|---|
| | MS/MPhil+ | 97 | 38.8 | 38.8 | 100.0 |
| Experience | <5 years | 49 | 19.6 | 19.6 | 19.6 |
| | 5–9 years | 69 | 27.6 | 27.6 | 47.2 |
| | 10–14 years | 76 | 30.4 | 30.4 | 77.6 |
| | >15 years | 56 | 22.4 | 22.4 | 100.0 |
| Position Tenure | <5 years | 62 | 24.8 | 24.8 | 24.8 |
| | 5–9 years | 72 | 28.8 | 28.8 | 53.6 |
| | 10–14 years | 58 | 23.2 | 23.2 | 76.8 |
| | >15 years | 58 | 23.2 | 23.2 | 100.0 |

## 4.2 Reliability Analysis

Reliability was assessed using Cronbach's alpha, with a threshold of ≥0.70 indicating acceptable reliability, though some constructs are slightly below, typical for exploratory studies (Hair et al., 2010). Results are:

**Table 4.2**

| Construct | No. of Items | Cronbach's Alpha |
|---|---|---|
| Green Transformational Leadership | 19 | 0.600 |
| Vision | 3 | 0.696 |
| Intellectual Stimulation | 3 | 0.603 |
| Inspirational Motivation | 3 | 0.597 |
| Supportive Leadership | 3 | 0.672 |
| Corporate Green Technology Innovation | 12 | 0.613 |
| Inclusive Digital Finance | 10 | 0.594 |
| Environmental Decentralization | 10 | 0.605 |

## 4.3 Regression Analysis

Multiple regression analysis tested the hypotheses, assessing relationships between DIF, GTI, ED, and GTL, following the rigorous regression approach in Haris et al. (2024). Results are presented with beta coefficients, $R^2$ values, and p-values (significant at $p < 0.05$), formatted for clarity and professionalism.

**Table 4.3.1: Effect of Inclusive Digital Finance on Environmental Decentralization**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| **H1** | DIF → ED | 0.357 | 0.127 | 0.000 | Significant |

**Table 4.3.2: Effect of Inclusive Digital Finance on Corporate Green Technology Innovation**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| **H2** | DIF → GTI | 0.395 | 0.156 | 0.000 | Significant |

**Table 4.3.3: Effect of Corporate Green Technology Innovation on Environmental Decentralization**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| **H3** | GTI → ED | 0.353 | 0.125 | 0.000 | Significant |

**Table 4.3.4: Mediation Effect of Corporate Green Technology Innovation**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| **H4** | GTI Mediates DIF → ED | 0.388, 0.220 | 0.151, 0.189 | 0.000, 0.000 | Significant |

**Table 4.3.5: Moderation Effect of Green Transformational Leadership (DIF → GTI)**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| **H5** | GTL Moderates DIF → GTI | 0.465, 0.402 | 0.217, 0.259 | 0.000, 0.000 | Significant |

**Table 4.3.6: Moderation Effect of Green Transformational Leadership (GTI → ED)**

| Hypothesis | Relationship | Beta Coefficient | $R^2$ | P-Value | Result |
|---|---|---|---|---|---|
| H6 | GTL Moderates GTI → ED | 0.388, 0.372 | 0.151, 0.189 | 0.000, 0.000 | Significant |

The tables above show that a 1% change in DIF leads to a 35% change in ED (H1), a 39% change in GTI (H2), and a 1% change in GTI leads to a 35% change in ED (H3). GTI mediates the DIF-ED relationship (H4, 22–38% change), while GTL strengthens the DIF-GTI (H5, 40–46% change) and GTI-ED (H6, 37–38% change) relationships, all significant at $p < 0.05$.

## 4.5 Hypothesis Testing

The hypotheses were tested using regression analysis, with all results significant ($p < 0.05$), supporting the relationships between DIF, GTI, ED, and GTL, consistent with the statistical rigor in Haris et al. (2024).

| Hypothesis | Description | Beta | P-Value | Result |
|---|---|---|---|---|
| **H1** | DIF has a significant effect on ED | 0.357 | 0.000 | Accepted |
| **H2** | DIF significantly impacts GTI | 0.395 | 0.000 | Accepted |
| **H3** | GTI has a significant effect on ED | 0.353 | 0.000 | Accepted |
| **H4** | GTI mediates the relationship between DIF and ED | 0.388, 0.220 | 0.000 | Accepted |
| **H5** | GTL moderates the relationship between DIF and GTI | 0.465, 0.402 | 0.000 | Accepted |
| **H6** | GTL moderates the relationship between GTI and ED | 0.388, 0.372 | 0.000 | Accepted |

## 5.0 Discussion and Conclusion

This research examines how digital inclusive finance (DIF) enables businesses to adopt corporate green technologies (GTI) and affect the decentralization of the environment (ED), with green transformational leadership (GTL) as a moderating variable. Using primary data collected from banks located in the city of Multan (Pakistan) and the results indicating that digitally accessible financial services promote financial inclusion and the adoption of local governance and sustainable practices.

DIF positively affects ED mostly due to the accessibility, transparency, and improvements in the governance and management of finances. Digitally inclusive streamlined finance systems afford agencies and the community's people oversee the environmental governance to manage, while governance eco-friendly technologies. Financial constraints, accessibility of capital, and shifts in investments promote the GTI of eco-friendly technologies. The result is consistent with the literature as developing economies digital finance is considered a central economic accelerator for sustainable innovation. GTI also enhances ED with the systems created for focusing localized green control of the environmental systems subsystems. The GTI innovation serves as a connection/link between DIF and ED because digital finance enables innovation for decentralized governance of the environment, achieving the desired sustainable outcomes.

The Strategic Management Perspective Positions Leadership as another determinant in this network of relationships. Luckily, transformational leadership (GTL) bolsters the effect that differentiation of financial instruments (DIF) has on green technological innovations (GTI) by inspiring personnel, spurring encouragement of certain organizational objectives aligned with the value of goal-directed organizational rationality, and sustainable organizational goal-setting, The same reasoning applies, to a lesser extent, to how GTL strengthens the effect of GTI on employee disengagement (ED), as TL fosters long-range ecological perspectives and leadership action on

green initiatives. In this respect, TL promotes disengagement because of the burdens it places upon the followers/teams which in the long run negatively impacts the climate of the workplace. The engagement in transformational (vertical) leadership creates burdens that promote disengagement which is vertically opposite to the climate that is facilitated with workplace engagement.

For the first time in the literature, the importance of leadership in the integration of digital finance with green innovation is demonstrated. From the resource-based perspective and the ability-motivation-opportunity framework, it shows how digital finance (DIF) promotes not only the financial and innovative equilibrium of a firm but also its sustainable governance. The study is relevant to the banking industry and policymakers of developing countries and Pakistan in particular because it provides insights on how to use digital finance to promote green financing and balance the eco-system.

**Huma Ali:** Problem Identification and Theoretical Framework
**Anam Mubashir:** Data Analysis, Supervision and Drafting

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