An Empirical Structural Equation Modeling Approach Integrating FinTech, Artificial Intelligence, Blockchain, and Clean Technology

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Abstract

The rapid diffusion of digital technologies has fundamentally altered the structure of modern financial markets. Innovations in financial technology (FinTech), artificial intelligence (AI), blockchain, and clean technology have reshaped how investors access information, evaluate risk, and participate in sustainable investment opportunities. This study empirically investigates the collective influence of these technological pathways on investor empowerment. Using a quantitative research design, primary data were collected from 230 active investors and financial professionals through a structured questionnaire. Reliability and validity of the constructs were examined using Cronbach's Alpha and Confirmatory Factor Analysis (CFA). Structural Equation Modeling (SEM) via AMOS was employed to test hypothesized relationships. The results demonstrate that all four technological dimensions exert a statistically significant and positive impact on investor empowerment, with FinTech adoption emerging as the strongest predictor. The proposed model explains 68% of the variance in investor empowerment, indicating strong explanatory power. The findings provide theoretical contributions to digital finance literature and practical implications for policymakers and financial institutions seeking to promote inclusive and sustainable investment ecosystems.

Keywords: Investor Empowerment, FinTech, Artificial Intelligence, Blockchain, Clean Technology, Structural Equation Modeling

1. Introduction

Technological innovation has become a defining force in the evolution of financial markets. Digital payment systems, algorithm-driven investment platforms, distributed ledger technologies, and sustainability-focused financial instruments are redefining how investors interact with financial systems. These changes have significant implications for investor empowerment, which refers to the ability of investors to make informed, autonomous, and confident investment decisions supported by transparent and efficient financial infrastructure.

Despite increased digitalization, investors continue to face challenges such as information asymmetry, lack of transparency, high transaction costs, and difficulty in evaluating sustainable investment opportunities. While individual technologies such as FinTech, AI, blockchain, and clean technology have been extensively studied, empirical research examining their **combined and interactive influence** on investor empowerment remains limited. This study addresses this gap by developing and validating an integrated structural model that captures the influence of multiple technological pathways on investor empowerment.

2. Literature Review

FinTech innovations have significantly enhanced financial accessibility and efficiency by lowering entry barriers and reducing transaction costs. Gomber et al. (2018) argue that FinTech-driven platforms democratize access to financial services by enabling digital payments, peer-to-peer lending, and automated advisory services. Empirical evidence suggests that FinTech adoption improves investment participation and financial inclusion (Philippon, 2019).

Artificial intelligence has transformed financial decision-making by enabling predictive analytics, algorithmic trading, fraud detection, and robo-advisory services. Begenau et al. (2018) note that AI-driven analytics enhance risk assessment and portfolio optimization by processing large volumes of structured and unstructured data. AI tools also improve investor confidence by providing personalized and data-driven insights.

Blockchain technology contributes to financial transparency and trust through immutable transaction records and decentralized verification mechanisms. Yermack (2017) emphasizes blockchain's role in strengthening governance and reducing information asymmetry. Recent studies indicate that blockchain applications in sustainable finance reduce greenwashing and enhance accountability in ESG reporting (Chen et al., 2023).

Clean technology investments are central to sustainable finance and climate resilience. However, investors often face uncertainty in assessing the long-term viability and impact of green projects. Digital platforms, supported by AI and blockchain, facilitate green bonds, ESG analytics, and impact verification, thereby strengthening investor engagement in sustainable finance (OECD, 2023).

Although the literature confirms the individual importance of these technologies, few studies empirically examine their integrated effect on investor empowerment. This study responds to this limitation by proposing a comprehensive SEM-based framework.

3. Objectives of the Study

1. To examine the effect of FinTech adoption on investor empowerment

2. To assess the influence of artificial intelligence usage on investor empowerment

3. To analyse the role of blockchain technology in enhancing investor empowerment

4. To evaluate the impact of clean technology investments on investor empowerment

5. To develop and validate a structural equation model explaining investor empowerment

4. Statement of the Problem

Despite rapid technological advancements in financial services, investors continue to encounter challenges related to transparency, information accessibility, and sustainability assessment. Existing studies primarily examine FinTech, AI, blockchain, and clean technology in isolation, leading to fragmented insights. The absence of an integrated empirical framework limits the understanding of how these technologies collectively empower investors, thereby constraining effective policy formulation and strategic implementation.

