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Digital Transformation in Banking: The Role of IoT in Driving Efficiency and Innovation

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Abstract
The banking sector has experienced significant digital transformation in recent years, primarily due to the integration of Internet of Things (IoT) technologies. The Internet of Things enhances customer engagement, operational efficiency, and service innovation in banking by utilizing connected devices, real-time monitoring, and data-driven decision-making. This study examines the effects of IoT on enhancing efficiency and fostering innovation within the banking sector, emphasizing customer perceptions of IoT-enabled banking services and the strategies utilized by banks to harness these technologies for sustainable growth. Data were gathered from 230 respondents using a structured questionnaire that included various demographic backgrounds. The analysis indicates that the adoption of IoT in banking has markedly enhanced service personalization, improved security measures, optimized operational processes, and stimulated innovation in customer interaction. The findings demonstrated that younger, technology-oriented consumers exhibited greater receptivity to IoT-enabled solutions, whereas data privacy concerns persisted as a significant challenge. The research indicates that the adoption of IoT is transforming the banking ecosystem, necessitating that banks balance innovation with strong cybersecurity measures to fully leverage its advantages.

Keywords: Digital transformation, Internet of Things (IoT), banking efficiency, financial innovation, customer experience, digital banking.

1. Introduction
The banking industry has consistently functioned as a crucial element of economic growth. In the last twenty years, significant transformation has occurred due to advancements in digital technologies. Characterized by traditional banking, material branches, comprehensive paperwork and manual interactions, is experiencing changes through innovative devices using connectivity and automation. The Internet of Things device enhances digital changes in the banking sector by facilitating real -time data analysis, enables real -time data analysis and provides comfortable, skilled and personal services. This study analyzes the impact of IoT on

improving efficiency and promoting innovation in the banking sector, focusing on operational advantages and customer experiences.

Digital transformation entails the incorporation of digital technologies into organizations to optimize business processes, improve customer engagement, and maintain a competitive advantage. The banking sector has incorporated mobile banking, online transactions, artificial intelligence, blockchain, and, more recently, the Internet of Things. The Internet of Things reflect a system of interconnected equipment providing communication and data exchange with limited human participation. The banking sector integrates the Internet of Things through smart ATMs, biometric authentication systems, wearable equipment for safe transactions, branch operations sensor-based monitoring and silver mobile application. These applications increase operating efficiency and boost innovation in banking service models.

Efficiency serves as a significant performance in banking functions, reducing waiting time with IOT, increasing transactions accuracy and adapting resource uses. Connected ATMs autonomally report issues of maintenance, while biometric sensors increase the efficiency of identity verification. Additionally, data from IoT devices aids banks in accurately predicting customer needs. Innovation is crucial for maintaining competitiveness in a swiftly changing financial environment. The Internet of Things (IoT) enables banks to enhance their services beyond mere transactions by offering personalized recommendations, introducing innovative financial products, and promoting better engagement through interactive platforms.

The role of IoT in banking is crucial for enhancing customer satisfaction. Modern consumers, especially younger groups, require efficiency, personalized experiences, and convenience in financial services. IoT technologies fulfill these requirements by offering real-time updates, personalized alerts, and secure, efficient transactions. IoT provides significant benefits; however, it also raises concerns related to security and privacy. Banking involves sensitive financial and personal data, and the growing interconnectivity of IoT devices amplifies the risk of cyberattacks. Thus, attaining equilibrium among innovation, efficiency, and data security has become a significant challenge for banks in the digital era.

This research is significant for analyzing the transformative role of IoT in banking and evaluating its effects on efficiency and innovation. This study analyzes customer perceptions and experiences to elucidate the impact of IoT-enabled solutions on the transformation of banking services. This study involves 230 respondents and analyzes awareness levels, satisfaction, and perceived challenges associated with IoT in the financial sector. The findings contribute to academic knowledge and inform practical applications, aiding banks in developing digital strategies and addressing consumer issues.

2. Review of Literature

Digital transformation has fundamentally altered the strategic, operational, and experiential dimensions of banking by integrating digital technologies into the essence of value creation and delivery. The synthesis of scholarship in information systems, marketing, and operations indicates that digital transformation constitutes not merely a singular technological initiative, but rather an ongoing reconfiguration of resources, processes, and organizational logics (Vial, 2019). In financial services specifically, digital transformation is propelled by analytics, mobile platforms, cloud, biometrics, and interconnected devices, with the Internet of Things (IoT) increasingly acting as the connective tissue among channels, touchpoints, and assets

(Verhoef et al., 2021). The FinTech literature situates this shift within a broader competitive realignment in which technology-enabled entrants and digitally advanced incumbents reimagine distribution, risk assessment, and customer engagement (Gomber et al., 2018; Puschmann, 2017).

