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Article

Impact of Fintech Adoption on Financial Inclusion and Banking Efficiency in Emerging Economies

Anitha A.[1], Manasa H.[2], R. Gayathri Bai[3], Nimit Sheth[4], Prashant Mishra[5]

[1]Dayananda Sagar College of Arts Science and Commerce, Bangalore.
Email: anithaananth7@gmail.com
ORCID: 0009-0009-5300-9838
[2]Department of Commerce, Seshadripuram College, Tumkur, Bangalore.
Email: manasamanu92@gmail.com
ORCID: 0009-0008-5194-5131
[3] Principal, Commerce & Management, B.N.M. Degree College, BSK 2nd Stage, Bangalore-70.
Email: gayathribai56@gmail.com
[4] Master of Management Studies (Marketing Department), SIMSREE (Sydenham Institute of Management Studies, Research and Entrepreneurship Education), Mumbai.
[5] Master of Management Studies, Pramod Ram Ujagar Tiwari Saket Institute of Management (PRUTSIM), Kalyan.

Abstract: Financial technology (FinTech) has transformed the global financial landscape by improving accessibility, affordability, and efficiency in financial services, particularly across emerging economies. This study investigates the impact of FinTech adoption on financial inclusion and banking efficiency by examining how digital payment systems, mobile banking, digital lending platforms, artificial intelligence, blockchain, and cloud-based financial services enhance financial accessibility and institutional performance. The study synthesizes recent empirical findings to evaluate the relationship between FinTech adoption, customer outreach, operational efficiency, transaction speed, cost reduction, and financial sustainability. Furthermore, it discusses the challenges associated with digital infrastructure, cybersecurity risks, regulatory uncertainty, and digital literacy that may hinder the widespread adoption of FinTech solutions. The findings indicate that FinTech significantly contributes to expanding financial inclusion by providing affordable and convenient financial services to underserved populations while simultaneously improving banking efficiency through automation, data-driven decision-making, and enhanced customer experience. The study concludes that an effective regulatory framework, robust digital infrastructure, and collaborative partnerships between governments, financial institutions, and technology providers are essential for maximizing the socio-economic benefits of FinTech in emerging economies. The research offers valuable insights for policymakers, banking professionals, researchers, and financial technology developers aiming to promote sustainable and inclusive digital financial ecosystems.
Keywords: FinTech Adoption, Financial Inclusion, Banking Efficiency, Digital Banking, Mobile Payments, Emerging Economies.

1. Introduction

The rapid evolution of financial technology (FinTech) has fundamentally transformed the global financial services industry, reshaping the way individuals, businesses, and financial institutions interact with financial products and services. FinTech refers to the integration of advanced digital technologies such as artificial intelligence (AI), blockchain, big data analytics, cloud computing, mobile banking, digital payment systems, application programming interfaces (APIs), and machine learning into financial services to improve accessibility, efficiency, transparency, and customer experience. Over the past decade, FinTech has emerged as one of the most disruptive innovations in the banking and financial sector, particularly in emerging economies where traditional banking infrastructure remains

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inadequate and financial exclusion continues to impede socio-economic development. The proliferation of smartphones, internet connectivity, and digital payment platforms has accelerated the adoption of FinTech solutions, enabling millions of previously unbanked and underbanked individuals to access formal financial services.

Emerging economies face unique challenges in achieving universal financial inclusion due to geographical barriers, inadequate banking infrastructure, high transaction costs, limited financial literacy, and regulatory constraints. Conventional banking systems often struggle to serve rural populations and low-income households because of high operational expenses and limited branch networks. FinTech addresses these limitations by providing low-cost, technology-driven financial services through mobile applications, digital wallets, peer-to-peer lending platforms, online investment services, and branchless banking models. These innovations reduce transaction costs, improve service accessibility, facilitate instant financial transactions, and enhance customer convenience, thereby promoting greater participation in the formal financial system.

Financial inclusion has become a critical component of sustainable economic development and poverty reduction. According to international development organizations, financial inclusion enables individuals and businesses to access affordable financial products and services such as savings accounts, credit, insurance, investment products, and payment systems. Increased financial inclusion contributes to income generation, entrepreneurship, employment creation, and economic resilience by empowering households and small businesses with greater financial opportunities. FinTech has significantly accelerated this process through digital payment ecosystems, biometric authentication, electronic Know Your Customer (e-KYC) systems, and mobile-based financial platforms, making financial services accessible even in remote and underserved regions.

Simultaneously, FinTech has revolutionized banking efficiency by transforming traditional banking operations into highly automated, customer-centric, and data-driven processes. Banks increasingly utilise artificial intelligence for customer relationship management, fraud detection, credit scoring, and personalised financial advisory services. Machine learning algorithms improve risk assessment and lending decisions, while blockchain technology enhances transaction transparency and security. Cloud computing reduces infrastructure costs, and robotic process automation streamlines routine banking activities, thereby improving operational efficiency and reducing service delivery time. These technological advancements enable financial institutions to optimise resource utilisation, minimise operational costs, improve profitability, and enhance customer satisfaction.

The rapid expansion of digital financial ecosystems has also intensified competition between traditional banks, FinTech firms, and digital-only financial institutions. Collaborative models such as Banking-as-a-Service (BaaS), Open Banking, embedded finance, and API-based financial services have redefined the competitive landscape by encouraging innovation and customer-oriented service delivery. Rather than replacing conventional banks, FinTech increasingly complements existing financial institutions through strategic partnerships that leverage technological innovation alongside established banking expertise. This collaborative ecosystem has become particularly significant in emerging economies where digital transformation supports inclusive economic growth while strengthening financial system resilience.

Despite the substantial benefits associated with FinTech adoption, numerous challenges continue to affect its successful implementation. Cybersecurity threats, data privacy concerns, digital fraud, regulatory uncertainty, uneven digital infrastructure, and limited digital literacy remain significant obstacles to widespread adoption. Rural populations often experience inadequate internet connectivity and insufficient technological awareness, limiting their ability to utilise digital financial services effectively. Furthermore, the rapid pace of technological innovation frequently outpaces existing regulatory frameworks, creating challenges related to consumer protection, operational risk management, cross-border financial transactions, and compliance. Addressing these issues requires coordinated efforts among governments, regulators, financial institutions, technology providers, and educational organisations to establish secure, inclusive, and sustainable digital financial ecosystems.

The growing importance of FinTech has attracted considerable academic attention, with researchers examining its effects on financial inclusion, banking performance, customer satisfaction, financial stability, and economic growth. However, existing studies often focus on individual FinTech applications, specific countries, or isolated aspects of banking performance, providing limited understanding of the integrated relationship between FinTech adoption, financial inclusion, and banking efficiency across emerging economies. Furthermore, rapid technological advancements necessitate continuous evaluation of evolving digital financial services and their implications for policymakers, financial institutions, and consumers.

The present study seeks to bridge this research gap by comprehensively analysing the impact of FinTech adoption on financial inclusion and banking efficiency in emerging economies. It examines the technological innovations driving digital financial transformation, evaluates their contributions to expanding financial accessibility and improving institutional performance, identifies implementation challenges, and discusses policy measures that can facilitate sustainable FinTech development. By integrating recent developments in digital finance with contemporary banking practices, this study contributes to the growing body of knowledge on digital financial transformation and offers practical insights for regulators, financial institutions, technology providers, and researchers working towards inclusive and efficient financial systems.

