EMERGING TECHNOLOGIES IN COMMERCE: ADOPTION, IMPACT, AND SOCIO-TECHNICAL INTEGRATION

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Abstract

Emerging technologies, including Artificial Intelligence (AI), blockchain, FinTech, Internet of Things (IoT), and Augmented/Virtual Reality (AR/VR), are transforming commerce by enabling efficiency, transparency, customer engagement, and financial inclusion. This study synthesizes secondary literature published between 2010 and 2025, integrating theoretical insights from Diffusion of Innovations (DOI), Technology Acceptance Model (TAM), and Socio-Technical Systems (STS) theory. A systematic literature review and bibliometric mapping were employed to identify adoption patterns, key outcomes, and moderating factors influencing technology deployment. Findings highlight the potential of hybrid technology adoption, the importance of socio-technical alignment, and persistent challenges including ethics, regulatory compliance, and digital inequality. The study proposes an integrative framework linking technologies, outcomes, and moderating factors, offering actionable insights for researchers, practitioners, and policymakers while outlining a future research agenda for sustainable and inclusive commerce.

Keywords: Emerging technologies, AI, blockchain, FinTech, IoT, AR/VR, commerce, socio-technical systems, adoption, bibliometric review

Introduction

The digital transformation of commerce has accelerated over the past decade, driven by the convergence of advanced technologies. Businesses and consumers increasingly rely on Artificial

Intelligence (AI) for personalization, blockchain for secure transactions, FinTech for financial accessibility, IoT for supply chain optimization, and AR/VR for immersive experiences. Collectively, these technologies promise enhanced efficiency, transparency, and inclusivity (Kumar et al., 2024; Gomber et al., 2018).

Despite rapid technological advancements, the adoption and impact of these innovations are heterogeneous. Challenges such as organizational readiness, regulatory uncertainty, ethical concerns, and socio-technical misalignment can hinder effective deployment (Baxter & Sommerville, 2011; The Guardian, 2024). Therefore, understanding adoption dynamics, key outcomes, and moderating factors is critical for designing strategies that maximize technological benefits while mitigating risks.

This study addresses these gaps through a systematic literature review (SLR) complemented by bibliometric mapping, synthesizing evidence on the adoption, applications, and socio-technical integration of emerging technologies in commerce. The research is guided by three theoretical lenses: Diffusion of Innovations (DOI), Technology Acceptance Model (TAM), and Socio-Technical Systems (STS) theory.

Theoretical Framing

This study draws on a multi-theoretical lens to capture the complex dynamics of technology adoption, implementation, and impact in commerce. By integrating Diffusion of Innovations (DOI), Technology Acceptance Model (TAM), and Socio-Technical Systems (STS) theory, the research aims to provide a holistic understanding of how emerging technologies are adopted, accepted, and embedded within commercial organizations and consumer ecosystems. Each theoretical perspective offers unique insights, while their combined application allows for a more nuanced analysis of technological transformation in commerce (Kumar et al., 2024; Queiroz & Wamba, 2019).

Diffusion of Innovations (DOI)

Rogers' Diffusion of Innovations (DOI) theory posits that the adoption of a new technology is influenced by five key attributes: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Relative advantage reflects the degree to which an innovation is perceived as better than the existing alternatives, while compatibility considers its alignment with users' needs, values, and past experiences. Complexity denotes the perceived difficulty of understanding and using the technology, whereas trialability relates to the possibility of testing the

technology on a limited basis before full-scale adoption. Observability captures how visible the benefits of adoption are to others, influencing social contagion effects.

In commercial contexts, DOI theory helps explain variation in adoption rates across organizations and consumers. For example, early adopters of AI-driven recommendation systems in e-commerce often exhibit higher technological literacy and risk tolerance, while late adopters may require evidence of demonstrable business outcomes and peer validation. Social networks and opinion leaders play a critical role in shaping adoption behavior, as users often rely on recommendations from trusted sources when evaluating new technologies (Paliwal et al., 2020). Communication channels, including digital marketing, professional networks, and industry forums, further facilitate knowledge diffusion and influence adoption decisions. The DOI framework is particularly useful in understanding heterogeneity in technology uptake across sectors, regions, and consumer demographics (Kumar et al., 2024).