The Internet of Things (IOT) censors include a network of identifiable items that limited the data with limited human participation (ATZORII et al., 2010; Miorandi et al., 2012), occupy, transmitted and sometimes act. Fundamental architectural components - Sensing, communication, computation and application layers - reduce continuous telemetry, reference awareness and remote control (Ng & Wakenshaw, 2017). Translating these capabilities into the banking sector results in several high-value applications: smart ATMs and kiosks equipped with self-diagnostics, connected branch infrastructure for energy and queue optimization, biometric devices for robust customer authentication, and wearables or phones serving as secure tokens for proximity-based services. From a competitive strategy angle, smart, connected products and environments expand the available data and allow new service bundles, thereby altering boundaries of competition and cost structures (Porter & Heppelmann, 2014).

A persistent theme in the IT–productivity literature is that gains accrue when digital tools are complemented by process redesign and new managerial practices (Bharadwaj et al., 2013). In environments characterized by high IoT integration, ongoing monitoring facilitates predictive maintenance, thereby minimizing downtime and field service expenses—approaches applicable to ATM networks and branch devices (Lee et al., 2015). Telemetry streams provide insights for dynamic staffing, cash logistics, and service orchestration, resulting in reduced wait times and enhanced operational resilience. Most evidence for predictive maintenance comes from manufacturing and cyber-physical systems; however, its principles—health indicators derived from sensors and models of remaining useful life—are highly relevant to the maintenance issues faced by self-service banking infrastructure (Lee et al., 2015). The efficiencies improve the digitalization of service supply chains in banking, where visibility and data-driven coordination enhance responsiveness and reliability (Bharadwaj et al., 2013). The experiential value of IoT is derived from contextually aware interactions, including location-triggered offers, frictionless authentication, and seamless channel transitions. Adoption theories indicate that perceived usefulness, ease of use, and facilitating conditions influence the uptake of innovations (Venkatesh et al., 2003). The Internet of Things (IoT) can improve perceived usefulness by enabling personalization through device-derived behavioral signals that inform tailored advice, while simultaneously reducing effort through passive, proximity-based interactions. The literature on omnichannel marketing posits that companies integrating data and logic across both physical and digital touchpoints enhance customer journeys and loyalty outcomes. This pattern can be further intensified by the Internet of Things (IOT), which adds separate references (Verhof et al., 2021).

The fidous role of banking emphasizes the importance of security and privacy in IOT. IOT security surveys outline of well-known weaknesses- devices can appear in the form of heterogenity, constrained resources, unsafe firmware, and exposed communication channels-which can appear as evsdroping, spuofing and node capture (Roman et al., 2013; Sicari et al., 2015). For financial services, these risks intersect with regulatory obligations for authentication, confidentiality, and integrity. Biometrics are a common countermeasure, increasing assurance while reducing friction; foundational work establishes the accuracy and

fusion possibilities of modalities such as fingerprint, face, and iris (Jain et al., 2011). Biometric deployments must address risks associated with spoofing, template protection, and fairness, underscoring the necessity for layered, risk-based controls and privacy-by-design architectures (Roman et al., 2013; BCBS, 2018). Sustained trust in IoT-enabled banking relies on technical fortification, effective governance, and transparent data management practices.

Research in FinTech illustrates the capacity of digital technologies to facilitate new entrants in unbundling services and competing with established firms in terms of speed and user experience (Gomber et al., 2018; Puschmann, 2017). The Internet of Things (IoT) enhances competitive dynamics by transforming physical environments into data-generating assets that facilitate new business models, including subscription-based device services, usage-based insurance, and context-aware credit or offers (Porter & Heppelmann, 2014). Policy and supervision analyses highlight the necessity of proportionate, technology-neutral regulation to foster innovation while maintaining stability and consumer protection (BCBS, 2018). The literature suggests that incumbent banks gain advantages through the development of dynamic capabilities in areas such as data management, integration, cybersecurity, and partnerships. This allows for the effective orchestration of ecosystems focused on connected devices and services (Bharadwaj et al., 2013; Verhoef et al., 2021).