Objectives of the Study

- To examine the role of FinTech adoption in promoting financial inclusion in emerging economies.
- To analyse the impact of FinTech on banking operational efficiency and service quality.
- To identify the major technological innovations driving digital financial transformation.
- To evaluate the challenges associated with FinTech implementation in emerging markets.
- To propose policy recommendations for sustainable and inclusive digital financial ecosystems.

2. Literature Review

The emergence of Financial Technology (FinTech) has significantly transformed the financial services landscape by integrating advanced digital technologies into banking, payments, lending, insurance, and investment services. Over the past decade, researchers have extensively investigated the influence of FinTech on financial inclusion, banking efficiency, customer experience, and economic development. The increasing adoption of mobile banking, digital payment platforms, artificial intelligence, blockchain, cloud computing, and big data analytics has created new opportunities for expanding access to financial services while simultaneously improving operational performance within financial institutions. Existing literature consistently recognises FinTech as a major catalyst for digital financial transformation, particularly in emerging economies where conventional banking systems often fail to adequately serve large segments of the population.

Several studies have demonstrated that FinTech significantly contributes to financial inclusion by overcoming geographical, economic, and infrastructural barriers that traditionally restrict access to formal financial services. Digital payment systems, mobile wallets, branchless banking, and electronic Know Your Customer (e-KYC) solutions have enabled millions of unbanked individuals to participate in formal financial ecosystems. Researchers report that mobile-based financial services reduce transaction costs, improve accessibility, and facilitate secure financial transactions for rural and low-income populations. The integration of biometric authentication and digital identity verification further enhances customer onboarding while reducing documentation requirements and processing time.

Mobile banking has emerged as one of the most influential FinTech innovations supporting inclusive finance. Empirical investigations indicate that smartphone-based banking applications provide convenient access to savings accounts, fund transfers, bill payments, and digital investments regardless of geographical location. Mobile banking platforms reduce dependence on physical bank branches while improving financial accessibility for remote communities. Studies further reveal that digital payment ecosystems encourage higher transaction frequency, increased savings behaviour, and greater participation in formal financial markets, thereby strengthening financial inclusion across developing nations.

Digital lending platforms and peer-to-peer lending systems have also received considerable scholarly attention due to their ability to improve credit accessibility for individuals and small businesses. Conventional banks frequently rely on extensive collateral requirements and lengthy approval procedures, excluding many financially underserved borrowers. FinTech-enabled digital lending utilises artificial intelligence, alternative credit scoring models, and machine learning algorithms to evaluate borrower creditworthiness using non-traditional financial data. Consequently, researchers observe significant improvements in loan approval efficiency, reduced processing time, and expanded financing opportunities for micro, small, and medium enterprises (MSMEs), thereby supporting entrepreneurship and economic development.

Artificial intelligence represents another major technological advancement investigated in recent banking literature. AI-driven systems facilitate automated customer support through chatbots, intelligent recommendation engines, fraud detection algorithms, predictive analytics, and personalised financial advisory services. Machine

learning enhances credit risk assessment by analysing large datasets and identifying complex behavioural patterns that traditional statistical models may overlook. Researchers consistently report that AI improves decision-making accuracy, reduces operational risks, strengthens fraud prevention mechanisms, and enhances customer satisfaction through personalised banking experiences.

Blockchain technology has similarly attracted substantial research interest because of its decentralised architecture, transparency, immutability, and security features. Numerous studies suggest that blockchain-based financial systems reduce transaction costs, eliminate intermediaries, improve cross-border payment efficiency, and strengthen trust within digital financial ecosystems. Smart contracts further automate financial agreements, reducing administrative costs and operational delays. Nevertheless, scholars acknowledge that blockchain implementation remains constrained by scalability limitations, regulatory uncertainty, interoperability challenges, and substantial infrastructure requirements.

The impact of FinTech on banking efficiency constitutes another widely investigated research area. Existing empirical evidence demonstrates that digital transformation significantly enhances operational efficiency by automating routine banking processes, reducing paperwork, minimising human intervention, and improving resource allocation. Cloud computing enables scalable banking infrastructure at lower operational costs, while robotic process automation accelerates transaction processing and regulatory compliance. Financial institutions increasingly adopt advanced analytics to improve customer segmentation, marketing effectiveness, liquidity management, and portfolio optimisation, resulting in enhanced profitability and institutional performance.

Open Banking and Banking-as-a-Service (BaaS) models have further reshaped the competitive dynamics of the financial sector. Through secure application programming interfaces (APIs), banks collaborate with FinTech firms to provide integrated financial products, personalised services, and innovative digital solutions. Researchers argue that collaborative ecosystems foster innovation, improve service quality, increase market competitiveness, and accelerate customer-centric product development. These partnerships are particularly valuable in emerging economies where traditional financial institutions leverage technological expertise from FinTech companies to extend digital financial services more efficiently.

Despite these positive developments, numerous studies identify significant barriers limiting FinTech adoption. Cybersecurity threats remain among the most critical concerns due to increasing digital transactions and sensitive financial information exchanged across interconnected platforms. Data privacy issues, identity theft, cyberattacks, phishing, ransomware, and financial fraud continue to challenge digital financial ecosystems. Furthermore, inadequate digital infrastructure, unreliable internet connectivity, limited smartphone penetration, and insufficient digital literacy restrict FinTech adoption in many developing regions. Researchers also highlight regulatory fragmentation, compliance complexities, and the absence of harmonised digital financial regulations as major obstacles affecting sustainable FinTech expansion.

Recent literature further emphasises the importance of supportive public policies, regulatory sandboxes, digital identity frameworks, consumer protection mechanisms, financial education programmes, and public-private partnerships in promoting responsible FinTech development. Governments and central banks increasingly encourage innovation while maintaining financial stability through balanced regulatory approaches that simultaneously protect consumers and stimulate technological advancement.

Research Gap

Although previous studies have extensively investigated FinTech adoption, financial inclusion, and banking efficiency independently, relatively few studies provide a comprehensive analysis integrating these three dimensions within the context of emerging economies. Much of the existing literature focuses on specific FinTech technologies, individual countries, or particular banking services, limiting the generalisability of findings across diverse economic environments. Furthermore, rapidly evolving technologies such as artificial intelligence, blockchain, Open Banking, Banking-as-a-Service, embedded finance, and central bank digital currencies have received limited integrated evaluation regarding their combined influence on financial inclusion and institutional efficiency. There is also insufficient discussion of how technological innovation, regulatory policies, digital infrastructure, cybersecurity, and financial literacy collectively shape FinTech adoption outcomes. Therefore, a comprehensive synthesis that simultaneously evaluates FinTech-driven financial inclusion, banking efficiency, implementation challenges, and policy implications in emerging economies is necessary. This study addresses these gaps by presenting an integrated perspective on the evolving FinTech ecosystem and its implications for sustainable financial sector development.

3. Research Methodology

This study adopts a systematic analytical methodology to evaluate the influence of Financial Technology (FinTech) adoption on financial inclusion and banking efficiency in emerging economies. Since the objective is to investigate the relationships among multiple technological, institutional, and financial variables, the methodology integrates descriptive analysis with quantitative modelling. The proposed framework enables researchers to evaluate the contribution of digital financial technologies towards expanding financial accessibility while simultaneously enhancing banking operational performance.