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), emphasizes perceived usefulness and perceived ease of use as primary determinants of technology adoption. Perceived usefulness reflects the degree to which a technology enhances performance or adds value, while perceived ease of use concerns the degree of effort required to operate the technology. TAM has been widely applied in commerce to understand consumer acceptance of emerging technologies such as AI-based personalization, mobile banking and FinTech solutions, and AR/VR-based immersive experiences (Gomber et al., 2018; Singh et al., 2022).

In practice, TAM provides actionable insights for organizations seeking to increase adoption. Technologies that are intuitive, user-friendly, and demonstrably beneficial are more likely to achieve rapid consumer acceptance. For example, FinTech applications offering seamless payment processing, real-time account management, and AI-powered fraud detection can enhance perceived usefulness, thereby accelerating adoption. Similarly, AR/VR-enabled shopping experiences that simplify navigation and offer immersive product visualization can reduce cognitive load, enhancing perceived ease of use. By focusing on user-centric design and tangible benefits, businesses can effectively influence adoption behavior and drive technology diffusion (Singh et al., 2022).

Socio-Technical Systems (STS) Theory

Socio-Technical Systems (STS) theory emphasizes the interdependence of technical systems, human actors, and organizational structures in shaping technology adoption and effectiveness (Baxter &

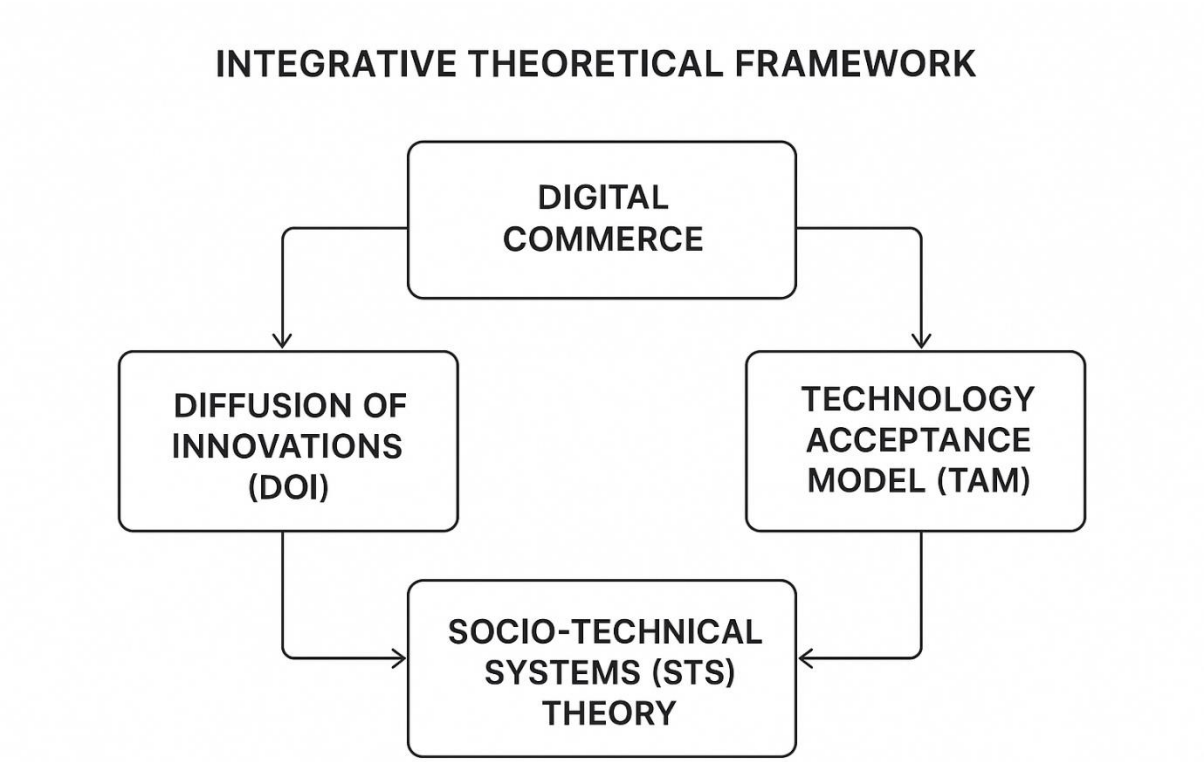
Sommerville, 2011). Successful integration of technologies such as AI, blockchain, or IoT requires alignment not only with technical infrastructure but also with organizational processes, governance mechanisms, workforce competencies, and regulatory frameworks (Queiroz & Wamba, 2019).