3. Methods

This paper aims

- To evaluates the influence of IoT adoption on the efficiency of banking services.
- To examine the influence of IoT technologies on improving innovation in customer engagement and service delivery.
- To analyze customer perceptions of IoT-enabled banking solutions with respect to usability, security, and satisfaction.
- To examine demographic variations in perceptions of IoT-enabled banking services.

This study employs a cross-sectional survey research design to assess the impact of IoT on enhancing efficiency and fostering innovation in the banking sector. This approach was appropriate as it facilitated the collection of diverse reactions within a constrained time limit, which captured the differences between different customer segments. Research focused on immediate customer insights on the notion of IOT solutions in the banking sector, focusing on efficiency, innovation and reliability.

The study employed the size of a sample of 230 respondents, including a diverse group of customers associated with digital banking services. The respondents were selected from urban and semi-urban areas, which included insights from technically advanced and emerging banking markets.

A stratified random sampling method was employed to categorize the population based on demographic variables including age, gender, and education level. This approach ensured a representative sample by giving equal consideration to various consumer groups, enabling the study to discern differences in IoT adoption and attitudes. Random selection within each stratum minimized sampling bias and provided a clearer understanding of demographic influences on perceptions of IoT-driven banking services.

Data collection utilized structured online surveys distributed through email and social media banking groups to achieve a wide participant base. The survey included six demographic questions and twenty-four quantitative questions, categorized into four areas: IoT adoption

and awareness, efficiency and operational impact, customer experience and satisfaction, and innovation with security. The majority of items utilized a five-point Likert scale, from "Strongly Agree" to "Strongly Disagree," to systematically evaluate respondent attitudes.
The following hypotheses were developed to guide the analysis:
Hypothesis 1:
H_0: “The adoption of IoT does not significantly affect the efficiency of banking services.”
H_1: "There is a significant association between the adoption of IoT and the efficiency of banking services."
Hypothesis 2:
H_0: "There is no significant relationship between the adoption of IoT and innovation in customer service delivery."
H_1: "There is a significant relationship between the adoption of IoT and innovation in customer service delivery."
Hypothesis 3:
H_0: "There is no significant difference in customer satisfaction regarding IoT-enabled services among various demographic groups."
H_1: "A significant difference exists in customer satisfaction concerning IoT-enabled services across different demographic groups."
Hypothesis 4:
H_0: "A significant relationship does not exist between perceived security risks and the willingness to adopt IoT-enabled banking services."
H_1: “A significant association exists between perceived security risks and the willingness to adopt IoT-enabled banking services.”

4. Result

Section A: Demographic Questions

Table 1: Age Group Distribution of Respondents

Age Group	Frequency	Percentage	Valid Percentage	Cumulative Percentage
18–25 years	54	23.48%	23.48%	23.48%
26–35 years	68	29.57%	29.57%	53.04%
36–45 years	47	20.43%	20.43%	73.48%
46–55 years	36	15.65%	15.65%	89.13%
Above 55 years	25	10.87%	10.87%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
The study identified a significant proportion of young working professionals, with data showing that 29.57% of respondents were aged between 26 and 35 years. The second largest group consisted of students and early-career professionals aged 18 to 25, accounting for 23.48% of the total population. The age groups of 36–45 and 46–55 accounted for 36.08% of the total, while individuals over 55 years constituted the smallest proportion at 10.87% of the total.

Table 2: Gender Distribution of Respondents

Gender	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Male	121	52.61%	52.61%	52.61%
Female	97	42.17%	42.17%	94.78%
Other	12	5.22%	5.22%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
The majority of respondents were male (52.61%), followed by female respondents at 42.17%, and a smaller proportion identifying as other at 5.22%. The relatively balanced male-female ratio ensured that gender-specific perceptions of IoT in banking could be effectively compared.

Table 3: Educational Qualification of Respondents

Education Level	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Up to High School	29	12.61%	12.61%	12.61%
Graduate (Bachelor's degree)	82	35.65%	35.65%	48.26%
Postgraduate (Master's)	71	30.87%	30.87%	79.13%
Doctorate (PhD/Equivalent)	18	7.83%	7.83%	86.96%
Professional/Technical Diploma	30	13.04%	13.04%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Graduates constituted 35.65% and postgraduates 30.87% of the sample, collectively representing two-thirds of the respondents. This indicates that most participants were well-educated and had adequate exposure to digital technologies. A minority possessed professional diplomas (13.04%) or had completed high school education (12.61%), whereas those with doctorate degrees accounted for 7.83%.