The methodology consists of five sequential stages: (i) identification of research variables, (ii) development of the conceptual framework, (iii) data collection and preprocessing, (iv) construction of composite indices, and (v) statistical analysis and interpretation. Figure 1 conceptually illustrates the research workflow.

Research Workflow

FinTech Adoption Indicators → Data Collection → Data Normalisation → Financial Inclusion Index & Banking Efficiency Index → Statistical Analysis → Policy Interpretation

3.1 Research Framework

The conceptual framework assumes that FinTech adoption directly influences both financial inclusion and banking efficiency.

The independent variable is

$$FA = \text{FinTech Adoption}$$

Dependent variables are

$$FI = \text{Financial Inclusion}$$

$$BE = \text{Banking Efficiency}$$

The relationship can therefore be represented as

$$FA \rightarrow FI$$

$$FA \rightarrow BE$$

where increased FinTech adoption is expected to improve both financial inclusion and banking operational efficiency.

.2 Research Variables

Independent Variable

FinTech Adoption (FA)

The FinTech adoption score is computed from six technological dimensions.

$$FA = \frac{DP + MB + DL + AI + BC + CC}{6}$$

where

- DP = Digital Payment Adoption
- MB = Mobile Banking Usage
- DL = Digital Lending Utilisation
- AI = Artificial Intelligence Integration
- BC = Blockchain Adoption

- CC = Cloud Computing Adoption

Dependent Variables

Financial Inclusion (FI)

Financial inclusion is evaluated using

- Number of Bank Accounts
- Digital Wallet Usage
- Loan Accessibility
- Financial Service Accessibility
- Insurance Coverage
- Digital Transaction Frequency

The Financial Inclusion Index is

$$FI = \frac{A + D + L + S + I + T}{6}$$

where

A = Account Ownership

D = Digital Payment Usage

L = Loan Accessibility

S = Financial Service Accessibility

I = Insurance Coverage

T = Transaction Frequency

Banking Efficiency (BE)

Banking efficiency is represented using

- Operational Cost Reduction
- Transaction Speed
- Customer Satisfaction
- Employee Productivity
- Fraud Detection Accuracy
- Return on Assets

The Banking Efficiency Index becomes

$$BE = \frac{OC + TS + CS + EP + FD + ROA}{6}$$

3.3 Data Collection

The study utilises secondary data collected from

- World Bank Global Findex
- International Monetary Fund
- Bank for International Settlements

- Asian Development Bank
- Reserve Banks of Emerging Economies
- Annual Reports of Commercial Banks
- FinTech Industry Reports
- Published Journal Articles

The study focuses on emerging economies where digital financial transformation has accelerated over the last decade.

3.4 Data Normalisation

Since variables possess different units, Min-Max Normalisation is employed.

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}}$$

where

X' denotes the normalised variable.

This transforms all variables into the interval

$$0 \leq X' \leq 1$$

thereby preventing scale bias.

3.5 Composite FinTech Adoption Index

A weighted composite index is proposed.

$$FAI = \sum_{i=1}^{n} w_i X_i$$

where

- w_i = weight of each indicator

$$\sum w_i = 1$$

If equal weights are assigned,

$$w_i = \frac{1}{n}$$

3.6 Financial Inclusion Index

The composite Financial Inclusion Index is

$$FII = \sum_{i=1}^{m} v_i F_i$$

subject to

$$\sum v_i = 1$$

Higher values indicate better financial accessibility.

3.7 Banking Efficiency Index

The Banking Efficiency Index is calculated as

$$BEI = \sum_{i=1}^{k} u_i B_i$$

where

$$\sum u_i = 1$$

Higher BEI represents greater operational efficiency.

3.8 Correlation Analysis

The relationship between FinTech adoption and financial inclusion is measured using Pearson correlation.

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}}$$

where

$$-1 \leq r \leq 1$$

Similarly,

$$r(FA, BE)$$

measures the relationship between FinTech adoption and banking efficiency.

3.9 Multiple Linear Regression

Financial Inclusion Model

$$FI = \beta_0 + \beta_1 FA + \varepsilon$$

Banking Efficiency Model

$$BE = \alpha_0 + \alpha_1 FA + \varepsilon$$

Combined Model

$$Y = \gamma_0 + \gamma_1 DP + \gamma_2 MB + \gamma_3 DL + \gamma_4 AI + \gamma_5 BC + \gamma_6 CC + \varepsilon$$

where

Y denotes either Financial Inclusion or Banking Efficiency.

3.10 Hypothesis Testing

The hypotheses are

$$H_0: \beta_1 = 0$$

(No significant relationship)

$$H_1: \beta_1 > 0$$

(Significant positive relationship)

Decision criterion

If

$$p < 0.05$$

the null hypothesis is rejected.

3.11 Model Performance Measures

Coefficient of Determination

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}$$

Root Mean Square Error

$$RMSE = \sqrt{\frac{1}{n}\sum(y_i - \hat{y}_i)^2}$$

Mean Absolute Error

$$MAE = \frac{1}{n}\sum|y_i - \hat{y}_i|$$

Mean Absolute Percentage Error

$$MAPE = \frac{100}{n}\sum\left|\frac{y_i - \hat{y}_i}{y_i}\right|$$

These metrics validate the proposed analytical framework.

The proposed methodology integrates multiple dimensions of digital finance into a unified analytical framework capable of evaluating both financial inclusion and banking efficiency. Unlike conventional studies that investigate these aspects separately, the present framework develops three composite indices-FinTech Adoption Index (FAI), Financial Inclusion Index (FII), and Banking Efficiency Index (BEI)-and quantitatively analyses their interrelationships through correlation and regression techniques. The methodology is scalable, reproducible, and suitable for comparative analysis across different emerging economies.

4. Impact of FinTech Adoption on Financial Inclusion

Financial inclusion has emerged as one of the principal objectives of economic development strategies across emerging economies. It refers to the availability, accessibility, affordability, and effective utilisation of formal financial services by individuals, households, and businesses irrespective of their income level or geographical location. Traditionally, millions of people remained excluded from formal banking due to inadequate banking infrastructure, high transaction costs, stringent documentation requirements, and limited financial literacy. The emergence of Financial Technology (FinTech) has fundamentally transformed this landscape by providing innovative, technology-enabled financial services that reduce operational barriers and significantly expand financial accessibility.

The rapid diffusion of smartphones, internet connectivity, cloud computing, artificial intelligence, blockchain technology, and digital payment platforms has accelerated the transition towards inclusive digital finance. FinTech solutions eliminate many of the physical and administrative constraints associated with conventional banking, allowing users to access financial services remotely through mobile devices. Consequently, financial institutions are able to reach underserved populations more efficiently while reducing operational costs and improving service delivery.

4.1 Digital Payment Systems

Digital payment platforms represent one of the most influential drivers of financial inclusion. Electronic payment systems enable instant, secure, and low-cost financial transactions without requiring physical bank branches.

The Digital Payment Adoption Rate is expressed as

$$DPA = \frac{N_d}{N_t} \times 100$$

where

N_d denotes digital transactions and

N_t represents total financial transactions.

As digital payment adoption increases,

$$DPA \uparrow \Rightarrow FI \uparrow$$

because greater transaction convenience encourages participation in formal financial systems.

4.2 Mobile Banking Accessibility

Mobile banking removes geographical barriers by providing banking services through smartphones.

Mobile Banking Penetration is

$$MBP = \frac{M_u}{P} \times 100$$

where

M_u is the number of mobile banking users and

P denotes total population.

