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# Modeling Factors Influencing Blockchain Adoption in Retail Banking: A DEMATEL-Based Approach

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**Abstract:** In the rapidly evolving digital landscape, integrating blockchain technology into retail banking has emerged as a pivotal strategy for operational efficiency and competitive differentiation. This study employs the Decision Making Trial and Evaluation Laboratory (DEMATEL) methodology to explore the relationships among the main factors shaping blockchain adoption, highlighting their direct and indirect effects on banks' implementation efforts. The findings reveal that technology cost exerts the strongest causal influence on blockchain adoption, significantly affecting all other factors. Moreover, the interaction between technology cost and blockchain scalability is mediated by regulatory requirements, customer acceptance, and industry collaboration. Specifically, regulatory compliance obligations and associated uncertainties can magnify the cost barrier, while higher expenses may discourage customer engagement and limit large-scale adoption. Simultaneously, collaborations among banks and technology partners can alleviate cost burdens, thereby promoting more widespread implementation. These findings highlight the need for careful financial planning, strategic investment, and regulatory engagement to manage the high costs inherent in blockchain projects. Furthermore, banks should consider proactive customer education to convey the benefits of blockchain-driven innovations, thereby building trust and encouraging utilization.

**Keywords:** blockchain adoption; retail banking; technology cost; regulatory compliance; system interoperability; system security; blockchain scalability; customer adoption; industry collaboration; DEMATEL

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## 1. Introduction

Blockchain technology has rapidly gained attention in the banking sector as a disruptive innovation capable of reshaping financial operations through its transparent and tamper-proof features (Alnsour, 2024; Jena, 2022; Kajla et al., 2024; Lu et al., 2024; Mafike & Mawela, 2022). By eliminating intermediaries and operating as a decentralized ledger system, blockchain holds the potential to streamline financial transactions, reduce operational inefficiencies, and strengthen trust among stakeholders (Mansoor et al., 2024; R. Mishra et al., 2023; Saheb & Mamaghani, 2021). These attributes make blockchain particularly attractive for retail banking services, where transaction security, speed, and cost-effectiveness are paramount (Jena, 2022; Kumari & Devi, 2022; Lu et al., 2024; R. Mishra et al., 2023). Correspondingly, global financial institutions have demonstrated increased interest and investment in blockchain-based solutions, targeting applications such as cross-border payments, identity verification, loan processing, and regulatory compliance (L. Mishra & Kaushik, 2023; R. Mishra et al., 2023). Despite this growing enthusiasm, real-world implementation of blockchain in banking has remained limited, attributed to various technological, organizational, and regulatory hurdles (Mafike & Mawela, 2022; Rahman et al., 2025; Saheb & Mamaghani, 2021).

Existing research indicates that blockchain adoption in banking involves a series of critical considerations, including scalability, security, interoperability with legacy systems, regulatory compliance, and cost implications (Mafike & Mawela, 2022). In many cases, adoption has been slow, especially in developing economies, where factors such as limited technological infrastructure, lack of regulatory clarity, and resistance to change can hinder successful implementation (Jena, 2022; Kumari & Devi, 2022; Mansoor et al., 2024). Even in more advanced markets, concerns over misinformation, overhyped claims, and organizational inertia have contributed to skepticism and uneven uptake (R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021). These multifaceted challenges underscore the need for a structured evaluation of the factors influencing blockchain adoption—particularly in retail banking, where consumer-facing transactions require rigorous reliability and security.

Prior studies have employed a range of methodologies to investigate factors influencing blockchain adoption in the financial sector. These include literature reviews and conceptual analyses (Arjun & Suprabha, 2020; Basori & Ariffin, 2022; Mafike & Mawela, 2022; Mbaidin et al., 2023; Miah et al., 2023; L. Mishra & Kaushik, 2023; Rahman et al., 2025; Shorman et al., 2020; Zachariadis et al., 2019; Zhang et al., 2020), empirical surveys (Alaeddin et al., 2021; Alnsour, 2024; Jena, 2022; Kumari & Devi, 2022; Mansoor et al., 2024; Mbaidin et al., 2024a, 2024b), and interview-based qualitative research (V. Chang et al., 2020; Saheb & Mamaghani, 2021; Suwanposri et al., 2021), each mainly focusing on individual determinants of adoption rather than the holistic interaction among them.

Multiple-criteria decision-making (MCDM) techniques have increasingly been utilized to examine factors influencing blockchain adoption in the banking and broader financial sector, but their application remains comparatively limited. For instance, Kajla et al. (2024) employed the Analytic Hierarchy Process (AHP) to identify the most important determinants of blockchain adoption in banking, and Lu et al. (2024) applied the Decision Making Trial and Evaluation Laboratory (DEMATEL) method to prioritize critical factors. While these studies highlight key adoption factors, they do not explore the specific interrelationships or feedback loops among them. In a subsequent effort, R. Mishra et al. (2023) also used DEMATEL and distinguished cause-and-effect factors, yet they did not comprehensively model the most prominent interrelationships. Other researchers, such as Chavali et al. (2024) and Banerjee and Chandani (2024), explored certain linkages among blockchain challenges using interpretive structural modeling, though their investigations targeted the broader financial sector rather than banking specifically. Despite these contributions, there remains a significant gap in research that systematically captures the interdependencies among blockchain adoption factors in banking, particularly using robust MCDM approaches. Both Lu et al. (2024) and R. Mishra et al. (2023), therefore, call for additional research applying MCDM techniques to explore diverse sets of factors in the banking context, ideally using large samples across various organizational settings.

Building on this body of work, the current study focuses specifically on retail banking and employs the DEMATEL approach to systematically examine how multiple interrelated factors influence blockchain adoption. Given that blockchain is a distributed technology requiring efficient coordination among multiple stakeholders across the sector, its adoption is primarily driven by regulatory constraints, technological feasibility, and market demand. While internal readiness is essential for implementation, as indicated by previous studies

(Alnsour, 2024; Kajla et al., 2024; Mbaidin et al., 2024a; Rahman et al., 2025; Suwanposri et al., 2021), this analysis prioritizes the broader industry-wide conditions that determine whether blockchain adoption is feasible at scale. Therefore, this study deliberately focuses on systemic and external factors rather than firm-specific capabilities.

Unlike prior studies, which either identified key factors or categorized them into cause-and-effect groups, this research aims to develop a more comprehensive understanding of how these factors dynamically interact within the banking environment. By more thoroughly modeling the interactions among these factors, the study addresses the gap in prior MCDM-based studies and sheds new light on how technological, regulatory, and market-driven factors collectively influence blockchain integration in these operations. Furthermore, this research utilizes an extensive sample of 74 seasoned experts—managers from the Greek banking sector—representing a relatively large cohort for DEMATEL. As the Greek banking sector has not been previously examined in this subject area, it offers a novel perspective on the challenges and opportunities of blockchain adoption in retail banking.