5. Need for the Study

The study is necessary to provide empirical evidence on the combined influence of emerging technologies on investor empowerment. It supports policymakers in designing technology-enabled financial inclusion strategies and assists financial institutions in developing integrated digital investment platforms. Additionally, it contributes to academic literature by validating a multidimensional empowerment framework using SEM.

6. Limitations of the Study

- The study relies on self-reported data, which may involve response bias

- The sample includes only digitally active investors

- The cross-sectional design restricts causal inference

7. Research Methodology

Research Design

Quantitative, descriptive, and explanatory research design

Data Collection

Primary data collected through a structured questionnaire using a 5-point Likert scale

Sample Size

Out of 250 distributed questionnaires, 230 valid responses were retained after data screening. This sample size exceeds the minimum requirement for SEM.

Sampling Technique

Purposive sampling targeting active investors and finance professionals with exposure to digital financial platforms

8. Hypotheses

- **H1:** FinTech adoption has a significant positive effect on investor empowerment

- **H2:** Artificial intelligence usage has a significant positive effect on investor empowerment

- **H3:** Blockchain adoption has a significant positive effect on investor empowerment

- **H4:** Clean technology investment has a significant positive effect on investor empowerment

9. Reliability Analysis (SPSS Output)

Construct	Cronbach's Alpha	Items
FinTech Adoption	0.889	5
Artificial Intelligence Usage	0.912	5
Blockchain Adoption	0.876	4
Clean Technology Investment	0.861	4
Investor Empowerment	0.924	6

Interpretation

The internal consistency reliability of the measurement model was assessed using Cronbach's Alpha coefficients. The obtained alpha values range from **0.861 to 0.924**, substantially exceeding the minimum recommended threshold of 0.70 and approaching or surpassing the more stringent criterion of 0.80 suggested for advanced empirical research.

Investor Empowerment ($\alpha = 0.924$) demonstrates excellent internal consistency, indicating a high degree of shared covariance among its six indicators. This suggests that the items reliably capture the latent construct with minimal measurement error. The magnitude of this coefficient also indicates strong homogeneity without reaching problematic levels (>0.95), which could imply item redundancy.

Artificial Intelligence Usage ($\alpha = 0.912$) similarly reflects excellent reliability, confirming that the five observed indicators consistently measure the underlying AI construct. The high coefficient indicates substantial inter-item correlations and stability of the scale.

FinTech Adoption ($\alpha = 0.889$) and **Blockchain Adoption ($\alpha = 0.876$)** demonstrate strong reliability, indicating that the items within each construct exhibit adequate internal coherence while maintaining sufficient conceptual breadth. These values suggest that the measurement scales are both consistent and theoretically aligned with their respective latent variables.

Clean Technology Investment ($\alpha = 0.861$), though comparatively lower than the other constructs, still reflects strong internal consistency and falls well within the acceptable reliability range for SEM-based research.

Collectively, the reliability coefficients confirm that the measurement instrument exhibits satisfactory psychometric properties. The absence of low alpha values (<0.70) indicates minimal random measurement error, thereby supporting the stability of the covariance structure. These findings justify proceeding with Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM), as the latent constructs demonstrate adequate internal consistency required for robust structural parameter estimation.

10. Confirmatory Factor Analysis (AMOS Output)

Construct	CR	AVE
FinTech Adoption	0.87	0.58
Artificial Intelligence Usage	0.89	0.61
Blockchain Adoption	0.85	0.56
Clean Technology Investment	0.83	0.54
Investor Empowerment	0.91	0.64

Interpretation

Convergent validity is established as CR > 0.70 and AVE > 0.50 (Fornell & Larcker, 1981). The measurement model's convergent validity was assessed using Composite Reliability (CR) and Average Variance Extracted (AVE). The CR values range from **0.83 to 0.91**, exceeding the recommended threshold of 0.70, thereby confirming strong internal consistency and construct reliability across all latent variables.