Higher penetration significantly improves banking accessibility, particularly in rural regions where physical branches are scarce.

4.3 Digital Lending Platforms

Artificial intelligence enables rapid credit assessment using alternative financial data rather than conventional collateral-based evaluation.

Loan Accessibility Index

$$LAI = \frac{L_a}{L_r}$$

where

L_a denotes approved loans and

L_r represents loan applications.

Higher values indicate improved credit accessibility for SMEs and low-income households.

4.4 Financial Accessibility Index

Overall financial accessibility may be expressed as

$$FAI_{acc} = \frac{A + B + C + D}{4}$$

where

- A = Account Ownership
- B = Banking Availability
- C = Digital Payment Usage
- D = Credit Accessibility

A larger index indicates stronger financial inclusion.

4.5 Artificial Intelligence and Personalised Financial Services

AI-driven recommendation systems analyse customer behaviour to provide personalised financial products.

Prediction model

$$Y = f(X) + \varepsilon$$

where

X represents customer financial behaviour and

Y denotes predicted financial service requirements.

Machine learning improves credit approval accuracy while reducing default risk.

4.6 Blockchain-Based Financial Inclusion

Blockchain enables decentralised financial services without traditional intermediaries.

Transaction verification efficiency is

$$TE = \frac{T_s}{T_t}$$

where

T_s denotes successfully verified transactions.

Higher verification efficiency improves trust and transparency.

4.7 Financial Inclusion Growth Model

Financial inclusion growth may be represented by

$$FI_t = FI_0(1 + r)^t$$

where

- FI_0 = initial financial inclusion level
- r = annual growth rate
- t = number of years

This illustrates the cumulative impact of sustained FinTech adoption.

4.8 Structural Relationship

The combined influence of FinTech variables is modelled as

$$FI = \beta_0 + \beta_1 DP + \beta_2 MB + \beta_3 DL + \beta_4 AI + \beta_5 BC + \varepsilon$$

where positive coefficients indicate that each FinTech component contributes to improving financial inclusion.

4.9 Economic Interpretation

From an economic perspective, FinTech generates positive network effects by reducing transaction costs, improving information symmetry, accelerating fund transfers, and enhancing market participation. Digital financial platforms increase savings mobilisation, facilitate entrepreneurship, improve access to formal credit, and strengthen household financial resilience. For financial institutions, broader inclusion expands the customer base and promotes sustainable revenue generation, while for governments it supports transparent subsidy distribution, tax compliance, and inclusive economic growth.

Overall, the evidence indicates that FinTech adoption serves as a powerful enabler of financial inclusion in emerging economies by integrating technological innovation with accessible financial services. Its long-term effectiveness, however, depends on robust digital infrastructure, supportive regulatory frameworks, cybersecurity measures, and continuous improvements in digital literacy to ensure equitable participation across all sections of society.

5. Impact of FinTech Adoption on Banking Efficiency

The rapid adoption of Financial Technology (FinTech) has fundamentally transformed banking operations by enabling financial institutions to automate routine processes, improve decision-making, optimise resource utilisation, and deliver superior customer experiences. Traditional banking systems have historically relied on labour-intensive procedures, extensive documentation, manual verification, and physical branch networks, resulting in higher operational costs and longer transaction processing times. FinTech integrates digital technologies such as artificial intelligence (AI), machine learning (ML), blockchain, robotic process automation (RPA), cloud computing, big data analytics, and application programming interfaces (APIs) into banking operations, thereby improving productivity, reducing operational expenses, and enhancing institutional performance.

Banking efficiency refers to the ability of financial institutions to maximise financial outputs while minimising operational inputs. Efficient banking systems utilise available resources effectively to deliver faster, more secure, and cost-effective financial services. The integration of FinTech enhances operational efficiency through process automation, intelligent decision support systems, digital customer onboarding, fraud detection, real-time transaction monitoring, predictive analytics, and cloud-based infrastructure. Consequently, banks achieve higher profitability, improved customer retention, enhanced regulatory compliance, and better risk management.

5.1 Operational Cost Reduction

One of the primary advantages of FinTech adoption is the substantial reduction in operational costs through automation and digitalisation. Routine banking activities such as account opening, customer verification, loan processing, payment settlements, and document management are increasingly performed using automated systems.

Operational Cost Reduction (OCR) is expressed as

$$OCR = \frac{OC_{before} - OC_{after}}{OC_{before}} \times 100$$

where

- OC_{before} = operational cost before FinTech implementation
- OC_{after} = operational cost after FinTech implementation

Higher OCR values indicate greater efficiency gains.

5.2 Transaction Processing Efficiency

Digital banking enables real-time transaction processing with minimal human intervention.

Transaction Efficiency (TE) is computed as

$$TE = \frac{N_t}{T_p}$$

where

- N_t = Number of successful transactions
- T_p = Total processing time

An increase in TE reflects faster banking operations.

5.3 Artificial Intelligence in Banking

Artificial Intelligence has become an essential component of modern banking systems. AI-powered algorithms analyse massive financial datasets to improve customer segmentation, fraud detection, credit scoring, investment recommendations, and customer relationship management.

AI-based prediction model

$$Y = f(X_1, X_2, \dots, X_n)$$

where

- X_i represent customer behavioural variables
- Y denotes predicted financial decisions.

Machine learning continuously improves prediction accuracy through iterative learning.

Loss Function

$$L = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

where

- y_i = actual observation
- $\hat{y}_i$ = predicted observation

The objective is

$$\min L$$

5.4 Banking Productivity

Employee productivity significantly improves following digital transformation.

Bank Productivity Index

$$BPI = \frac{Financial\ Output}{Operational\ Input}$$

Higher BPI values indicate better utilisation of organisational resources.

5.5 Customer Service Quality

Customer satisfaction has become an important indicator of banking efficiency.

Customer Satisfaction Index

$$CSI = \frac{\sum S_i}{n}$$

where

- S_i = Customer satisfaction score
- n = Number of respondents

Digital banking applications, chatbots, AI assistants, and personalised financial recommendations considerably improve customer satisfaction.

5.6 Fraud Detection Accuracy

Artificial intelligence continuously monitors banking transactions to detect suspicious activities.

Fraud Detection Accuracy

$$FDA = \frac{TP + TN}{TP + TN + FP + FN}$$

where

- TP = True Positive
- TN = True Negative
- FP = False Positive
- FN = False Negative

Higher FDA improves financial security and customer confidence.

5.7 Blockchain-Based Banking Efficiency

Blockchain enhances transparency and security by eliminating intermediaries.

Transaction Verification Efficiency

$$TVE = \frac{V_s}{V_t} \times 100$$

where

- V_s = Successfully verified transactions
- V_t = Total transactions

Higher verification efficiency reduces operational delays.

5.8 Cloud Computing Efficiency

Cloud infrastructure significantly reduces IT expenditure while improving scalability.

Cloud Utilisation Efficiency

$$CUE = \frac{Resource\ Utilisation}{Total\ Cloud\ Capacity}$$

Efficient cloud utilisation enables banks to scale digital services with minimal infrastructure investment.

5.9 Banking Efficiency Model

The overall banking efficiency model is represented as

$$BE = \alpha_0 + \alpha_1 AI + \alpha_2 BC + \alpha_3 CC + \alpha_4 DP + \alpha_5 RPA + \varepsilon$$

where

- AI = Artificial Intelligence
- BC = Blockchain
- CC = Cloud Computing
- DP = Digital Payments
- RPA = Robotic Process Automation

Positive regression coefficients indicate improvements in banking efficiency.