The remainder of this paper is organized as follows: Section 2 offers a systematic review of existing literature on blockchain adoption factors in the banking and broader financial context. Section 3 details the DEMATEL methodology and describes the sample selection and data collection processes. Section 4 presents the empirical findings and highlights the identified cause-and-effect relationships among adoption factors. Finally, Section 5 discusses the implications of the results for managers, acknowledges the study's limitations, and proposes paths for future research.

## 2. Literature Review

This section explores the systemic and external factors influencing blockchain adoption in retail banking through a comprehensive literature review. A systematic methodology was employed to build a robust bibliographic dataset. First, a focused search in the Scopus database was conducted in late 2024, targeting articles with the keywords "blockchain AND (bank* OR financ*) AND (factors OR determinants OR drivers OR enablers OR barriers OR obstacles OR inhibitors OR challenges OR constraints) in their titles". This yielded 84 publications. To refine the dataset and ensure academic rigor, we excluded 37 book chapters and conference papers, retaining 47 peer-reviewed journal articles and reviews. Two authors independently assessed these publications based on relevance to blockchain adoption determinants in retail banking, considering factors such as empirical evidence, theoretical contribution, and industry focus. As a result, 25 publications were selected for further analysis, while 22 were excluded. A content analysis of these 25 studies was conducted using MAXQDA 2022. Independent coding by two researchers ensured reliability, followed by cross-validation to resolve discrepancies. Through this process, seven overarching factors influencing blockchain adoption in retail banking were identified. These factors, categorized by thematic significance, are detailed in the following subsections.

### 2.1. Regulatory Framework and Compliance

Regulatory framework and compliance are pivotal in shaping blockchain adoption in retail banking, functioning both as a key driver and a challenging barrier. On one hand, blockchain's capacity to enhance transparency, automate compliance, and address anti-money laundering requirements appeals to financial institutions operating under stringent oversight (V. Chang et al., 2020; Mansoor et al., 2024; Mbaidin et al., 2024a; Zhang et al., 2020). On the other hand, the rapid evolution of blockchain technology has outpaced regulatory regimes, creating mismatched frameworks and legal uncertainties that hinder broader implementation (Chavali et al., 2024; Saheb & Mamaghani, 2021). Many jurisdictions lack specific guidelines, and fragmented governance across borders complicates compliance obligations by introducing varying standards and privacy concerns (Banerjee & Chandani, 2024; Lu et al., 2024; Mbaidin et al., 2023; R. Mishra et al., 2023; Shorman et al., 2020). Moreover, blockchain's immutability and decentralized nature can conflict with existing data protection laws, underscoring the need for tailored regulations and globally harmonized policies (Mafike & Mawela, 2022; Rahman et al., 2025). As governments and central banks remain cautious toward decentralized systems, supportive legislation and unified governance structures are essential to mitigate legal risks, foster interoperability, and fully realize blockchain's potential in retail banking (Basori & Ariffin, 2022; Kajla et al., 2024; Miah et al., 2023; Suwanposri et al., 2021; Zachariadis et al., 2019).

### *2.2. Blockchain Scalability*

Scalability is widely recognized as a pivotal factor in blockchain adoption for retail banking, given the sector's need for high-speed, high-volume, and real-time transaction processing that existing blockchain systems often struggle to support (Alaeddin et al., 2021; Arjun & Suprabha, 2020; Banerjee & Chandani, 2024; V. Chang et al., 2020; Chavali et al., 2024; Kajla et al., 2024; Lu et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Zachariadis et al., 2019; Zhang et al., 2020). The so-called "scalability trilemma"—the difficulty of simultaneously achieving decentralization, security, and high throughput—remains a major technological hurdle, as limited block sizes, prolonged confirmation times, and energy-intensive consensus mechanisms constrain performance and hinder broader adoption (Alaeddin et al., 2021; Banerjee & Chandani, 2024; V. Chang et al., 2020; Chavali et al., 2024; Mbaidin et al., 2023; R. Mishra et al., 2023; Saheb & Mamaghani, 2021; Zhang et al., 2020). These challenges are compounded by blockchain systems' high computing power and storage requirements, the complexity of integrating with legacy banking infrastructures, and the stringent real-time demands of financial transactions (Arjun & Suprabha, 2020; Kajla et al., 2024; Mafike & Mawela, 2022; Rahman et al., 2025; Zachariadis et al., 2019). Proposed solutions—such as sharding, off-chain scaling techniques, and alternative consensus protocols like Proof-of-Stake—seek to enhance throughput and overall efficiency (Miah et al., 2023; Shorman et al., 2020), yet issues of standardization, compatibility, and governance must be resolved before blockchain can be smoothly scaled for large-scale retail banking operations (Kajla et al., 2024; Rahman et al., 2025; Zachariadis et al., 2019).

### *2.3. System Interoperability with Blockchain*

System interoperability with blockchain is widely recognized as a critical factor influencing its adoption in retail banking. Research consistently points to the challenges of integrating blockchain with legacy enterprise systems, as most traditional banking infrastructures were not designed to accommodate decentralized technologies (Chavali et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; Saheb & Mamaghani, 2021). The lack of universal standards and standardized communication protocols across different blockchain platforms further complicates this integration, leading to inefficiencies, higher operational costs, and limited data exchange between financial institutions (R. Mishra et al., 2023; Shorman et al., 2020; Zachariadis et al., 2019). Moreover, siloed and highly centralized banking operations exacerbate these issues, making seamless compatibility with decentralized blockchain networks particularly difficult (V. Chang et al., 2020; Rahman et al., 2025). Despite these hurdles, scholars emphasize that blockchain's transformative potential depends on its ability to function within existing banking systems without causing disruptions, underscoring the importance of alignment with current infrastructures (Kajla et al., 2024; Lu et al., 2024). Addressing interoperability challenges will require industry-wide coordination to develop common frameworks, protocols, and permissioned networks, enabling controlled integration and ensuring blockchain's benefits can be fully exploited in the banking sector (Miah et al., 2023).