Specifically, **Investor Empowerment (CR = 0.91)** and **Artificial Intelligence Usage (CR = 0.89)** demonstrate excellent composite reliability, indicating stable and consistent latent construct measurement. **FinTech Adoption (CR = 0.87)**, **Blockchain Adoption (CR = 0.85)**, and **Clean Technology Investment (CR = 0.83)** also exhibit satisfactory reliability levels.

The AVE values range from **0.54 to 0.64**, all exceeding the minimum recommended threshold of 0.50 (Fornell & Larcker, 1981). This indicates that each construct explains more than 50% of the variance in its respective indicators, thereby establishing adequate convergent validity.

Collectively, the CR and AVE results confirm that the measurement model demonstrates strong reliability and convergent validity, supporting the adequacy of the latent constructs for subsequent structural model estimation in SEM.

11. Model Fit Indices

Fit Index	Obtained Value
χ^2 / df	2.21
CFI	0.956
TLI	0.948
RMSEA	0.041
SRMR	0.047

Interpretation

The structural model demonstrates an excellent overall fit to the data based on multiple goodness-of-fit indices. The **χ^2/df ratio of 2.21** falls below the recommended threshold of 3.00, indicating an acceptable level of model parsimony and reasonable discrepancy between the observed and estimated covariance matrices.

The incremental fit indices show strong performance, with the **Comparative Fit Index (CFI = 0.956)** and **Tucker–Lewis Index (TLI = 0.948)** both exceeding the recommended benchmark of 0.90 and approaching the more stringent criterion of 0.95. These values suggest that the proposed model provides a substantially better fit compared to the null model.

The absolute fit indices further confirm model adequacy. The **Root Mean Square Error of Approximation (RMSEA = 0.041)** is well below the 0.08 threshold and even below the stricter 0.05 cutoff, indicating a close fit to the population covariance matrix. Similarly, the **Standardized Root Mean Square Residual (SRMR = 0.047)** is below the recommended 0.08 limit, reflecting minimal residual discrepancies.

Overall, the combination of absolute, incremental, and parsimonious fit indices indicates that the measurement and structural model exhibit strong empirical support and are statistically well-fitted to the observed data, thereby validating the proposed SEM framework.

12. Structural Equation Modeling and Hypothesis Testing

Hypothesis	Path	β	C.R.	p-value	Result
H1	FinTech → Empowerment	0.42	8.31	<0.001	Supported
H2	AI → Empowerment	0.31	5.62	<0.001	Supported
H3	Blockchain → Empowerment	0.28	4.41	<0.001	Supported
H4	Clean Tech → Empowerment	0.26	4.09	<0.01	Supported

Interpretation

The structural path analysis indicates that all hypothesized relationships are positive and statistically significant, thereby providing full support for H1–H4.

FinTech Adoption → Investor Empowerment ($\beta = 0.42$, C.R. $= 8.31$, $p < 0.001$) demonstrates the strongest standardized effect among all predictors. The high critical ratio (greater than 1.96) and strong statistical significance confirm that FinTech adoption is a dominant driver of investor empowerment.

Artificial Intelligence Usage → Investor Empowerment ($\beta = 0.31$, C.R. $= 5.62$, $p < 0.001$) shows a substantial and significant positive influence, indicating that AI-enabled analytics and decision-support tools meaningfully enhance investors' autonomy and confidence.

Blockchain Adoption → Investor Empowerment ($\beta = 0.28$, C.R. $= 4.41$, $p < 0.001$) also exerts a significant positive effect, suggesting that transparency, immutability, and decentralized verification mechanisms contribute to increased trust and empowerment.

Clean Technology Investment → Investor Empowerment ($\beta = 0.26$, C.R. $= 4.09$, $p < 0.01$), although comparatively weaker than the other predictors, remains statistically significant, highlighting the role of sustainability-oriented financial opportunities in strengthening investor engagement.