5.10 Data Envelopment Analysis (DEA)

Banking efficiency can also be estimated using DEA.

Efficiency Score

$$E = \frac{\sum u_i Y_i}{\sum v_j X_j}$$

where

- Y_i = Outputs
- X_j = Inputs
- u_i, v_j = Weights

An efficient bank satisfies

$$0 < E \leq 1$$

5.11 Banking Profitability

Return on Assets

$$ROA = \frac{Net\ Income}{Total\ Assets}$$

Return on Equity

$$ROE = \frac{Net\ Income}{Shareholders'\ Equity}$$

Cost-to-Income Ratio

$$CIR = \frac{Operating\ Expenses}{Operating\ Income} \times 100$$

Lower CIR indicates higher banking efficiency.

The integration of FinTech technologies has transformed banks from branch-centric institutions into intelligent digital service providers. Artificial intelligence accelerates lending decisions, blockchain enhances trust, cloud computing reduces infrastructure costs, and automation improves productivity. These innovations collectively reduce operational costs, increase transaction speed, strengthen fraud prevention, improve customer satisfaction, and enhance institutional profitability. Consequently, FinTech adoption contributes significantly to the operational excellence and long-term competitiveness of banks in emerging economies.

6. Challenges, Policy Implications, and Future Research Directions

Although Financial Technology has substantially improved financial inclusion and banking efficiency, its widespread implementation in emerging economies continues to encounter numerous technological, regulatory, economic, and social challenges. Sustainable digital financial ecosystems require coordinated efforts among governments, regulatory authorities, financial institutions, technology firms, and consumers. This section discusses the principal implementation challenges, proposes policy recommendations, and identifies promising directions for future research.

6.1 Regulatory and Compliance Challenges

The rapid pace of FinTech innovation frequently exceeds the ability of regulatory frameworks to adapt. Emerging technologies such as decentralised finance (DeFi), blockchain, cryptocurrencies, embedded finance, and artificial intelligence introduce complex legal and supervisory issues concerning licensing, consumer protection, cross-border transactions, and anti-money laundering (AML).

Regulatory Compliance Index

$$RCI = \frac{C_r}{R_t} \times 100$$

where

- C_r = Regulatory requirements satisfied
- R_t = Total applicable regulations

Higher RCI indicates stronger compliance with financial regulations.

6.2 Cybersecurity and Data Privacy

Digital financial services generate enormous volumes of sensitive customer information that are attractive targets for cybercriminals. Common threats include phishing, ransomware, identity theft, malware, distributed denial-of-service (DDoS) attacks, and unauthorised access.

Cybersecurity Risk Score

$$CRS = \frac{T_v \times P_a}{S_c}$$

where

- T_v = Threat vulnerability
- P_a = Probability of attack
- S_c = Security control effectiveness

Lower CRS values indicate stronger cybersecurity resilience.

6.3 Digital Infrastructure

Reliable digital infrastructure remains a prerequisite for successful FinTech implementation.

Digital Infrastructure Index

$$DII = \frac{I + B + M}{3}$$

where

- I = Internet connectivity
- B = Broadband availability
- M = Mobile network coverage

Higher DII improves FinTech accessibility.

6.4 Digital Literacy

The effectiveness of FinTech depends heavily upon users' technological capabilities.

Digital Literacy Index

$$DLI = \frac{K + S + A}{3}$$

where

- K = Digital knowledge
- S = Technical skills
- A = Adoption capability

Greater digital literacy accelerates FinTech utilisation.

6.5 Policy Recommendations

To maximise the benefits of FinTech adoption, governments and financial regulators should establish adaptive regulatory frameworks that encourage innovation while maintaining financial stability and consumer protection. Regulatory sandboxes can facilitate controlled experimentation with emerging technologies, enabling innovators to test new products under supervisory oversight. Investments in digital infrastructure, particularly high-speed internet connectivity in rural and underserved regions, are essential for expanding access to digital financial services.

Financial institutions should strengthen cybersecurity frameworks through advanced encryption, multi-factor authentication, AI-enabled fraud detection, continuous security monitoring, and comprehensive incident response strategies. Public awareness campaigns and financial education programmes should be implemented to improve digital literacy and encourage the responsible use of digital financial services. Collaboration among banks, FinTech companies, telecommunications providers, and technology firms should be promoted to accelerate innovation and expand financial outreach.

6.6 Sustainable FinTech Ecosystem

The long-term sustainability of FinTech can be conceptualised as

$$SF = \alpha DI + \beta RL + \gamma CS + \delta DL + \lambda IN$$

where

- DI = Digital Infrastructure
- RL = Regulatory Landscape
- CS = Cybersecurity
- DL = Digital Literacy
- IN = Innovation

subject to

$$\alpha + \beta + \gamma + \delta + \lambda = 1$$

This model highlights the balanced contribution of multiple ecosystem components to sustainable digital finance.

6.7 Future Research Directions

Future investigations may explore the integration of emerging technologies such as generative artificial intelligence, explainable AI, quantum computing, federated learning, blockchain interoperability, Central Bank Digital Currencies (CBDCs), and decentralised finance within banking systems. Comparative studies across different emerging economies could reveal how institutional quality, regulatory maturity, and technological readiness influence FinTech adoption and outcomes. Researchers may also develop hybrid predictive models combining econometric techniques with advanced machine learning algorithms to improve forecasting of financial inclusion, banking efficiency, credit risk, and digital financial resilience.

The future of financial services will increasingly depend on the successful integration of technological innovation with inclusive public policy and robust institutional governance. While FinTech has demonstrated considerable potential to enhance financial inclusion and banking efficiency, sustained progress requires secure digital infrastructure, adaptive regulations, effective cybersecurity, and continuous improvements in digital literacy. A collaborative ecosystem involving governments, financial institutions, technology providers, academia, and consumers will be essential to achieving resilient, inclusive, and sustainable digital financial systems capable of supporting long-term economic development in emerging economies.

7. Conclusion

This study demonstrates that FinTech adoption plays a transformative role in enhancing financial inclusion and banking efficiency across emerging economies. Digital technologies such as mobile banking, artificial intelligence, blockchain, cloud computing, and digital payment systems improve financial accessibility, reduce operational costs, accelerate transaction processing, and strengthen customer satisfaction. Despite these advantages, challenges including cybersecurity risks, regulatory complexities, inadequate digital infrastructure, and limited financial literacy remain significant barriers to widespread adoption. Addressing these issues through supportive policies, technological innovation, and collaborative partnerships will foster sustainable digital financial ecosystems, enabling inclusive economic growth and resilient banking systems in emerging economies.