### 2.4. System Security

System security stands as a pivotal factor in blockchain adoption for retail banking, as heightened security concerns and perceived risks can significantly discourage users from embracing blockchain-based services (Jena, 2022; Kumari & Devi, 2022; Lu et al., 2024; R. Mishra et al., 2023; Saheb & Mamaghani, 2021). Despite blockchain's security-enhancing attributes—such as cryptographic hashing, decentralized consensus mechanisms, digital signatures, and immutability—which collectively safeguard transactions from fraud, unauthorized access, and data manipulation (Alnsour, 2024; Basori & Ariffin, 2022; Kajla et al., 2024; Mansoor et al., 2024; Mbaidin et al., 2023, 2024a, 2024b; Miah et al., 2023; L. Mishra & Kaushik, 2023; Rahman et al., 2025; Shorman et al., 2020; Suwanposri et al., 2021; Zhang et al., 2020), vulnerabilities still exist, including coding flaws, 51% attacks, weak identity-verification standards, and limitations in smart contracts (Alaeddin et al., 2021; Banerjee & Chandani, 2024; V. Chang et al., 2020; Chavali et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; Saheb & Mamaghani, 2021; Zachariadis et al., 2019). Malicious actors can exploit these weaknesses, leading to potential financial losses, data corruption, and breaches—outcomes that heighten apprehension among banks and regulators (Arjun & Suprabha, 2020; V. Chang et al., 2020; Kajla et al., 2024; Zhang et al., 2020). Consequently, robust security protocols, skilled professionals, formal governance frameworks, and strict adherence to data protection regulations are critical to preserving confidentiality, integrity, and availability within blockchain-based banking solutions (Alaeddin et al., 2021; Banerjee & Chandani, 2024; Saheb & Mamaghani, 2021; Zachariadis et al., 2019).

### 2.5. Technology Cost

Technology cost remains a pivotal consideration in retail banking's blockchain adoption, as high initial investments in hardware, software, integration, and training create significant financial barriers (Banerjee & Chandani, 2024; Kajla et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2024a; Saheb & Mamaghani, 2021; Zhang et al., 2020). These challenges are exacerbated by the energy-intensive nature of consensus mechanisms, transaction fees, and continuous computational requirements, which further inflate operational expenses (V. Chang et al., 2020; Chavali et al., 2024; Mbaidin et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025). Upgrading from legacy systems imposes additional financial burdens, especially for institutions that have already heavily invested in traditional infrastructures (Alaeddin et al., 2021; Miah et al., 2023; Shorman et al., 2020). Moreover, smaller banks in developing countries often struggle to allocate sufficient budgets amid unstable economic conditions (Kajla et al., 2024; Mbaidin et al., 2023). Large-scale implementation can also be hindered by transaction throughput limitations and risks of payment instability, compounding operational costs (Arjun & Suprabha, 2020). Nonetheless, blockchain can potentially deliver long-term cost savings by eliminating intermediaries, reducing manual processes, and lowering overall operational expenses (Alnsour, 2024; Mbaidin et al., 2024a, 2024b; L. Mishra & Kaushik, 2023; R. Mishra et al., 2023). However, achieving higher scalability may demand greater computational resources, thus impacting cost-effectiveness (Mafike & Mawela, 2022). Consequently, financial readiness and strategic planning have become imperative for banks of all sizes to justify and manage the costs associated with secure, scalable, and efficient blockchain solutions (Suwanposri et al., 2021).

### 2.6. Customer Adoption

Customer adoption in retail banking depends on social influence, trust, transparency, awareness, perceived ease of use, and user engagement, all of which shape clients' willingness to embrace blockchain-based services (Alnsour, 2024; V. Chang et al., 2020; Kajla et al., 2024; Kumari & Devi, 2022; Mansoor et al., 2024; Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021). Social influence is pivotal because peers' acceptance can significantly influence individual adoption decisions (Kumari & Devi, 2022). Likewise, trust in blockchain's security, transparency, and lower perceived effort positively impact consumer intentions, although skepticism about privacy, regulatory gaps, and cryptocurrency volatility persists (V. Chang et al., 2020; Mansoor et al., 2024). Public mistrust, limited awareness, and a lack of compelling use cases further hinder adoption, with many users resistant to change and still placing greater trust in traditional banking models (Alnsour, 2024; Kajla et al., 2024; Mbaidin et al., 2023; Miah et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021). To address these obstacles, banks are encouraged to invest in education, financial literacy, and trust-building initiatives while highlighting potential benefits—including lower transaction costs, faster settlements, and secure data storage—to strengthen user engagement (Alnsour, 2024; V. Chang et al., 2020; Kajla et al., 2024; Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025).

### *2.7. Industry Collaboration*

Industry collaboration is widely recognized as a pivotal factor in advancing blockchain adoption within retail banking, as it unites financial institutions, regulatory bodies, and technology providers to establish shared standards, reduce implementation risks, and drive coordinated innovation (Arjun & Suprabha, 2020; Kajla et al., 2024; Mbaidin et al., 2023; Zhang et al., 2020). The lack of unified frameworks and the absence of consensus on best practices can fragment adoption efforts and undermine the potential benefits of blockchain (Banerjee & Chandani, 2024; Saheb & Mamaghani, 2021). By forming consortia, banks, fintech firms, and regulators can collectively develop blockchain solutions for core banking functions—such as payments, settlements, and Know Your Customer processes—thereby promoting interoperability, standardization, and regulatory compliance (V. Chang et al., 2020; Rahman et al., 2025; Shorman et al., 2020). These collaborative networks also facilitate governance and stakeholder education and address interoperability challenges, emphasizing the need for joint decision-making among industry participants (Miah et al., 2023; L. Mishra & Kaushik, 2023; Suwanposri et al., 2021; Zachariadis et al., 2019). Ultimately, broad-based cooperation across the financial ecosystem accelerates blockchain integration and alleviates concerns about losing intermediary roles, demonstrating that a cooperative rather than competitive approach can yield greater industry-wide benefits (V. Chang et al., 2020; Mafike & Mawela, 2022; Suwanposri et al., 2021).

### *2.8. Comprehensive Overview of Factors Influencing Blockchain Adoption in Retail Banking*

Table 1 provides a concise overview of the factors influencing blockchain adoption in retail banking, as discussed in the previous sections. Each factor is described with its core definition and corresponding references.

**Table 1.** Overview of factors influencing blockchain adoption in retail banking.

| Factors | References |
|---|---|
| **F1-Regulatory framework and compliance:** The mandatory adherence to legal and policy requirements governing how banks implement and operate blockchain solutions. It encompasses all rules, standards, and oversight measures ensuring blockchain's lawful and transparent use in retail banking. | (Banerjee & Chandani, 2024; Basori & Ariffin, 2022; V. Chang et al., 2020; Chavali et al., 2024; Kajla et al., 2024; Lu et al., 2024; Mafike & Mawela, 2022; Mansoor et al., 2024; Mbaidin et al., 2023, 2024a; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Suwanposri et al., 2021; Zachariadis et al., 2019; Zhang et al., 2020) |