For instance, implementing blockchain-based supply chain solutions in retail requires technical infrastructure for transaction recording and data security, while simultaneously necessitating training staff, redesigning operational workflows, and ensuring compliance with legal and regulatory standards. Similarly, AI-driven analytics for customer engagement must be complemented by human oversight, decision-making protocols, and organizational policies to ensure ethical and effective use. STS theory highlights that neglecting the social or organizational dimensions can undermine the potential benefits of technological adoption, leading to resistance, operational inefficiencies, and suboptimal outcomes (Baxter & Sommerville, 2011).

Integrative Lens

By integrating DOI, TAM, and STS, this study constructs a comprehensive theoretical framework to analyze adoption dynamics, user acceptance, and socio-technical alignment in commerce. DOI provides insights into adoption patterns and the influence of social systems, TAM explains the cognitive and perceptual factors driving user acceptance, and STS emphasizes organizational and systemic alignment. The integrative approach enables a nuanced understanding of both individual and organizational factors affecting technology adoption, offering a foundation for developing the conceptual model for this study (Kumar et al., 2024; Queiroz & Wamba, 2019).

This multi-theoretical framing allows researchers and practitioners to identify not only which technologies are likely to be adopted but also how they should be implemented and managed within complex commercial ecosystems. It provides a holistic perspective for assessing adoption barriers, designing user-centric interventions, and aligning technological innovation with organizational objectives, policy requirements, and social contexts.



Methodology

This study adopts a systematic literature review (SLR) complemented by bibliometric mapping to comprehensively analyze the adoption, application, and socio-technical integration of emerging technologies in commerce. The methodology was designed to ensure rigor, transparency, and reproducibility, addressing both qualitative and quantitative dimensions of scholarly research.

Research Approach

A **Systematic Literature Review (SLR)** allows for structured identification, evaluation, and synthesis of existing knowledge on emerging technologies in commerce (Kitchenham, 2004; Tranfield et al., 2003). Unlike traditional narrative reviews, SLR ensures transparency in the selection, inclusion, and exclusion of studies, minimizing bias and providing a reproducible evidence base. By systematically collating studies across multiple technology domains—AI, blockchain, FinTech, IoT, and AR/VR—this approach identifies patterns, gaps, and critical success factors for adoption.

Complementing SLR, **bibliometric mapping** provides a quantitative overview of the literature. Techniques such as co-citation, co-word, and thematic cluster analysis allow visualization of research trends, influential authors, and emerging thematic areas (Aria & Cuccurullo, 2017). Bibliometric mapping thus uncovers structural and intellectual patterns in research, highlighting the

interconnectedness of concepts and providing a robust foundation for conceptual framework development.

Data Sources

The literature corpus was drawn from multiple high-quality and reputable sources to ensure coverage of both academic and practical perspectives. Data were retrieved from Scopus, Web of Science, IEEE Xplore, ScienceDirect, MDPI, and SSRN, spanning peer-reviewed journal articles, conference proceedings, and policy reports published between 2010 and 2025. This period captures the rapid evolution of commerce-related technologies, including early exploratory research and more mature applications. Selection of these databases ensured comprehensive coverage across disciplines, including computer science, management, finance, and social sciences.

Search Strategy

The search strategy employed Boolean operators to combine technology-specific and commerce-specific keywords. Examples include:

- (“AI” OR “machine learning”) AND (“e-commerce” OR “retail”)
- (“Blockchain” AND “supply chain”)
- (“FinTech” AND “financial inclusion”)

These combinations ensured that both broad and domain-specific studies were captured. Keyword refinement and pilot searches were conducted iteratively to maximize relevance while minimizing noise from unrelated domains.