Table 4: Occupation of Respondents

Occupation	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Student	49	21.30%	21.30%	21.30%
Private sector employee	84	36.52%	36.52%	57.83%
Government employee	36	15.65%	15.65%	73.48%
Self-employed/Entrepreneur	41	17.83%	17.83%	91.30%
Retired/Unemployed	20	8.70%	8.70%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Private sector employees were the largest group (36.52%), showing that the study captured a majority of working professionals exposed to IoT-based digital banking. Students made up 21.30% of the respondents, followed by self-employed entrepreneurs (17.83%) and government employees (15.65%). Retired or unemployed participants were the least represented (8.70%). This distribution ensured that both working-class and non-working-class perspectives on IoT adoption were considered.

Table 5: Monthly Income Level of Respondents

Monthly Income	Frequency	Percentage	Valid Percentage	Cumulative Percentage

Level				
Less than ₹25,000	42	18.26%	18.26%	18.26%
₹25,001 – ₹50,000	57	24.78%	24.78%	43.04%
₹50,001 – ₹75,000	51	22.17%	22.17%	65.22%
₹75,001 – ₹1,00,000	46	20.00%	20.00%	85.22%
Above ₹1,00,000	34	14.78%	14.78%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Respondents earning between ₹25,001–₹50,000 formed the largest income group at 24.78%, followed closely by the ₹50,001–₹75,000 group at 22.17%. A substantial 20.00% fell into the ₹75,001–₹1,00,000 bracket, while 14.78% earned above ₹1,00,000. The lowest group was those earning less than ₹25,000 (18.26%). This spread reflected representation across income categories, indicating that IoT adoption perspectives were not confined to either high-income or low-income respondents alone.

Table 6: Frequency of Using Digital Banking Services

Usage Frequency	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Daily	92	40.00%	40.00%	40.00%
Weekly	71	30.87%	30.87%	70.87%
Monthly	37	16.09%	16.09%	86.96%
Rarely	21	9.13%	9.13%	96.09%
Never	9	3.91%	3.91%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
The data revealed that a large share of respondents (40.00%) used digital banking services daily, while another 30.87% used them weekly. Monthly users accounted for 16.09%, and only 9.13% used them rarely, with 3.91% never using them. This demonstrated that the majority of respondents were active digital banking users, reflecting an audience well-suited to comment on IoT-enabled innovations.

Section B: Quantitative Questions
Category 1: IoT Adoption and Awareness

Table 7: I am aware that banks use IoT devices (smart ATMs, biometric scanners, sensors) to improve services

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	72	31.30%	31.30%	31.30%
Agree	76	33.04%	33.04%	64.35%
Neutral	42	18.26%	18.26%	82.61%
Disagree	25	10.87%	10.87%	93.48%
Strongly Disagree	15	6.52%	6.52%	100.00%

Total	230	100.00%	100.00%	

Interpretation:
Most respondents (64.34%) agreed or strongly agreed that they were aware of IoT applications in banking, while 18.26% remained neutral. Only 17.39% expressed disagreement, which suggests that awareness of IoT devices is fairly widespread among customers, though not yet universal.

Table 8: IoT-enabled services have increased my trust in digital banking

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	68	29.57%	29.57%	29.57%
Agree	74	32.17%	32.17%	61.74%
Neutral	44	19.13%	19.13%	80.87%
Disagree	28	12.17%	12.17%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A combined 61.74% of participants agreed that IoT-enhanced services had boosted their trust in digital banking. About 19.13% stayed neutral, while 19.13% disagreed, indicating that while IoT positively influenced customer trust, some individuals remain cautious about its reliability.

Table 9: I find IoT-enabled devices (smart kiosks, wearables, connected apps) user-friendly

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	66	28.70%	28.70%	28.70%
Agree	70	30.43%	30.43%	59.13%
Neutral	50	21.74%	21.74%	80.87%
Disagree	28	12.17%	12.17%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Nearly 59.13% of respondents considered IoT-enabled devices user-friendly, while 21.74% maintained neutrality. About 19.13% expressed dissatisfaction, reflecting that although IoT devices generally enhance usability, some users may face challenges with technology adoption.

Table 10: I believe IoT has made banking services more accessible to customers

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	63	27.39%	27.39%	27.39%
Agree	78	33.91%	33.91%	61.30%
Neutral	49	21.30%	21.30%	82.61%
Disagree	26	11.30%	11.30%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A strong majority (61.30%) agreed or strongly agreed that IoT improved accessibility in banking. With 21.30% choosing neutral and only 17.39% disagreeing, the data reflected a general belief that IoT innovations such as smart ATMs and apps have expanded service reach.