**Table 1.** *Cont.*

| Factors | References |
|---|---|
| **F2-Blockchain scalability:** The capacity of a blockchain system to efficiently handle increasing transaction volumes, user demands, and data loads. It focuses on maintaining performance and reliability as usage grows over time. | (Alaeddin et al., 2021; Arjun & Suprabha, 2020; Banerjee & Chandani, 2024; V. Chang et al., 2020; Chavali et al., 2024; Kajla et al., 2024; Lu et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Zachariadis et al., 2019; Zhang et al., 2020) |
| **F3-System interoperability with blockchain:** The ability of blockchain technology to integrate seamlessly with a bank's existing IT infrastructure and external platforms. It ensures consistent data exchange and functionality across diverse systems. | (V. Chang et al., 2020; Chavali et al., 2024; Kajla et al., 2024; Lu et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Zachariadis et al., 2019) |
| **F4-System security:** The safeguards and protocols that protect blockchain solutions from vulnerabilities, unauthorized access, and malicious activities. It emphasizes preserving the integrity, confidentiality, and availability of system data. | (Alaeddin et al., 2021; Alnsour, 2024; Arjun & Suprabha, 2020; Banerjee & Chandani, 2024; Basori & Ariffin, 2022; V. Chang et al., 2020; Chavali et al., 2024; Jena, 2022; Kajla et al., 2024; Kumari & Devi, 2022; Lu et al., 2024; Mafike & Mawela, 2022; Mansoor et al., 2024; Mbaidin et al., 2023, 2024a, 2024b; Miah et al., 2023; L. Mishra & Kaushik, 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Suwanposri et al., 2021; Zachariadis et al., 2019; Zhang et al., 2020) |
| **F5-Technology cost:** The financial investment required to acquire, implement, and maintain blockchain solutions in retail banking. It includes expenditures on hardware, software, integration, staff training, and ongoing operations. | (Alaeddin et al., 2021; Alnsour, 2024; Arjun & Suprabha, 2020; Banerjee & Chandani, 2024; V. Chang et al., 2020; Chavali et al., 2024; Kajla et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023, 2024a, 2024b; Miah et al., 2023; L. Mishra & Kaushik, 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Suwanposri et al., 2021; Zhang et al., 2020) |
| **F6-Customer adoption:** The extent to which retail banking clients accept and utilize blockchain-based services. It involves user perceptions, trust, and willingness to embrace new technology offerings. | (Alnsour, 2024; V. Chang et al., 2020; Kajla et al., 2024; Kumari & Devi, 2022; Mansoor et al., 2024; Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021) |
| **F7-Industry collaboration:** The collective efforts among banks and other stakeholders to share resources, knowledge, and standards in developing blockchain solutions. It aims to foster coordinated progress and common frameworks within the sector. | (Arjun & Suprabha, 2020; Banerjee & Chandani, 2024; V. Chang et al., 2020; Kajla et al., 2024; Mafike & Mawela, 2022; Mbaidin et al., 2023; Miah et al., 2023; L. Mishra & Kaushik, 2023; Rahman et al., 2025; Saheb & Mamaghani, 2021; Shorman et al., 2020; Suwanposri et al., 2021; Zachariadis et al., 2019; Zhang et al., 2020) |

## 3. Methodology

This section offers a detailed explanation of the DEMATEL methodology and outlines the sampling methods and data collection procedures employed in this study.

### *3.1. DEMATEL Methodology*

This study employs the DEMATEL methodology to analyze the factors influencing blockchain adoption in retail banking, identified through a systematic literature review. DEMATEL is recognized for its capacity to explicitly model and quantify complex causal relationships among multiple factors, offering a distinct advantage over other multi-criteria decision-making methods such as the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), the Analytical Network Process (ANP), and Interpretive Structural Modeling (ISM) (Ahuja et al., 2019; Chrysikopoulos et al., 2024; Kouhizadeh et al., 2021; Moktadir et al., 2020). Unlike AHP and TOPSIS, which primarily focus on ranking alternatives based on predefined criteria, DEMATEL goes beyond simple prioritization by systematically mapping interdependencies among factors.

Similarly, while ANP accounts for feedback loops, it does not visualize cause-and-effect chains as clearly as DEMATEL. ISM, though useful for structuring relationships, lacks DEMATEL's capability to quantify the degree of influence among factors.

Developed in the 1970s at the Battelle Memorial Institute's Geneva Research Center, DEMATEL has been extensively applied across various sectors—including business, healthcare, technology, and environmental management—to address complex issues through a structured analytical approach (Bai & Sarkis, 2013; Hsu & Lee, 2014; Khan et al., 2022; Wu & Chang, 2015; Zhao et al., 2021). By organizing factors into cause-and-effect groups using matrices and diagrams, DEMATEL facilitates the prioritization of factors and enhances the understanding of their direct and indirect interactions (Ahuja et al., 2019; C.-C. Chang & Chen, 2018; Kouhizadeh et al., 2021; Moktadir et al., 2020; Wu & Chang, 2015). This capability is crucial for identifying leverage points—factors that significantly influence the system—which can guide strategic decision-making for blockchain integration. The method's unique ability to visualize and quantify interrelationships makes it particularly suitable for this study, as it enables a structured analysis of the complicated adoption dynamics in retail banking. The implementation of DEMATEL in this research follows a structured five-step process (Chountalas et al., 2024; Khan et al., 2022; Moktadir et al., 2020; Wu & Chang, 2015), incorporating precise mathematical formulations as outlined by Moktadir et al. (2020).

#### 3.1.1. Step 1: Constructing the Initial Average Direct-Relation Matrix

The first step in the DEMATEL methodology involves creating the average direct-relation matrix to quantify the direct influences among the factors affecting blockchain adoption in retail banking. This matrix is developed by aggregating the evaluations from multiple experts, who assess the impact of each factor on every other factor using a scale from 0 (no influence) to 4 (very high influence) (Ahuja et al., 2019; Khan et al., 2022; Kouhizadeh et al., 2021; Zhao et al., 2021). Suppose there are $n$ identified factors and $H$ experts participating in the assessment. Each expert $k$ provides an $(n \times n)$ matrix $X^k = \left[x_{ij}^k\right]$, where $x_{ij}^k$ represents expert $k$'s evaluation of the influence of factor $i$ on factor $j$. The collection of these matrices from all experts is denoted as $X^1 = \left[x_{ij}^1\right], X^2 = \left[x_{ij}^2\right], \ldots, X^H = \left[x_{ij}^H\right]$. The average direct-relation matrix $M = \left[\widetilde{x}_{ij}\right]$ is then calculated by averaging the individual expert matrices using the following formula:

$$\widetilde{x}_{ij} = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^k \tag{1}$$

This aggregated matrix $M$ synthesizes the collective judgments of the experts and serves as the foundational input for subsequent analysis in the DEMATEL process.

#### 3.1.2. Step 2: Calculating the Normalized Direct Relation Matrix

Following the creation of the Average Direct Relation Matrix $M$ in the initial step, the next phase involves normalizing this matrix to obtain the Normalized Direct Relation Matrix $P$. This normalization adjusts the influence values to a consistent scale, facilitating accurate comparisons among the factors influencing blockchain adoption in retail banking. To calculate the normalization factor $S$, the minimum value is selected between the reciprocals of the maximum sums of the absolute values of the rows and columns in $M$. This is mathematically expressed as:

$$S = \min\left[\frac{1}{\sum_{j=1}^{n}\left|\widetilde{x}_{ij}\right|}, \frac{1}{\sum_{i=1}^{n}\left|\widetilde{x}_{ij}\right|}\right] \tag{2}$$

Once $S$ is determined, the normalized direct relation matrix $P$ is computed by multiplying each element of $M$ by $S$: $P = M \times S$. This process ensures that all elements $P$ have values between 0 and 1, preserving the proportional relationships among the factors while standardizing their influence scores.