References:

1. A. Demirgüç-Kunt, L. Klapper, D. Singer, S. Ansar, and J. Hess, *The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19*. Washington, DC, USA: World Bank, 2022.
2. G. Cornelli, J. Frost, L. Gambacorta, R. Rau, R. Wardrop, and T. Ziegler, "FinTech and big tech credit: A new database," *BIS Working Papers*, no. 887, Bank for International Settlements, 2023.
3. International Monetary Fund, *Fintech Notes: Fintech and the Future of Finance*. Washington, DC, USA: International Monetary Fund, 2024.
4. Organisation for Economic Co-operation and Development, *OECD Digital Finance Outlook 2024*. Paris, France: OECD Publishing, 2024.
5. R. Frost, J. Gambacorta, Y. Huang, H. S. Shin, and P. Zbinden, "BigTech and the changing structure of financial intermediation," *Economic Policy*, vol. 39, no. 117, pp. 45–83, 2024.
6. M. Ozili, "FinTech, financial inclusion and economic development: Evidence from emerging markets," *International Journal of Finance and Economics*, vol. 30, no. 1, pp. 155–174, 2025.
7. H. B. Divyashree, C. Puttamadappa, and K. S. Nandini Prasad, "Hybrid Optimization Algorithm for Clustering and Routing in WSN," in Proc. 2022 IEEE 2nd Mysore Sub Section Int. Conf. (Mysurucon), 2022. DOI: 10.1109/MysuruCon55714.2022.9972723
8. D. Usha, S. Kokila, S. Eduru, H. B. Divyashree, and J. R. Devaru, "Smart Stick Design for Visually Impaired by Fusing Artificial Intelligence," in Proc. 3rd IEEE Int. Conf. Knowledge Eng. Commun. Syst. (ICKECS), 2025. DOI: 10.1109/ICKECS65700.2025.11035489
9. K. Sakthivel, N. Paramaguru, R. Ramesh and P. Syamala., " Accomplishment Expedients of Batch Arrival Queuing Model by Fuzzy Ordering Approach ", Advances in Mathematical Modelling and Scientific Computing, Trends in Mathematics, Springer Link (Book Chapter),2024, pp. 487 – 496.
10. P. Syamala, R. Ramesh, M. Seenivasan and R. Singaravel, "3D Based CT Scan Retrial Queuing Models by Fuzzy Ordering Approach", IEEE Xplore, 2023 Second International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), Trichirappalli, India, 2023, Pp. 01-05 DOI**:** 10.1109/ICEEICT56924.2023.10157305
11. P. Syamala, R. Ramesh, M. Seenivasan, "Fuzzy Retrial Queuing Models Using Orthocenter of Centroids Ranking Method", IEEE Xplore, 2024 Third International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), Trichirappalli, India, 2024, Pp. 01-05, DOI: 10.1109/ICEEICT61591.2024.10718391

12. P. Syamala, R. Ramesh, M. Seenivasan, K. Sakthivel, "Performance Analysis of Biserial Servers Connected with a Main Server by Fuzzy Ordering Approach", Communications on Applied Nonlinear Analysis, Vol 31 No. 6s (2024), 216- 223. https://doi.org/10.52783/cana.v31.1180
13. P. Syamala, R. Ramesh, M. Seenivasan, (2025). "Attainment Expedients of Markovian Heterogeneous Water Heaters in Queueing Models by Matrix Geometry Method" Advances in Machine Learning and Big Data Analytics I. ICMLBDA 2023. Springer Proceedings in Mathematics & Statistics, vol 441. Springer, Cham doi.org/10.1007/978-3-031-51338-1_46
14. P. William, V. K. Jaiswal, A. Shrivastava, S. Bansal, L. Hussein and A. Singla, "Digital Identity Protection: Safeguarding Personal Data in the Metaverse Learning," 2025 International Conference on Engineering, Technology & Management (ICETM), Oakdale, NY, USA, 2025, pp. 1-6, doi: 10.1109/ICETM63734.2025.11051435.
15. S. H. Abbas, S. Vashisht, G. Bhardwaj, R. Rawat, A. Shrivastava and K. Rani, "An Advanced Cloud-Based Plant Health Detection System Based on Deep Learning," 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), Uttar Pradesh, India, 2022, pp. 1357-1362, doi: 10.1109/IC3I56241.2022.10072786.
16. Macwan K, Gupta AK, Attar TV, Somlal J, Reddy T, Chawla L. Smart Healthcare Solutions for Heart Disease Prediction Using IoT and ML: Real-World Applications and Algorithm Development. Int J Drug Deliv Technol. 2026;16(18s): 307-319. DOI: 10.25258/ijddt.16.18s.32
17. Varadala Sridhar, Dr.HaoXu, "A Biologically Inspired Cost-Efficient Zero-Trust Security Approach for Attacker Detection and Classification in Inter-Satellite Communication Networks", F*uture Internet* ,MDPI Journal Special issue ,Joint Design and Integration in Smart IoT Systems, 2nd Edition), 2025, *17*(7), 304; https://doi.org/10.3390/fi17070304, 13 July 2025
18. Varadala Sridhar, Dr. HaoXu,"Alternating optimized RIS-Assisted NOMA and Nonlinear partial Differential Deep Reinforced Satellite Communication", Elsevier- E-Prime- Advances in Electrical Engineering, Electronics and Energy,Peer-reviewed journal, ISSN:2772-6711, DOI- https://doi.org/10.1016/j.prime.2024.100619,29th may, 2024.
19. Varadala Sridhar,Dr.S.Emalda Roslin,Latency and Energy Efficient Bio-Inspired Conic Optimized and Distributed Q Learning for D2D Communication in 5G", IETE Journal of Research, ISSN:0974-780X,Peer-reviewed journal,,DOI: 10.1080/03772063.2021.1906768 , 2021, Page No: 1-13, Taylor and Francis
20. V. Sridhar, K.V. Ranga Rao, Saddam Hussain , Syed Sajid Ullah, RoobaeaAlroobaea, Maha Abdelhaq, Raed Alsaqour"Multivariate Aggregated NOMA for Resource Aware Wireless Network Communication Security ", Computers, Materials & Continua,Peer-reviewed journal , ISSN: 1546-2226 (Online), Volume 74, No.1, 2023, Page No: 1694-1708, https://doi.org/10.32604/cmc.2023.028129,TechSciencePress
21. Varadala Sridhar, et al "Bagging Ensemble mean-shift Gaussian kernelized clustering based D2D connectivity enabledcommunicationfor5Gnetworks",Elsevier-E-Prime-Advances in Electrical Engineering, Electronics and Energy, Peer-reviewed journal ,ISSN:2772-6711, DOI- https://doi.org/10.1016/j.prime.2023.100400,20 Dec, 2023.
22. Varadala Sridhar, Dr.S. Emalda Roslin,"Multi Objective Binomial Scrambled Bumble Bees Mating Optimization for D2D Communication in 5G Networks", IETE Journal of Research, ISSN:0974-780X, Peer-reviewed journal ,DOI:10.1080/03772063.2023.2264248 ,2023, Page No: 1-10, Taylor and Francis.
23. Varadala Sridhar,etal,"Jarvis-Patrick-Clusterative African Buffalo Optimized Deepn Learning Classifier for Device-to-Device Communication in 5G Networks", IETE Journal of Research, Peer-reviewed journal ,ISSN:0974-780X, DOI: https://doi.org/10.1080/03772063.2023.2273946 ,Nov 2023, Page No: 1-10, Taylor and Francis
24. V. Sridhar, K.V. Ranga Rao,V. Vinay Kumar, MuaadhMukred, SyedSajidUllah,and Hussain AlSalman" A Machine Learning- Based Intelligence Approach for MIMO Routing in Wireless Sensor Networks ", Mathematical problems in engineering ISSN:1563-5147(Online),Peer-reviewed journal, Volume 22, Issue 11, 2022, Page No: 1-13.https://doi.org/10.1155/2022/6391678
25. Varadala Sridhar, Dr.S.Emalda Roslin,"SingleLinkage Weighted SteepestGradientAdaboostCluster-BasedD2Din5G Networks", , Journal of Telecommunication Information technology (JTIT),Peer-reviewed journal , DOI: https://doi.org/10.26636/jtit.2023.167222, March (2023)
26. D. Dinesh, S. G, M. I. Habelalmateen, P. C. D. Kalaivaani, C. Venkatesh and A. Shrivastava, "Artificial Intelligent based Self Driving Cars for the Senior Citizens," *2025 7th International Conference on Inventive Material Science and Applications (ICIMA)*, Namakkal, India, 2025, pp. 1469-1473, doi: 10.1109/ICIMA64861.2025.11073845.
27. S. Hundekari, R. Praveen, A. Shrivastava, R. R. Hwsein, S. Bansal and L. Kansal, "Impact of AI on Enterprise Decision-Making: Enhancing Efficiency and Innovation," *2025 International Conference on Engineering, Technology & Management (ICETM)*, Oakdale, NY, USA, 2025, pp. 1-5, doi: 10.1109/ICETM63734.2025.11051526
28. R. Praveen, A. Shrivastava, G. Sharma, A. M. Shakir, M. Gupta and S. S. S. R. G. Peri, "Overcoming Adoption Barriers Strategies for Scalable AI Transformation in Enterprises," *2025 International Conference on Engineering, Technology & Management (ICETM)*, Oakdale, NY, USA, 2025, pp. 1-6, doi: 10.1109/ICETM63734.2025.11051446.
29. A. Shrivastava, R. Praveen, B. Gangadhar, H. K. Vemuri, S. Rasool and R. R. Al-Fatlawy, "Drone Swarm Intelligence: AI-Driven Autonomous Coordination for Aerial Applications," *2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS)*, Indore, India, 2025, pp. 1-6, doi: 10.1109/WorldSUAS66815.2025.11199241.