Inclusion and Exclusion Criteria

The review applied strict **inclusion criteria**: publications must be peer-reviewed, commerce-focused, published in English between 2010–2025, and present empirical, theoretical, or policy insights relevant to technology adoption. Conversely, **exclusion criteria** eliminated opinion pieces, non-peer-reviewed blogs, irrelevant studies, or research with low methodological rigor. These criteria ensured the dataset was both reliable and relevant for evidence synthesis.

Screening and Data Extraction

A **three-stage screening process** was implemented: first, titles and abstracts were screened for relevance; second, full-text articles were evaluated against inclusion criteria; third, data were extracted into a structured coding matrix using NVivo software. Extracted data included bibliographic

information, technological focus, methodological approach, key findings, and identified gaps. This structured extraction facilitated thematic synthesis and comparative analysis across technologies and studies.

Bibliometric Mapping

Bibliometric analysis was conducted using **VOSviewer** and **Bibliometrix in R**. Co-citation analysis identified the most influential authors and publications; co-word analysis mapped recurring themes and keywords across studies; and cluster analysis revealed thematic groupings, emerging trends, and research gaps. This visualization helped identify highly interconnected topics, underexplored research areas, and potential avenues for cross-technology integration.

Literature Review

The literature review synthesizes key insights from research on AI, blockchain, FinTech, IoT, and AR/VR in commerce, highlighting applications, adoption barriers, and cross-cutting challenges.

Artificial Intelligence (AI)

Artificial Intelligence has emerged as a critical driver of digital transformation in commerce. AI enables predictive analytics, personalized recommendations, automated customer service, and operational optimization, enhancing efficiency and customer satisfaction (Kumar et al., 2024; Gomber et al., 2018). For instance, AI-powered recommendation engines in e-commerce platforms optimize product suggestions, increasing conversion rates and sales. However, challenges persist. Algorithmic bias, lack of transparency, and ethical concerns around data privacy and decision-making continue to constrain adoption (The Guardian, 2024). Researchers emphasize the need for explainable AI frameworks and regulatory oversight to ensure responsible implementation (Shin et al., 2021).

Blockchain

Blockchain technology provides transparency, immutability, and traceability in transactions and supply chains, addressing inefficiencies and fraud risks (Paliwal et al., 2020; Queiroz & Wamba, 2019). Applications include secure payment settlements, provenance tracking, and decentralized marketplaces. Despite these advantages, blockchain adoption faces cost barriers, scalability limitations, and regulatory uncertainties. High energy consumption and interoperability issues also pose challenges, particularly for SMEs and developing economies. Research suggests hybrid blockchain models and public-private partnerships as potential solutions to enhance adoption.

FinTech

FinTech innovations facilitate financial inclusion, digital payments, peer-to-peer lending, and microfinance, reducing transaction costs and expanding access to underserved populations (Gomber et al., 2018). Mobile banking and digital wallets have revolutionized retail and small business finance. Yet, FinTech adoption is tempered by cybersecurity risks, systemic vulnerabilities, and regulatory tensions. Scholars advocate for robust cybersecurity frameworks, adaptive regulations, and consumer literacy programs to maximize benefits while minimizing risks (Lee & Shin, 2018).

IoT and Logistics

The Internet of Things (IoT) transforms logistics, inventory management, and predictive maintenance by providing real-time data on products, assets, and processes (Singh et al., 2022). IoT enables dynamic routing, supply chain optimization, and enhanced monitoring of critical assets. Limitations include infrastructure requirements, data integration complexity, and security vulnerabilities, particularly in cross-organizational networks. Research highlights the importance of standardized protocols, cloud integration, and secure communication channels to ensure seamless adoption.

AR/VR

Augmented Reality (AR) and Virtual Reality (VR) technologies create immersive and interactive retail experiences, enhancing consumer engagement and brand differentiation (Pantano et al., 2020). AR/VR allows virtual try-ons, interactive product displays, and gamified shopping experiences. However, adoption is constrained by hardware costs, device accessibility, and uncertain return on investment (ROI). Studies suggest that consumer education, content-rich applications, and integration with e-commerce platforms can enhance adoption and perceived value.