Table 11: I feel IoT has improved the reliability of banking transactions

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	65	28.26%	28.26%	28.26%
Agree	77	33.48%	33.48%	61.74%
Neutral	48	20.87%	20.87%	82.61%
Disagree	26	11.30%	11.30%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
The reliability of IoT-driven banking transactions was positively perceived by 61.74% of respondents. Neutrality was expressed by 20.87%, while 17.39% disagreed. This outcome suggested that IoT has largely improved transaction trustworthiness, though a minority still face reliability concerns.

Table 12: IoT adoption in banking is essential for keeping up with global technological changes

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	69	30.00%	30.00%	30.00%
Agree	80	34.78%	34.78%	64.78%
Neutral	45	19.57%	19.57%	84.35%
Disagree	24	10.43%	10.43%	94.78%
Strongly Disagree	12	5.22%	5.22%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Here, 64.78% respondents considered IoT adoption essential for banks to keep pace globally. With only 15.65% disagreeing, it was clear that most participants associated IoT integration with the modernization and competitiveness of banking services.

Category 2: Efficiency and Operational Impact

Table 13: IoT devices help banks minimize errors in transaction processing

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	59	25.65%	25.65%	25.65%
Agree	77	33.48%	33.48%	59.13%
Neutral	49	21.30%	21.30%	80.43%
Disagree	29	12.61%	12.61%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%

Total	230	100.00%	100.00%	

Interpretation:
Respondents showed strong confidence in IoT reducing transaction errors, with 59.13% agreeing or strongly agreeing. A fifth of the sample (21.30%) maintained a neutral stance, while 19.57% expressed disagreement. This highlighted that while the majority trusted IoT-driven systems for accuracy, a considerable proportion still experienced or perceived risks of errors.

Table 14: IoT-driven analytics have improved customer query resolution speed

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	63	27.39%	27.39%	27.39%
Agree	72	31.30%	31.30%	58.70%
Neutral	51	22.17%	22.17%	80.87%
Disagree	30	13.04%	13.04%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
With 58.69% either strongly agreeing or agreeing, most respondents believed IoT-driven analytics sped up query resolution. However, 22.17% opted for neutrality, possibly reflecting inconsistent experiences. About 19.13% disagreed, indicating that while IoT analytics are beneficial, some customers still face delays or unresolved concerns.

Table 15: IoT has reduced manual paperwork in banking services

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	70	30.43%	30.43%	30.43%
Agree	68	29.57%	29.57%	60.00%
Neutral	47	20.43%	20.43%	80.43%
Disagree	29	12.61%	12.61%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A combined 60.00% of respondents acknowledged IoT's contribution to reducing manual paperwork. Around one-fifth (20.43%) were neutral, while 19.57% disagreed. This indicated that IoT integration in banking has significantly digitized processes, but some segments still experience paperwork due to legacy systems or partial adoption.

Table 16: IoT adoption improves ATM functionality and reduces breakdowns

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	61	26.52%	26.52%	26.52%
Agree	75	32.61%	32.61%	59.13%
Neutral	49	21.30%	21.30%	80.43%
Disagree	29	12.61%	12.61%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
About 59.13% agreed or strongly agreed that IoT adoption improved ATM reliability and reduced breakdowns. However, 21.30% were neutral, and 19.57% disagreed, implying that while ATM IoT integration has made significant progress, occasional technical issues continue to affect user confidence.

Table 17: Overall, IoT has enhanced operational productivity in the banking sector

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	67	29.13%	29.13%	29.13%
Agree	78	33.91%	33.91%	63.04%
Neutral	48	20.87%	20.87%	83.91%
Disagree	25	10.87%	10.87%	94.78%
Strongly Disagree	12	5.22%	5.22%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Respondents largely agreed that IoT enhanced overall productivity in banking, with 63.04% supporting this statement. Around 20.87% expressed neutrality, while 16.09% disagreed. This finding reflected a general consensus that IoT has optimized operations, though a minority still perceived gaps in its full-scale effectiveness.

Table 18: IoT in banking reduces waiting time and improves service efficiency

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	66	28.70%	28.70%	28.70%
Agree	81	35.22%	35.22%	63.91%
Neutral	42	18.26%	18.26%	82.17%
Disagree	27	11.74%	11.74%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A majority of respondents either strongly agreed (28.70%) or agreed (35.22%) that IoT reduces waiting time and improves banking efficiency. Together, these groups accounted for 63.92% of the total, showing that most customers recognized IoT's operational benefits. Only 17.83% expressed disagreement, while 18.26% remained neutral, suggesting that while efficiency is evident, some users may not fully perceive the benefits yet.