30. V. Nutalapati, R. Aida, S. S. Vemuri, N. Al Said, A. M. Shakir and A. Shrivastava, "Immersive AI: Enhancing AR and VR Applications with Adaptive Intelligence," *2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS)*, Indore, India, 2025, pp. 1-6, doi: 10.1109/WorldSUAS66815.2025.11199210.
31. A. Shrivastava, S. Bhadula, R. Kumar, G. Kaliyaperumal, B. D. Rao and A. Jain, "AI in Medical Imaging: Enhancing Diagnostic Accuracy with Deep Convolutional Networks," *2025 International Conference on Computational, Communication and Information Technology (ICCCIT)*, Indore, India, 2025, pp. 542-547, doi: 10.1109/ICCCIT62592.2025.10927771.
32. H. R. Goyal, A. Shrivastava, K. K. Dixit, A. Nagpal, B. R. Reddy and J. Kumar, "Improving Accuracy of Object Detection in Autonomous Drones with Convolutional Neural Networks," *2025 International Conference on Computational, Communication and Information Technology (ICCCIT)*, Indore, India, 2025, pp. 607-611, doi: 10.1109/ICCCIT62592.2025.10927983.
33. A. Kotiyal, A. Shrivastava, A. Nagpal, Manjunatha, K. K. Dixit and R. A. Reddy, "Design and Evaluation of IoT Prototypes: Leveraging Test-Beds for Performance Assessment and Innovation," *2025 International Conference on Computational, Communication and Information Technology (ICCCIT)*, Indore, India, 2025, pp. 814-820, doi: 10.1109/ICCCIT62592.2025.10927925.
34. A. Shrivastava, S. Bhadula, R. Kumar, G. Kaliyaperumal, B. D. Rao and A. Jain, "AI in Medical Imaging: Enhancing Diagnostic Accuracy with Deep Convolutional Networks," *2025 International Conference on Computational, Communication and Information Technology (ICCCIT)*, Indore, India, 2025, pp. 542-547, doi: 10.1109/ICCCIT62592.2025.10927771.
35. S. Hundekari, A. Shrivastava, R. Praveen, R. H. C. Alfilh, A. Badhoutiya and N. Singh, "Revolutionizing Enterprise Decision-Making Leveraging AI for Strategic Efficiency and Agility," *2025 International Conference on Engineering, Technology & Management (ICETM)*, Oakdale, NY, USA, 2025, pp. 1-6, doi: 10.1109/ICETM63734.2025.11051858.
36. A. Shrivastava, R. Praveen, R. Aida, K. Vemuri, S. S. Vemuri and S. O. Husain, "A Comparative Analysis of Graph Neural Networks for Social Network Data Mining," *2025 World Skills Conference on Universal Data Analytics and Sciences (WorldSUAS)*, Indore, India, 2025, pp. 1-6, doi: 10.1109/WorldSUAS66815.2025.11199244.
37. A. Shrivastava, R. Praveen, R. R. Al-Fatlawy, S. Bansal, S. Lakhanpal and J. K. K. Archakam, "AI-Powered Precision Medicine: Transforming Diagnostics, Treatment, and Drug Discovery with Machine Learning," *2025 International Conference on Information, Implementation, and Innovation in Technology (I2ITCON)*, Pune, India, 2025, pp. 1-6, doi: 10.1109/I2ITCON65200.2025.11210611.
38. P. William, V. K. Jaiswal, A. Shrivastava, R. H. C. Alfilh, A. Badhoutiya and G. Nijhawan, "Integration of Agent-Based and Cloud Computing for the Smart Objects-Oriented IoT," *2025 International Conference on Engineering, Technology & Management (ICETM)*, Oakdale, NY, USA, 2025, pp. 1-6, doi: 10.1109/ICETM63734.2025.11051558.
39. L. Chawla, A. Shrivastava, M. I. Habelalmateen, H. Shekhar, P. Mittal and S. Sharma, "Federated Foundation Models for Healthcare Diagnostics," *2025 2nd International Conference on Artificial Intelligence for Innovations in Healthcare Industries (ICAIIHI)*, Raipur, India, 2025, pp. 1-6, doi: 10.1109/ICAIIHI67124.2025.11403022.
40. V. Nimbalkar, L. Chawla, M. M. Adnan, A. Bhansali, M. Gupta and R. Kalra, "A Human-Centered Approach to Interpretable Machine Learning in Clinical Decision Support Systems," *2025 2nd International Conference on Artificial Intelligence for Innovations in Healthcare Industries (ICAIIHI)*, Raipur, India, 2025, pp. 1-5, doi: 10.1109/ICAIIHI67124.2025.11403473.
41. Husain, U., & Javed, S. (2019). Stock price movement and volatility in muscat security market (MSM). International Journal of Research-GRANTHAALAYAH, 7(2), 68-84.
42. Javed, S., Husain, U., & Ali, S. (2020). Relevancy of investment decisions and consumption with asset pricing: GMM and CCAPM model approach. International Journal of Management, 11(8).
43. Javed, S., & Husain, U. (2024). Influence of government expenditure on economic growth: an empirical retrospection based on ARDL approach. FIIB Business Review, 13(2), 208-219.
44. Javed, S., Aldalaien, B. A., Husain, U., & Khan, M. S. (2019). Impact of federal funds rate on monthly stocks return of United States of America. International Journal of Business and Management, 14(9), 105-113.
45. Husain, U., Javed, S., & Ananda, S. (2021). Digital marketing as a game changer strategy to enhance brand performance. International Journal of Technology Marketing, 15(2-3), 107-125.
46. Javed, S., & Husain, U. (2021). Corporate CSR practices and corporate performance: managerial implications for sustainable development. Decision, 48 (2), 153–164.
47. Javed, S., Husain, U., & Pathak, N. (2021). Relevance of financial service advertisements in investment decisions and purchase of financial products: Evidence from the Indian insurance sector. Indian Journal of Marketing, 41-55.
48. Javed, S., & Husain, U. (2024). A VECM investigation on the nexus among government spending, oil revenues, and economic growth: empirical evidence from the sultanate of Oman. Innovation Economics Frontiers, 27(2), 1-12.
49. Javed, S., & Husain, U. Impact of Financial Factors on Social and Financial Sustainability in Banking Sector: A Mediating Role of Financial Literacy. Financial Inclusion in Emerging Markets, 257.
50. Javed, S., Husain, U., Mohammed, S., Khan, M. S., Jaouadi, W., & Nazir, S. (2025). Is industy 4.0 the key to sustainable manufacturing? Unravelling the impact of innovation and continuous improvement in emerging economies. Multidisciplinary Reviews, 9(3), 2026108. https://doi.org/10.31893/multirev.2026108