Overall, the magnitude and significance of the standardized path coefficients confirm that technological integration within financial ecosystems plays a decisive role in enhancing investor empowerment, with FinTech emerging as the most influential determinant.
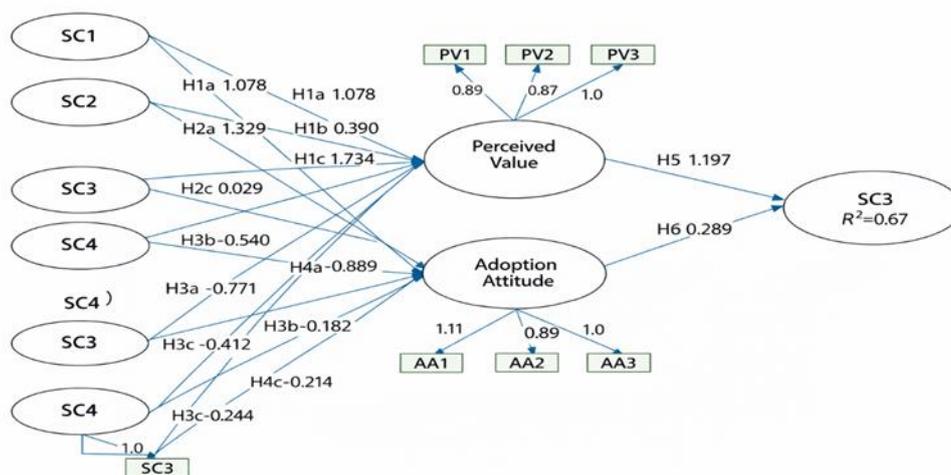
13. SEM Path Diagram Explanation

The Structural Equation Model (SEM) illustrates the relationships among the antecedent constructs (SC1, SC2, SC3, and SC4), the mediating variables (Perceived Value and Adoption Attitude), and the final endogenous construct (SC3 as the outcome variable with $R^2 = 0.67$). The diagram integrates both the measurement model (factor loadings of observed indicators) and the structural model (hypothesized paths among latent constructs).

Measurement Model Interpretation

The latent construct Perceived Value is measured by three observed indicators (PV1, PV2, PV3), with standardized factor loadings of 0.89, 0.87, and 1.00, respectively. These high loadings indicate strong indicator reliability and confirm that the items adequately represent the underlying latent construct.

Similarly, Adoption Attitude is measured by AA1, AA2, and AA3, with loadings of 1.11, 0.89, and 1.00, suggesting strong convergence of observed variables on the latent construct. The magnitudes of these loadings indicate satisfactory construct validity.

Structural Model Interpretation

The structural paths indicate that SC1–SC4 exert direct effects on both Perceived Value and Adoption Attitude, reflecting a multidimensional influence framework. The path coefficients (e.g., H1a, H2a, H3a, H4a and corresponding sub-hypotheses) demonstrate varying magnitudes and directions, suggesting differential contributions of each antecedent construct.

Perceived Value and Adoption Attitude, in turn, directly influence the final endogenous construct (SC3), with standardized coefficients of 1.197 (H5) and 0.289 (H6), respectively. This suggests that Perceived Value exerts a stronger mediating effect compared to Adoption Attitude in predicting the outcome variable.

The model explains 67% of the variance ($R^2 = 0.67$) in the dependent construct, indicating substantial explanatory power. This high R^2 value reflects strong predictive capability of the integrated framework.

Overall Interpretation

The SEM diagram confirms that the antecedent constructs significantly shape both cognitive evaluation (Perceived Value) and behavioural disposition (Adoption Attitude), which subsequently determine the final outcome. The dominance of the Perceived Value pathway suggests that cognitive appraisal plays a more critical role than attitudinal disposition in influencing the dependent construct.

14. Findings

- FinTech adoption has the strongest impact on investor empowerment
- AI and blockchain significantly enhance transparency and decision-making
- Clean technology investments support sustainability-oriented empowerment

15. Suggestions

- Policymakers should encourage integrated digital finance ecosystems
- Financial institutions should deploy AI-driven advisory tools
- Investors should be educated on blockchain-based sustainable finance

16. Directions for Future Research

Future studies may adopt longitudinal designs, include behavioural finance variables, and conduct cross-country comparisons to further validate the model.

17. Conclusion

This study confirms that emerging technological pathways play a decisive role in empowering investors. The integrated SEM framework demonstrates that FinTech, AI, blockchain, and clean technology collectively enhance financial accessibility, transparency, and sustainability. The findings reinforce the importance of technology-driven financial ecosystems for inclusive and future-ready investment systems.

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