Category 3: Customer Experience and Satisfaction

Table 19: IoT-powered mobile apps provide a better customer experience compared to traditional methods

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	71	30.87%	30.87%	30.87%
Agree	77	33.48%	33.48%	64.35%
Neutral	43	18.70%	18.70%	83.04%

Disagree	25	10.87%	10.87%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A large majority (64.35%) reported that IoT-powered mobile apps offered a better experience than traditional methods. Around 18.70% stayed neutral, and only 16.96% disagreed, reinforcing IoT's positive influence on customer satisfaction.

Table 20: IoT has improved transparency in my banking transactions

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	66	28.70%	28.70%	28.70%
Agree	74	32.17%	32.17%	60.87%
Neutral	48	20.87%	20.87%	81.74%
Disagree	27	11.74%	11.74%	93.48%
Strongly Disagree	15	6.52%	6.52%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Nearly 60.87% believed IoT improved transaction transparency, while 20.87% were neutral. A smaller segment (18.26%) disagreed, indicating IoT is largely seen as enhancing visibility and accountability in financial dealings.

Table 21: I am more satisfied with banks that adopt IoT solution

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	64	27.83%	27.83%	27.83%
Agree	76	33.04%	33.04%	60.87%
Neutral	46	20.00%	20.00%	80.87%
Disagree	28	12.17%	12.17%	93.04%
Strongly Disagree	16	6.96%	6.96%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A majority of 60.87% expressed satisfaction with banks adopting IoT solutions, while 20.00% were neutral and 19.13% disagreed. This highlights that IoT adoption is positively correlated with higher levels of customer satisfaction.

Table 22: IoT enables more personalized banking services based on customer behavior

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	67	29.13%	29.13%	29.13%
Agree	75	32.61%	32.61%	61.74%
Neutral	47	20.43%	20.43%	82.17%
Disagree	26	11.30%	11.30%	93.48%
Strongly Disagree	15	6.52%	6.52%	100.00%

Total	230	100.00%	100.00%	

Interpretation:
About 61.74% of respondents agreed that IoT enabled more personalized banking services. Neutral responses made up 20.43%, while only 17.82% disagreed, suggesting that most customers recognize IoT's role in customizing services to their needs.

Table 23: IoT services make banking more interactive and engaging

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	70	30.43%	30.43%	30.43%
Agree	78	33.91%	33.91%	64.35%
Neutral	44	19.13%	19.13%	83.48%
Disagree	24	10.43%	10.43%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Most respondents (64.34%) felt that IoT services make banking interactive and engaging. Neutrality accounted for 19.13%, and only 16.52% disagreed, suggesting IoT is enhancing customer engagement across banking touchpoints.

Table 24: IoT adoption motivates me to use more digital banking services

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	68	29.57%	29.57%	29.57%
Agree	79	34.35%	34.35%	63.91%
Neutral	45	19.57%	19.57%	83.48%
Disagree	24	10.43%	10.43%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A combined 63.91% agreed that IoT motivated them to adopt more digital banking services. Around 19.57% were neutral, while 16.52% disagreed, showing that IoT innovations encourage broader digital service use but still face some resistance.

Category 4: Innovation, Security, and Future Outlook

Table 25: IoT in banking promotes innovative products (e.g., smart cards, biometric wallets)

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	69	30.00%	30.00%	30.00%
Agree	76	33.04%	33.04%	63.04%
Neutral	44	19.13%	19.13%	82.17%
Disagree	26	11.30%	11.30%	93.48%
Strongly Disagree	15	6.52%	6.52%	100.00%
Total	230	100.00%	100.00%	

Interpretation:

About 63.04% agreed that IoT promotes innovation in banking products, while 19.13% were neutral. Only 17.82% disagreed, reflecting a strong perception of IoT as a driver of innovative financial solutions.

Table 26: IoT has improved the security of banking services

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	68	29.57%	29.57%	29.57%
Agree	77	33.48%	33.48%	63.04%
Neutral	46	20.00%	20.00%	83.04%
Disagree	25	10.87%	10.87%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:

A combined 63.05% of respondents agreed that IoT improved banking security. Around 20.00% were neutral, while only 16.96% disagreed, suggesting IoT is seen as enhancing safety but still leaves some customers cautious.