Cross-Cutting Challenges

Across all technologies, ethics, trust, regulatory compliance, and digital inclusion emerge as critical challenges. Issues such as algorithmic fairness, cybersecurity, data governance, and equitable access must be addressed to ensure sustainable adoption. Research gaps remain in longitudinal studies, hybrid technology integration, and socio-technical governance, particularly in emerging markets. Scholars argue for multi-stakeholder collaboration, iterative policy frameworks, and continuous monitoring to optimize the benefits of emerging technologies in commerce (Queiroz et al., 2021; Paliwal et al., 2020).

Synthesis & Integrative Framework

The synthesis of literature on emerging technologies in commerce highlights a complex interplay between technology capabilities, organizational and consumer outcomes, and moderating socio-technical factors. By integrating insights from AI, blockchain, FinTech, IoT, and AR/VR research, it is evident that technology adoption is not merely a technical issue but a multidimensional phenomenon shaped by human, organizational, and regulatory contexts.

Key Findings

The review reveals technology-specific contributions that enhance commerce across multiple dimensions. AI improves operational efficiency through predictive analytics, automation, and personalization, while blockchain strengthens transparency and traceability across supply chains. FinTech innovations expand financial inclusion and reduce transaction costs, IoT optimizes logistics and real-time asset tracking, and AR/VR technologies enrich customer engagement through immersive experiences. Collectively, these technologies facilitate enhanced operational performance, improved user experience, and broader market accessibility (Kumar et al., 2024; Gomber et al., 2018; Singh et al., 2022).

At the same time, cross-cutting challenges emerge consistently across technologies. Ethical concerns—such as algorithmic bias, privacy violations, and misuse of consumer data—pose significant barriers to adoption. Trust and transparency are crucial for consumer acceptance, especially in blockchain and FinTech contexts. Regulatory compliance remains a challenge due to heterogeneous global standards, and the digital divide limits equitable access, particularly in emerging markets (Queiroz & Wamba, 2019; The Guardian, 2024). These shared challenges underscore the need for coordinated governance and socially responsible technology design.

Finally, the literature emphasizes the importance of socio-technical alignment for successful adoption. Emerging technologies must be congruent with organizational processes, employee capabilities, and broader institutional frameworks. Misalignment between technical infrastructure and organizational culture or governance structures can result in suboptimal outcomes, delayed implementation, or outright failure of digital initiatives (Baxter & Sommerville, 2011; Queiroz & Wamba, 2019). Effective adoption requires a holistic view that integrates technical functionality with social, ethical, and regulatory considerations.

Integrative Socio-Technical Framework

Building on these findings, an integrative socio-technical framework is proposed to conceptualize the interrelationships between technologies, outcomes, and moderating factors. The model positions technologies as inputs, including AI, blockchain, FinTech, IoT, and AR/VR, which drive core outcomes such as efficiency, trust, engagement, and inclusion. Surrounding these outcomes are moderating factors—regulation, organizational capabilities, socio-technical alignment, and ethics/privacy—that shape and constrain the translation of technological potential into real-world impact.

This framework illustrates the layered, interconnected nature of technology adoption in commerce. Technological capabilities alone are insufficient; adoption success depends on the interplay with human actors, organizational structures, and external regulatory and social environments. For instance, AI-driven personalization may enhance customer engagement, but privacy concerns and inadequate organizational governance could undermine trust and limit effectiveness. Similarly, blockchain may enhance transparency, but scalability constraints and regulatory uncertainty can moderate its impact.