#### 3.1.3. Step 3: Calculate the Total Relation Matrix

The third step in the DEMATEL methodology involves deriving the total relation matrix $T$ to capture both direct and indirect influences among the factors affecting blockchain adoption in retail banking. This step builds upon the normalized direct relation matrix $P$ obtained previously, utilizing matrix operations to fully represent the complex interrelationships between factors. The total relation matrix $T$ is calculated using the following formula: $T = P[I - P]^{-1}$. In this equation, $I$ represents the identity matrix of the same dimensions as $P$. The term $[I - P]^{-1}$ denotes the inverse of the matrix resulting from subtracting $P$ from $I$. By multiplying $P$ with this inverse matrix, the total relation matrix $T$ encompasses the cumulative effects—both direct and indirect—that each factor has on the others within the system.

#### 3.1.4. Step 4: Calculating and Visualizing the Prominence and Net Effects of Factors

In this step, the prominence and net effects of each factor influencing blockchain adoption in retail banking are determined and illustrated using the total relation matrix $T = \left[t_{ij}\right]_{n\times n}$. This analysis quantifies how much each factor affects others and how much it is affected in return. To compute these metrics, the sum of each row $r_i$ and each column $c_j$ of the matrix $T$ is calculated as follows:

$$r_i = \sum_{j=1}^{n} t_{ij}, \forall i \quad (3)$$

$$c_j = \sum_{i=1}^{n} t_{ij}, \forall j \quad (4)$$

Here, $r_i$ represents the total influence exerted by factor $i$ on all other factors, while $c_j$ denotes the total influence received by factor $j$ from all other factors. The prominence of each factor is determined by the sum $\left(r_i + c_j\right)$, which reflects its overall importance within the system. The net effect is calculated by the difference $\left(r_i - c_j\right)$, indicating whether a factor primarily acts as a cause or an effect. A positive net effect suggests that the factor predominantly influences others (a net cause). In contrast, a negative net effect implies that it is mainly influenced by other factors (a net effect).

These values are then used to construct the prominence and net effect diagram. In this graphical representation, the prominence $\left(r_i + c_j\right)$ is plotted on the horizontal axis, and the net effect $\left(r_i - c_j\right)$ is plotted on the vertical axis. This diagram aids in visually distinguishing between factors that are key drivers and those that are more responsive within the network.

#### 3.1.5. Step 5: Visualizing the Most Significant Causal Relationships Among Factors

In the final step of the DEMATEL methodology, the most significant causal relationships among the factors influencing blockchain adoption in retail banking are identified and graphically represented. This visualization focuses on highlighting interactions that have a substantial impact, thereby aiding decision-makers in prioritizing areas of strategic importance. To determine which relationships are significant enough to be included in the diagram, a threshold value $\theta$ is established. In this study, we adopt the threshold calculation $\theta = \mu + \sigma$, where $\mu$ is the mean and $\sigma$ is the standard deviation of all the values in the Total Relation Matrix, a choice supported by established studies, including Kouhizadeh et al. (2021), Moktadir et al. (2020), and Huang et al. (2022). Only the relationships with influence values exceeding this threshold $\theta$ are considered significant and are depicted with directed arrows in the causal diagram. This selective process—an inherent feature of DEMATEL—ensures that the visualization emphasizes the most impactful interactions, preventing less significant relationships from cluttering the analysis and potentially obscuring critical insights.

### 3.2. Sample Information and Data Collection

Participants in this study were selected through convenience and snowball sampling techniques, which are commonly employed in similar research (Kouhizadeh et al., 2021; Moktadir et al., 2020), to access specialized expertise in the niche domain of blockchain adoption in banking. A purposive approach was followed to recruit experts with a balanced mix of backgrounds in retail banking and blockchain technology to ensure a comprehensive evaluation of the interrelationships among blockchain adoption factors. This strategy helped capture diverse perspectives on adoption dynamics. The factors were initially identified in the literature (refer to Section 2) and further validated by three experts, each possessing over 20 years of experience in the banking sector. These experts confirmed the relevance and clarity of the factors before the wider participant group was engaged. To conduct the evaluation, participants were provided with questionnaires that outlined each factor in detail. They were then instructed to evaluate how each factor affected the others using a structured $7 \times 7$ pairwise comparison matrix. This matrix employed a five-level scale, spanning from 0 (indicating no influence) to 4 (indicating a very high influence), to measure the degree of impact.

A total of 74 valid responses were collected, reflecting a robust sample size for DEMATEL-based studies in this domain. The sample consisted of a diverse group of professionals from the Greek retail banking sector, averaging 14.3 years of industry experience. Participants held high-level managerial and directorial roles across various commercial banks. Their positions included branch directors and senior executives responsible for technology strategy, digital transformation, compliance, innovation, and risk management. This managerial-level focus ensured participants had the requisite insight into blockchain adoption challenges and enablers. Regarding educational qualifications, most participants held advanced degrees, primarily master's degrees in finance, business administration, and information technology, reinforcing the expertise level of the respondent pool.

To assess the consistency of expert judgments in the DEMATEL analysis, we computed the Intraclass Correlation Coefficient (ICC) using a two-way mixed-effects model with average measures (ICC(3, k)). ICC is well-suited for this purpose as it captures the degree of consistency among raters while accounting for the ordinal nature of DEMATEL ratings, making it a robust measure of rater reliability in this context. The ICC results indicate a strong level of consistency among raters (ICC(3, k) = 0.871, $p < 0.001$). This suggests that, while individual ratings vary to some extent, the aggregated expert evaluations are highly reliable, making the derived DEMATEL causal relationships robust.

## 4. Results

This section presents the primary insights from the DEMATEL analysis in two distinct parts. The first part (Section 4.1) focuses on analyzing each factor's significance and overall influence, corresponding to the fourth step of the DEMATEL approach. The second part (Section 4.2) explores the strongest causal relationships between the factors, aligning with the methodology's step 5. The essential matrices utilized in steps 1 through 3—the average direct relation matrix, the normalized direct relation matrix, and the total relation matrix—are provided in Appendix A (Table A1).

### 4.1. Prominence and Net Effects of Factors

This analysis assesses the impact of various factors on blockchain adoption in retail banking. Table 2 presents the calculated prominence and net effect values for each factor. Additionally, Figure 1 visually represents these metrics, plotting prominence on the horizontal axis and net effect on the vertical axis.