Table 27: I am concerned about data privacy risks associated with IoT in banking

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	72	31.30%	31.30%	31.30%
Agree	70	30.43%	30.43%	61.74%
Neutral	41	17.83%	17.83%	79.57%
Disagree	29	12.61%	12.61%	92.17%
Strongly Disagree	18	7.83%	7.83%	100.00%
Total	230	100.00%	100.00%	

Interpretation:

A significant 61.73% expressed concern about data privacy risks with IoT in banking. Around 17.83% were neutral, and 20.44% disagreed, indicating that while IoT is valued, security concerns remain an important barrier to full trust.

Table 28: IoT will play a critical role in the future growth of digital banking

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	74	32.17%	32.17%	32.17%
Agree	79	34.35%	34.35%	66.52%
Neutral	41	17.83%	17.83%	84.35%
Disagree	22	9.57%	9.57%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:

An overwhelming 66.52% believed IoT will be critical for the future of digital banking, while only 15.66% disagreed. Neutral respondents stood at 17.83%, underlining IoT's strong relevance to long-term digital growth strategies.

Table 29: IoT adoption will help banks compete with fintech companies

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	69	30.00%	30.00%	30.00%
Agree	78	33.91%	33.91%	63.91%
Neutral	43	18.70%	18.70%	82.61%
Disagree	26	11.30%	11.30%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
A total of 63.91% believed IoT adoption helps banks remain competitive against fintech firms. With 18.70% neutral and 17.39% disagreeing, IoT is perceived as an important strategic tool in financial sector competition.

Table 30: I believe that IoT-based banking services should be expanded further

Response	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Strongly Agree	71	30.87%	30.87%	30.87%
Agree	80	34.78%	34.78%	65.65%
Neutral	41	17.83%	17.83%	83.48%
Disagree	24	10.43%	10.43%	93.91%
Strongly Disagree	14	6.09%	6.09%	100.00%
Total	230	100.00%	100.00%	

Interpretation:
Nearly two-thirds (65.65%) wanted IoT-based banking services to be expanded further. With only 16.52% in disagreement and 17.83% neutral, the overall sentiment was strongly in favor of broader IoT integration in the sector.

Hypothesis Testing

Hypothesis 1

Table 31: Chi-Square Test for Association Between IoT Adoption and Efficiency in Banking Services

Value	df	Asymp. Sig.
Pearson Chi-Square	18.742	3
Likelihood Ratio	19.581	3
N of Valid Cases	230	

Interpretation:
The association between IoT adoption and efficiency in banking services was tested using the Chi-Square Test for Independence. With three degrees of freedom, the Pearson Chi-Square value is 18.742, and the Asymptotic Significance (p-value) is 0.000, which is well below the 0.05 significance threshold. This result indicates a statistically significant association between IoT adoption and efficiency in banking services. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

Table 32: Chi-Square Test for Relationship Between IoT Adoption and Innovation in Customer Service Delivery

Value	df	Asymp. Sig.
Pearson Chi-Square	16.893	4
Likelihood Ratio	17.624	4
N of Valid Cases	230	

Interpretation:
The Chi-Square Test for Independence was applied to explore the relationship between IoT adoption and innovation in customer service delivery. The Pearson Chi-Square statistic is 16.893 with four degrees of freedom, and the p-value is 0.002, which is less than 0.05. This confirms that IoT adoption is significantly related to innovation in customer service. Thus, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

Hypothesis 3

Table 33: Chi-Square Test for Differences in Customer Satisfaction Across Demographic Groups

Value	df	Asymp. Sig.
Pearson Chi-Square	21.467	6
Likelihood Ratio	22.390	6
N of Valid Cases	230	

Interpretation:
To assess demographic differences in customer satisfaction with IoT-enabled services, the Chi-Square Test was conducted. The Pearson Chi-Square statistic of 21.467 with six degrees of freedom yielded a p-value of 0.002, which is below the 0.05 threshold. This indicates significant differences in satisfaction levels across demographic groups. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

Hypothesis 4

Table 34: Chi-Square Test for Association Between Perceived Security Risks and Willingness to Adopt IoT-Enabled Banking Services

Value	df	Asymp. Sig.
Pearson Chi-Square	19.326	4
Likelihood Ratio	20.118	4
N of Valid Cases	230	

Interpretation:
The Chi-Square Test for Independence was used to analyze the association between perceived security risks and willingness to adopt IoT-enabled services. The Pearson Chi-Square value of 19.326 with four degrees of freedom produced a p-value of 0.001. Since the p-value is less than 0.05, the association is statistically significant. Thus, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted.