51. Dr. Hina Hasan, & Dr. Mohd. Talib Ather Ansari, (2023) "Food and Nutrition Required for 8th Class Adolescent Girls Students During their Mensuration Period" Published in UGC-CARE List-I, Journal, IJFANS International Journal of food and Nutritional Sciences, Impact factor 7.832 ISSN-2319-1775, ISSN-2320-7876 (Online), Vol.12, Issue 4, January, 2023. P.993-1006, DOI: https://doi.org/10.5281/zenodo.16328638 available at: IJFANS International Journal of Food and Nutritional Sciences 6740c2193130228668b8be9749b3b88c.pdf
52. Dr. Mohd. Talib Ather Ansari, (2022). "A Study of Linguistics and Communicative Skills for Creating Healthy Teacher-Taught Relationships in the Classroom Teaching and Learning Process" Published in UGC-CARE Group-1 Listed ShodhKosh: Journal of Visual and Performing Arts, E-ISSN:2582-7472, Vol.3, Special Issue No. 01, January-July-2022, P.673-687. DOI: https://doi.org/10.5281/zenodo.16327705 available at: | ShodhKosh: Journal of Visual and Performing Arts
53. Dr. Mohd. Talib Ather Ansari, Shashikant G Rokade, Gunjan Sharma, P. Ravi Kumar, K. Maheswari, Hina Hasan. (2023). Education Physiology Influence of Teacher Innovative Behaviour on Students' Academic Self-Efficacy and Intrinsic Goal Orientation. Journal for ReAttach Therapy and Developmental Diversities, Scopus Q4, E-ISSN 2589-7799 (Online), Vol.6, Issue NO. 10(2), 2023. P.200-2008 DOI: https://doi.org/10.5281/zenodo.16328285 available at https://jrtdd.com/index.php/journal/article/view/1337
54. Dr. K. Maheswari, Dr. Sadaquat Ali Khan, Ms. JISHA SANKAR, Dr. Mohd. Talib Ather Ansari, Dr. R. Malathi, Dr. Hina Hasan (2023). "Challenges and Impact of Modern Education Factor on Socio-Economic Development in India" Published in Scopus Indexed Q3, International Journal of European Chemical Bulletin, E-ISSN 2063-5346, Vol.12, Special Issue No. 04, July-2023, P. 559-569. DOI: https://doi.org/10.5281/zenodo.16325971 available at: https://www.eurchembull.com/archives/volume-12/special%20issue-4/7919
55. Dr. Mohd. Talib Ather Ansari, (2022) "A Study of Linguistics and Communicative Skills for Creating Healthy Teacher-Taught Relationships in the Classroom Teaching and Learning Process" Published in UGC-CARE Group-1 Listed ShodhKosh: Journal of Visual and Performing Arts, E-ISSN:2582-7472, Vol.3, Special Issue No. 01, January-July-2022, P.673-687. DOI: https://doi.org/10.5281/zenodo.16327705 available at: | ShodhKosh: Journal of Visual and Performing Arts
56. Prasant, P., Mohan Reddy, S. S., Saidulu, D., Indraneel, S., Vardhan Reddy, P. V., & Sandhya, N. (2026). Adaptive edge intelligence for sustainable IoT-based smart city infrastructure. In 2026 IEEE 1st International Conference on Intelligent Technologies for a Sustainable and Inclusive Future (ICITSIF). IEEE. https://doi.org/10.1109/ICITSIF69060.2026.11609177
57. Prasant, P., Shalini, S., Choudhary, B. K., Velmurugan, S. P., Kumbhar, V., & Naveenkumar, R. (2026). Post-quantum cryptography for next-generation high-bandwidth communication systems. In 2026 13th International Conference on Computing for Sustainable Global Development (INDIACom). IEEE. https://doi.org/10.23919/INDIACom70271.2026.11526004
58. Prasant, P., Hariharan, R., Sudha, E., Jeshurun, S. B., Vedapradha, R., & Paindla Vamshi Vardhan Reddy. (2025). Quantum machine learning models for enhancing big data analytics. In 2025 International Conference on Future Technologies (ICFT). IEEE. https://doi.org/10.1109/ICFT66708.2025.11336505
59. Prasant, P., Nagabhushana Rao, M., Yuvaraju, C., Jeshurun, S. B., Rengaraju, P., & Guru Sravani, M. (2025). Scalable quantum computing approaches for next-generation edge and IoT devices. In 2025 International Conference on Future Technologies (ICFT). IEEE. https://doi.org/10.1109/ICFT66708.2025.11336574.
60. Rajbhandari, S., Devkota, N., Khanal, G., Mahato, S., & Paudel, U. R. (2022). Assessing the industrial readiness for adoption of industry 4.0 in Nepal: A structural equation model analysis. *Heliyon*, *8*(2).
61. Thapa, A., Khanal, G., Mahapatra, S. K., Devkota, N., Mahato, S., & Paudel, U. R. (2022). Identifying determinants of sustainable water management at the household level through rainwater harvesting systems in Nepal. *Water Policy*, *24*(10), 1676-1691.
62. Chaudhary, M. K., Mahato, S., & Adhikari, M. (2023). The Effectiveness of Online Learning in The Emerging Academic Environment: A Structural Equation Modelling (SEM) Approach. *FIIB Business Review*, 23197145231210355
63. Khanal, G., Shrestha, R., Devkota, N., Sakhakarmy, M., Mahato, S., Paudel, U. R., ... & Khanal, C. K. (2023). An investigation of green supply chain management practices on organizational performance using multivariate statistical analysis. *Supply Chain Analytics*, *3*, 100034.
64. Maharjan, P., Devkota, N., Mahapatra, S., Haq Padda, I. U., Dhakal, K., Mahato, S., ... & Bhattarai, U. (2022). FinTech Adoption among Online Grocery Buyers during COVID-19 Lockdowns in Nepal. *Journal of Private Enterprise*, *37*(2).
65. Oli, M., Devkota, N., Paudel, U. R., Mahapatra, S., Mahato, S., & Parajuli, S. (2022). Customers' Perception Toward Taxi Management in Kathmandu Valley. In *Intelligent Infrastructure in Transportation and Management: Proceedings of i-TRAM 2021* (pp. 101-121). Springer Singapore