**Table 2.** Prominence and net effect values.

| Factors | $r_i$ | $c_j$ | $r_i+c_j$ | $r_i-c_j$ | Impact |
|---|---|---|---|---|---|
| F1: Regulatory framework and compliance | 3.275 | 2.993 | 6.268 | 0.282 | Cause |
| F2: Blockchain scalability | 2.975 | 3.749 | 6.724 | −0.774 | Effect |
| F3: System interoperability with blockchain | 2.704 | 3.436 | 6.139 | −0.732 | Effect |
| F4: System security | 2.648 | 3.337 | 5.986 | −0.689 | Effect |
| F5: Technology cost | 4.074 | 2.991 | 7.064 | 1.083 | Cause |
| F6: Customer adoption | 3.391 | 2,880 | 6.271 | 0.512 | Cause |
| F7: Industry collaboration | 3.317 | 2.998 | 6.315 | 0.319 | Cause |

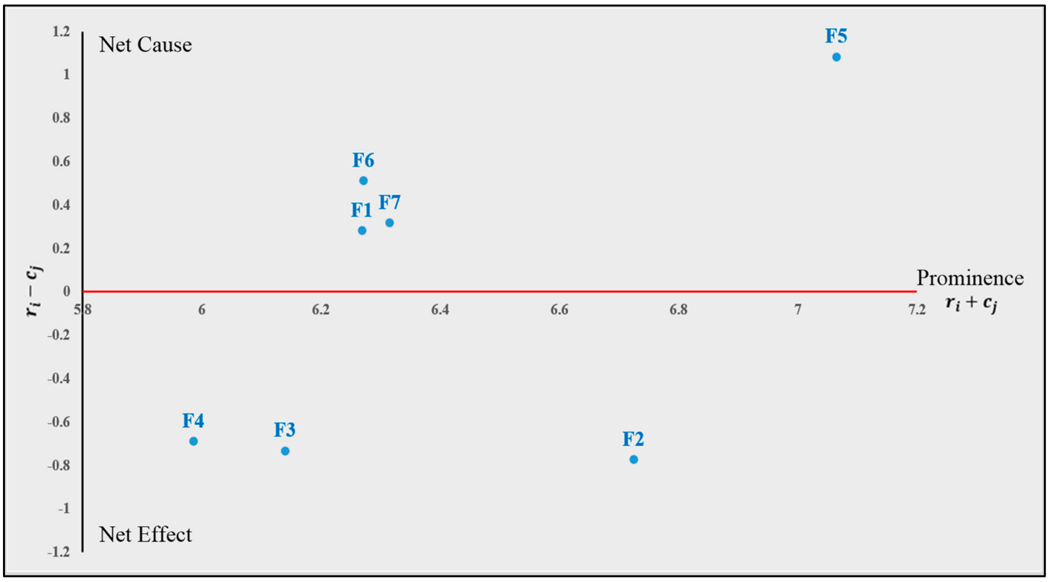


**Figure 1.** Prominence and net effect diagram.

The analysis indicates that "technology cost" is the most significant factor in blockchain adoption within retail banking, as evidenced by its highest prominence score. This factor serves as a primary driver, demonstrating a positive net effect that positions it as a key influence on blockchain integration. Other important causative factors include "regulatory framework and compliance", "customer adoption", and "industry collaboration". These elements drive changes in the retail banking ecosystem, exerting influence rather than being influenced.

In contrast, "blockchain scalability" is identified as the second most significant factor, functioning primarily as an effect factor with negative net effects. This suggests that scalability issues typically arise as responses to initiatives in other areas rather than as primary drivers. Similarly, "system security" and "system interoperability with blockchain" are largely shaped by other factors. These effect factors indicate that advancements or challenges in security and interoperability often result from changes initiated by the aforementioned causative factors.

### *4.2. Most Significant Causal Relationships Among Factors*

The total relation matrix provides a detailed overview of the causal interactions among factors affecting blockchain adoption in retail banking. A threshold was set to identify the most significant relationships by adding the mean and standard deviation of all matrix values, as explained in Section 3. Any relationship surpassing this threshold is deemed highly significant and is visually distinguished in the matrix using red italics (refer to Table A1 in Appendix A). Using these key values, the significant causal relationships diagram was created and is displayed in Figure 2.

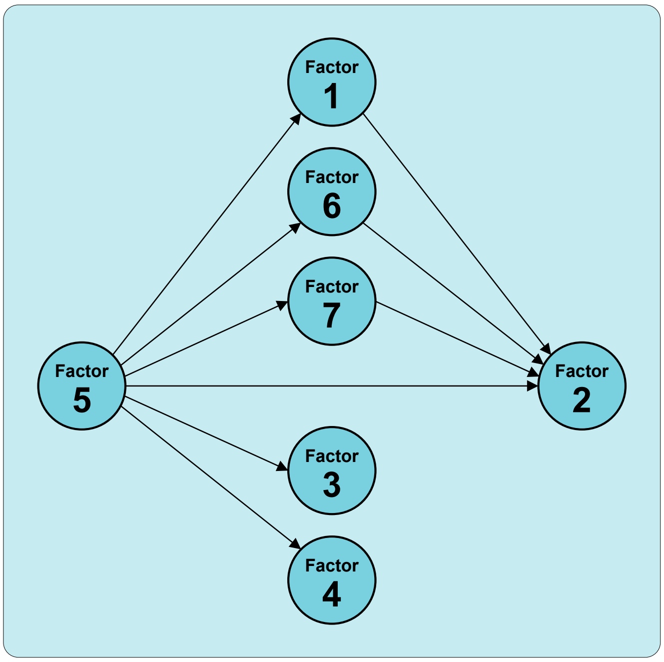


**Figure 2.** Significant causal relationships.

This figure reveals how the key factors influencing blockchain adoption in retail banking are interconnected. Analyzing these structured relationships provides important insights into how strategic interventions can affect the network, potentially enhancing the adoption process and overcoming existing challenges.

The primary finding of this analysis is that technology costs significantly influence all other factors related to blockchain adoption in retail banking. Specifically, the expense associated with blockchain solutions can restrict scalability, prompting banks to pursue smaller, incremental implementations rather than comprehensive deployments. Additionally, costly technology can hinder the integration of blockchain with existing systems, resulting in a slower adoption rate or continued reliance on legacy systems. Financial constraints on investments in secure blockchain infrastructure may leave systems vulnerable and discourage overall adoption. Furthermore, high technology costs can deter regulatory compliance initiatives, as banks may hesitate to invest in expensive technology amidst regulatory uncertainties. The financial burden on banks may also result in increased service fees or a limited range of blockchain-based services, which could affect customer acceptance of these new solutions. Lastly, the substantial costs of blockchain implementation may create barriers to collaboration, as certain industry participants may lack the necessary resources to invest equitably, leading to fragmented or delayed joint initiatives.