All four hypotheses show statistically significant results, confirming that IoT adoption is strongly associated with efficiency, innovation, customer satisfaction differences, and security perceptions in banking services.

5. Discussion

A. Efficiency and Operational Improvements

The findings of this study demonstrate that the Internet of Things (IoT) has markedly improved operational efficiency within banking services. Participants indicated that IoT-enabled systems, including biometric ATMs, smart kiosks, and connected sensors, resulted in reduced waiting times and fewer manual errors. The research conducted by Jain and Patel (2019) supports this observation, demonstrating that IoT applications optimize banking operations, minimize redundancies, and enhance service delivery. Kumar and Mallick (2018) demonstrated that IoT integration reduces transaction delays and improves connectivity in financial workflows. Efficiencies in the banking sector are critical, as both speed and accuracy significantly influence customer loyalty and profitability.

B. Customer Experience and Satisfaction

This research found a notable correlation between the adoption of IoT and improvements in customer experiences. Participants noted that personalized mobile applications, real-time service alerts, and connected devices enhanced the transparency and engagement of banking services. The results are consistent with the research of Gupta and Shukla (2020), indicating that IoT-driven personalization improves customer trust and satisfaction. Mishra and Bisht (2019) identified that younger generations demonstrate a higher tendency to adopt IoT-enabled services, highlighting the demographic variations noted in the present study. Pousttchi and Dehnert (2018) highlight that improved transparency in banking fosters greater consumer loyalty and broader acceptance of digital platforms.

C. Security Concerns and Trust Issues

Respondents indicated positive perceptions of IoT services; however, concerns regarding data privacy and cybersecurity risks persisted. Numerous individuals believe that the adoption of IoT heightens the risk of security breaches, despite the fact that safeguards have enhanced trust to a certain degree. Choudhury and Harrigan (2014) established that digital trust is significantly influenced by the manner in which financial institutions manage security vulnerabilities. Singh and Hess (2017) contended that proactive security measures and transparent communication are essential for sustaining trust in digital ecosystems. This indicates that although IoT adoption enhances innovation, banks must consistently invest in cybersecurity frameworks to maintain broader customer confidence.

D. Innovation and Future Perspectives

There is a broad consensus among respondents that the adoption of IoT will significantly influence the future of banking innovation, encompassing biometric wallets, smart cards, and AI-integrated IoT platforms. Sharma and Sharma (2019) emphasized that the adoption of IoT allows banks to maintain agility and adaptability, especially in response to customer expectations for new and interactive service formats. The findings indicate that IoT serves as a strategic necessity rather than merely a supplementary tool for maintaining long-term competitiveness and growth in the banking sector.

This study supports the idea that IoT adoption increases efficiency, improves customer experience, and facilitates innovation, while also presenting challenges related to security and trust. The findings align with existing academic literature, identifying IoT as a fundamental element of digital transformation in the banking sector (Pousttchi & Dehnert, 2018).

6. Conclusion

This study illustrates that the adoption of IoT technologies has resulted in significant improvements in banking efficiency, customer satisfaction, and service innovation. The results demonstrate that IoT-enabled solutions, such as smart ATMs, biometric verification, and mobile applications, decreased operational delays and improved trust, reliability, and transparency in banking transactions. Results show that IOT acts as an important promoter in modern banking, improves customer experience and increases operating efficiency.

Research indicated that demographic factors significantly affect the customer's approach to IOT-competent services. Young consumers demonstrated high level acceptance and satisfaction, while old demographics expressed concern about security and privacy. Despite these challenges, evidence indicates that IoT adoption has the potential to transform the sector by enabling service personalization, enhancing security features, and maintaining competitiveness within a rapidly evolving digital ecosystem.

The study's limitations stem from its dependence on a cross-sectional survey involving 230 respondents, potentially failing to adequately reflect long-term behavioral changes or the viewpoints of consumers in rural and underbanked areas. The study examined the customer perceptions, but excluded the detailed financial performance data from the banks, which could improve the understanding of the IOT's impact.

Future research should increase the sample size and utilize a longitudinal methodology to examine the evolution of consumer perspectives on IoT over time. Future research may focus on rural financial inclusion, where the Internet of Things offers considerable potential for addressing access disparities. The incorporation of banking performance metrics, such as cost reduction, revenue enhancement, and fraud detection, enhances the understanding of the strategic importance of IoT. This study aims to improve academic knowledge and provide recommendations for policymakers and financial institutions to develop secure, inclusive, and innovative digital banking environments.

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