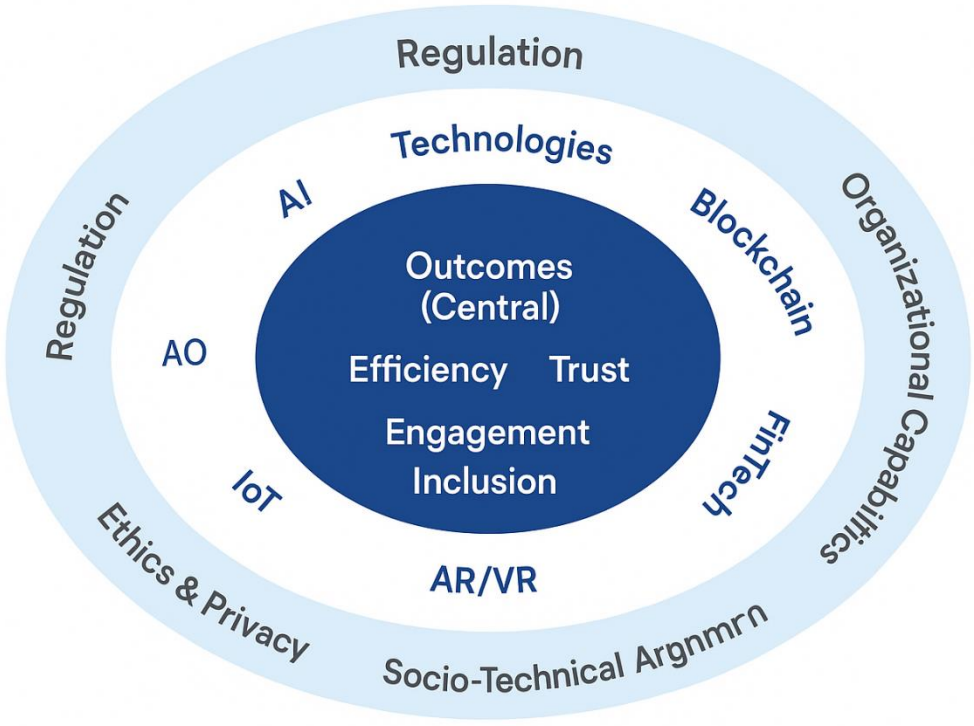


Figure 1 Integrative Socio-Technical Framework

Figure 1 depicts this conceptual model as a layered system: technologies feeding into outcomes, enveloped by moderating socio-technical factors. This visualization underscores the multi-level

dependencies and highlights areas where intervention—technical, managerial, or policy-oriented—can optimize outcomes.

Implications

For researchers, the framework points to opportunities for exploring hybrid technology adoption, cross-industry comparative studies, and socio-ethical impacts of emerging commerce technologies. Longitudinal and mixed-method studies can deepen understanding of how socio-technical alignment evolves over time and under different regulatory regimes.

For practitioners, the framework emphasizes the need to align technological investments with business strategy, organizational readiness, and governance mechanisms. Effective adoption requires capacity building, process reengineering, and proactive management of ethical and privacy concerns. The framework also highlights the benefits of integrated technology strategies that leverage synergies across AI, blockchain, IoT, and FinTech applications.

For policymakers, the findings underscore the importance of fostering adaptive regulation that balances innovation with consumer protection. Data privacy laws, digital inclusion initiatives, and supportive infrastructure are critical to enabling broad access and trust in emerging technologies. Policies that encourage cross-sector collaboration, responsible innovation, and ethical AI deployment can significantly enhance technology adoption and societal benefits.

Discussion

Practical Implications

The adoption of emerging technologies such as Artificial Intelligence (AI), blockchain, FinTech, Internet of Things (IoT), and Augmented/Virtual Reality (AR/VR) is reshaping business operations and consumer experiences in profound ways. These technologies collectively enhance operational efficiency by automating routine processes, optimizing supply chains, and enabling real-time data-driven decision-making. For example, AI-driven analytics can predict consumer behavior, while blockchain ensures secure, transparent financial transactions.

From a customer experience perspective, technologies such as AR/VR provide immersive and interactive engagement, improving product visualization and personalized recommendations. IoT devices facilitate real-time monitoring and predictive maintenance in industries ranging from

manufacturing to logistics, thereby reducing downtime and operational costs. FinTech innovations, including mobile payments and digital lending, are expanding financial inclusion, particularly in regions with limited access to traditional banking.