The analysis also reveals that the regulatory environment, customer adoption, and industry collaboration mediate the relationship between technology cost and blockchain scalability. Compliance costs resulting from regulatory requirements can intensify the effects of technology costs on scalability, as organizations are required to allocate resources to meet regulatory standards before considering scalable blockchain investments. Moreover, when technology costs result in increased fees or restricted service offerings, customer adoption may decline, which in turn constrains the demand necessary to justify scalable blockchain solutions. Finally, high technology costs may hinder or slow collaborative efforts across the industry, limiting the sharing of resources and insights that could facilitate the development of scalable and efficient blockchain applications.

## 5. Discussion and Conclusions

This study examined the factors affecting blockchain adoption in retail banking by employing the DEMATEL methodology to analyze their cause-and-effect relationships. Integrating results from a systematic literature review with insights from managers in the banking sector, the research highlighted the significant roles and impacts of these factors on adoption processes. This approach identified key areas where strategic interventions could substantially enhance adoption practices. Moreover, it provided a detailed understanding of how various factors interact within the retail banking context, establishing a robust foundation for the study's subsequent findings and implications.

### *5.1. Discussion of the Key Findings*

The findings of the DEMATEL analysis highlighted four overarching issues for understanding the dynamics between the factors influencing blockchain adoption in retail banking: (a) the primacy of technology cost and the mediating roles of (b) regulatory framework and compliance, (c) customer adoption, and (d) industry collaboration on the relationship between technology cost and blockchain scalability.

Before exploring each of these issues, it is essential to contextualize them within the specific characteristics of the banking sector in the geographic region under study. In particular, following the 2009 financial downturn, Greek banks faced severe liquidity shortages, high non-performing loans, and a loss of depositor confidence, leading to capital controls in 2015 that restricted cash withdrawals and cross-border transactions (Magoutas et al., 2022). Although these measures have since been lifted, the banking sector remains hesitant to undertake large-scale investments, particularly in advanced emerging technologies, instead limiting their focus to essential digital services such as online and mobile banking personalization, chatbots for customer support, and contactless payments (Challoumis & Eriotis, 2024). Regulatory pressures, capital adequacy requirements, customer reluctance, and a slow economic recovery continue to influence financial decision-making, reinforcing a conservative stance on technology adoption. As a result of this experience, Greek banks have likely adopted a more cost-conscious approach, which may explain why the managers participating in this study identified technology cost as the most significant determinant of blockchain adoption.

Similarly, market-specific conditions in different geographic locations may lead banking executives elsewhere to assign different priorities. For instance, evidence from developing economies suggests that scalability limitations, lack of interoperability among blockchain service providers, and the absence of a favorable regulatory environment constitute the primary barriers to blockchain adoption (Mbaidin et al., 2023). While these challenges—corresponding to Factors 2, 3, and 1, respectively, as codified in this study—are also significant in the Greek context, they may be even more pronounced in developing countries, where institutional and infrastructural constraints further exacerbate adoption difficulties.

Taking these contextual considerations into account, the following subsections present a detailed examination of the four key issues identified in this study.

#### 5.1.1. Technology Cost as a Primary Driver

The identification of technology cost as the most significant factor among those examined in this study underscores its critical influence on blockchain adoption in retail banking. This reflects the substantial financial investment required for the implementation of blockchain solutions, which mainly includes the acquisition of new technology, its integration with existing systems, staff training, and ongoing maintenance. Prior studies similarly highlight that high initial investments pose a major barrier, particularly for smaller banks and institutions in developing economies struggling with budget constraints (Kajla et al., 2024; Mbaidin et al., 2023; Zhang et al., 2020). Banks operate in an environment characterized by strict regulatory requirements and intense competition. As a result, they are fully aware of the financial implications of adopting new technologies. Given that this study relied on the expert insights of managers in the banking sector, the particular emphasis they placed on technology cost appears reasonable. Specifically, their practical experience with budget allocations and financial constraints likely leads them to place significant importance on the challenges banks face when considering major technological overhauls. Additionally, uncertainties regarding return on investment and the evolving nature of blockchain technology make managers cautious in financial decision-making. Literature supports this caution, pointing out that high operational expenses related to energy-intensive consensus mechanisms and computational requirements increase uncertainty about long-term cost-effectiveness (Alaeddin et al., 2021; Banerjee & Chandani, 2024; R. Mishra et al., 2023; Shorman et al., 2020). The results of this study also indicate that technology cost directly affects other critical factors. For example, without sufficient investments, banks may struggle to achieve the necessary scalability, interoperability, and security required for the successful deployment of blockchain, a finding corroborated by previous research (Kajla et al., 2024; Mafike & Mawela, 2022; Miah et al., 2023). From the above, it is evident that technology cost largely shapes the trajectory of blockchain adoption across the entire retail banking sector.

#### 5.1.2. Regulatory Framework and Compliance as a Mediator

The regulatory framework and compliance emerge as a significant mediator, acting as a critical bridge influencing how technology costs impact the scalability of blockchain initiatives. In the highly regulated banking sector, compliance with laws and regulations is a de facto priority. This often requires the commitment of substantial resources to ensure adherence, as also highlighted in previous studies (Mafike & Mawela, 2022; Miah et al., 2023). Within this context, regulatory requirements can complicate blockchain implementation, necessitating additional features such as enhanced security protocols, data privacy measures, and audit capabilities. These compliance obligations can significantly increase technology costs, as banks must allocate additional capital for customizing solutions to meet regulatory standards. This issue becomes even more complex due to the persistent uncertainty surrounding blockchain regulation. Indeed, the literature highlights this uncertainty, noting the rapid pace of blockchain technology development has outpaced regulatory clarity, discouraging significant investment by banks (Chavali et al., 2024; Saheb & Mamaghani, 2021). Thus, without clear guidance from regulatory bodies, banks may currently hesitate to invest heavily in scalable blockchain solutions, fearing that future regulations may require costly adjustments. Furthermore, compliance requirements can slow down scalability efforts by imposing strict controls that limit the speed and flexibility of blockchain systems. For example, anti-money laundering and know-your-customer regulations require thorough verification processes, which may hinder the rapid transaction processing that characterizes blockchain.

#### 5.1.3. Customer Adoption as a Mediator

Customer adoption also plays a decisive role in mediating the relationship between technology cost and blockchain scalability. In retail banking, customer acceptance is essential for the successful deployment of new technologies. However, high technology costs may lead to increased charges for customers or the removal of certain user-friendly features, which could act as deterrents to customer adoption. After all, if customers perceive blockchain-based services as expensive, complex, or lacking significant added value compared to existing systems, they are likely to reduce their demand. This, in turn, will create considerable challenges for blockchain scalability. Scalability relies on increased demand to achieve economies of scale, which will drive further investments in infrastructure and development. However, without sufficient demand, banks will remain confined to limited applications and will not be able to advance large-scale blockchain initiatives. Earlier literature supports this assertion by noting that blockchain scalability is constrained by technological limitations and customer engagement, as widespread adoption is necessary to justify financial investments in expanding blockchain infrastructures (Mbaidin et al., 2023; Miah et al., 2023; R. Mishra et al., 2023; Saheb & Mamaghani, 2021). Additionally, with low demand, customer feedback will also be very limited, meaning that there will not be enough data available to drive further improvements and innovations, which are essential for scaling up operations.