The success of technology adoption, however, is contingent on multiple organizational factors. Infrastructure readiness—including high-speed internet, cloud computing capabilities, and robust cybersecurity measures—is foundational. Equally important is organizational culture and human capital; employees need training and support to leverage new tools effectively. Strategic alignment between technological adoption and organizational goals is critical to ensure that digital transformation initiatives yield measurable outcomes rather than remaining pilot projects or isolated experiments.

Trade-offs and Risks

While emerging technologies offer significant advantages, they also introduce trade-offs and potential risks that organizations must address proactively:

Artificial Intelligence (AI) provides personalization and predictive insights, yet it raises ethical concerns about privacy and data security. Algorithmic bias may perpetuate discrimination if models are trained on unrepresentative datasets. Organizations must implement fairness audits, data anonymization, and transparent AI practices.

Blockchain enhances transparency, immutability, and traceability, but its energy-intensive nature and high operational costs pose challenges for large-scale deployment. Scalability issues, particularly in public blockchains, can limit transaction throughput.

Digital financial solutions expand access and convenience, but the increasing incidence of cybersecurity threats, identity theft, and fraud requires rigorous regulatory oversight, secure authentication mechanisms, and user awareness programs.

IoT enables operational monitoring and predictive maintenance, while AR/VR improves experiential engagement. However, both depend heavily on infrastructure availability and can exacerbate digital inequality if underserved populations lack access to high-speed networks or compatible devices.

Policy Recommendations

Policymakers and industry leaders should consider the following to support responsible and sustainable technology adoption:

1. Regulatory frameworks should encourage innovation while protecting users, including dynamic policies for AI, blockchain, and digital payments. Sandbox environments can help organizations experiment safely.
2. Codes of conduct for AI and digital commerce should address bias, accountability, and transparency. Ethical oversight boards can guide organizations in implementing responsible AI and data practices.
3. Governments and corporations should invest in skill development, digital literacy, and affordable infrastructure to reduce the digital divide and ensure equitable access to emerging technologies.
4. Joint initiatives between academia, industry, and government can facilitate pilot testing, validation, and governance of technology applications.
5. Organizations and regulators should implement ongoing evaluation of adoption impacts, tracking outcomes on efficiency, user satisfaction, financial inclusion, and social equity.

Conclusion and Future Research Directions

Emerging technologies possess transformative potential for organizations, consumers, and society at large. However, realizing this potential requires careful socio-technical alignment, ethical governance, regulatory support, and inclusive policies.

Key Insights

1. Technologies improve efficiency, engagement, trust, and inclusion, enabling organizations to enhance performance and competitiveness.
2. Adoption outcomes are influenced by organizational readiness, regulatory environment, ethical standards, and technological infrastructure.
3. Integration of multiple technologies (AI, IoT, AR/VR, blockchain, and FinTech) can create synergistic effects but requires holistic planning and risk management.

Actionable Recommendations

1. **For Organizations:** Phased implementation strategies, continuous training programs, and alignment of digital initiatives with strategic objectives are critical. Scenario planning and pilot testing help mitigate adoption risks.

2. **For Policymakers:** Adaptive regulations, inclusive digital policies, and public-private partnerships are essential to support innovation while safeguarding users.
3. **For Researchers:** Longitudinal studies examining organizational performance, consumer behavior, and adoption barriers provide empirical evidence for policy and managerial decisions. Cross-cultural validation ensures the applicability of findings in diverse contexts.
4. **For Industry–Academia Collaboration:** Interdisciplinary research fosters innovation and evidence-based strategies, facilitating the development of ethical, scalable, and user-centric solutions.

Future Research Directions

1. Investigate the long-term effects of emerging technologies on productivity, customer satisfaction, and organizational resilience.
2. Examine synergistic applications of AI–IoT, AR/VR–AI, and Blockchain–IoT to identify best practices, performance benefits, and interoperability challenges.
3. Explore how ethical frameworks, privacy regulations, and compliance measures influence adoption outcomes and societal trust.
4. Develop strategies to increase access for SMEs, marginalized populations, and underserved regions, addressing infrastructure gaps and skill shortages.
5. Combine bibliometric analysis, case studies, and quantitative research to provide robust, multi-dimensional insights into technology adoption trends, risks, and benefits.

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