#### 5.1.4. Industry Collaboration as a Mediator

Industry collaboration is the third factor identified as a key mediator influencing the scalability of blockchain in the context of technology cost. Collaboration between banks and other financial institutions can help distribute the burden of high technology costs. Industry stakeholders could reduce individual expenses through the joint pooling of resources, sharing knowledge, and developing common standards. However, this is not easy, as proprietary interests and competitive pressures within the sector may make banks hesitant to engage in collaborations that require sharing sensitive information or strategic advantages. Another parameter that must be considered regarding collaboration challenges is the disparity in resources among financial institutions. While large banks may have the capital to invest in blockchain technology, smaller institutions may struggle to follow the same path due to limited financial resources. This inequality may ultimately hinder the formation of effective partnerships. Despite these challenges, banks must move toward effective joint initiatives that will lead to the development of widely accepted scalable solutions, benefiting the industry as a whole. Otherwise, the sector will be characterized by fragmented systems and incompatibilities that impede scalability. Prior literature reinforces this necessity, suggesting that broad-based cooperation and the establishment of joint governance structures are crucial to overcoming fragmentation and interoperability barriers (Banerjee & Chandani, 2024; Mbaidin et al., 2023; Zachariadis et al., 2019).

### *5.2. Managerial Implications*

The findings of this study provide valuable insights for banking executives and decision-makers regarding blockchain adoption, recognizing technology cost as the most influential factor. Given the significant financial investment required, banks must adopt a strategic financial planning approach, including a comprehensive cost-benefit analysis. In this context, they should consider both the initial implementation expenses and the ongoing costs related to maintenance, security, and compliance with regulatory provisions. Banks with limited resources may need to explore alternative funding methods, such as partnerships with fintech companies or industry consortia, to offset cost burdens while remaining competitive. Regulatory framework and compliance emerge as a critical mediator in blockchain scalability, requiring banks to engage proactively with regulatory bodies. The evolving nature of blockchain regulations demands investments in regulatory intelligence and legal expertise to ensure compliance and anticipate future requirements. Integrating compliance functionalities into blockchain solutions from the outset and utilizing regulatory technology can streamline compliance processes and reduce costs. Customer adoption also plays a vital role in blockchain scalability. High technology costs may lead to increased service charges or a reduction in user-friendly features, discouraging adoption by customers. To address this issue, banks should invest in customer education and communication strategies to highlight the benefits of blockchain, such as enhanced security and faster transactions. Ensuring the seamless integration of blockchain-based services into existing digital banking platforms and collecting customer feedback can further drive adoption and continuous improvement. Industry collaboration is another key factor influencing blockchain scalability. Partnerships among banks and financial institutions can facilitate resource sharing and standardization, reducing individual financial burdens. However, concerns over proprietary interests and competition may create barriers to collaboration. Banks must find a balance between cooperation and maintaining a competitive advantage, possibly through blockchain consortia. Large banks with greater financial capacity can also support smaller institutions to promote broader industry-wide adoption. Finally, the study highlights the risks associated with fragmented blockchain implementations. Without industry-wide interoperability, inefficiencies may arise, limiting the potential benefits of blockchain. Banks should prioritize interoperability through common technical standards and governance frameworks to enhance system compatibility, reduce redundancies, and facilitate efficient transaction processing across the sector.

In addition to financial planning and regulatory compliance, banks must also confront the inherent conflict between the immutable characteristics inherent to blockchain technology and the General Data Protection Regulation (GDPR), especially concerning the "right to be forgotten". In particular, blockchain possesses inherent tamper-proof characteristics that conflict with GDPR obligations, permitting individuals to request the erasure of their personal data (Politou et al., 2018). Arguably, these technical solutions facilitate partial adherence to GDPR while at the same time preserving the fundamental security principles of blockchain. Additionally, retail banks can benefit from the integration of privacy-preserving architectures and privacy-enhancing technologies—like zero-knowledge proofs and chameleon hashes—that present a viable advancement opportunity. Furthermore, the design of blockchain-based systems with compliance considerations—such as utilizing pointers to off-chain data rather than storing personal data on-chain—can reduce potential legal and technical issues (Politou et al., 2021).

The Digital Operational Resilience Act (DORA), effective from January 2025, will introduce further regulatory complexity, resulting in additional implications for blockchain adoption and technology cost dynamics within the banking sector. In particular, DORA seeks to standardize Information and Communication Technologies (ICT) risk management approaches by mandating that financial institutions establish effective incident response frameworks, perform threat-led penetration testing, and oversee third-party ICT risks (Neumannová et al., 2023). These technical requirements increase the financial burden of compliance, especially for smaller banks with limited ICT capabilities and compliance potential. In addition, DORA mandates oversight of critical third-party providers—including blockchain-as-a-service platforms—and, therefore, necessitates stringent due diligence, contractual clarity, and auditability (Kun, 2024). Although these mandates may elevate operational costs in the short term, they could also provide strategic incentives for banks to participate in industry consortia, co-develop regulatory-compliant solutions, and pool relevant managerial resources to meet resilience standards in a more efficient way. Therefore, DORA may act as both a regulatory hurdle and a catalyst for the adoption of cutting-edge technologies in various industries, including the banking industry, encouraging strategic investments in more secure, interoperable, and scalable blockchain systems capable of withstanding systemic digital risks.

### 5.3. Limitations and Future Research Directions

This study acknowledges several limitations that should be considered. Firstly, it relies on expert opinions to evaluate the relationships among factors influencing blockchain adoption in retail banking. While valuable, expert insights can be subjective and shaped by individual biases, professional backgrounds, or organizational priorities. Although the DEMATEL methodology helps mitigate this limitation, the findings remain dependent on the composition of the expert panel. Future research should incorporate a broader range of stakeholders, such as policymakers, technology providers, and end-users, to obtain a more comprehensive perspective.

Furthermore, the study is limited to the retail banking sector and does not account for differences in other financial sectors. Blockchain adoption in investment banking, insurance, or non-traditional financial services may follow different patterns due to varying regulatory requirements, operational structures, and customer expectations. Future studies should conduct comparative analyses across multiple financial sectors to identify sector-specific drivers and barriers, leading to more tailored implementation strategies.

Another limitation of this study is its cross-sectional approach, which captures a static view of the factors influencing blockchain adoption in retail banking. However, blockchain adoption is highly dynamic, particularly in response to evolving technological advancements and regulatory landscapes. Recent EU regulatory developments (2020–2024), such as the Markets in Crypto-Assets Regulation, the Digital Operational Resilience Act, and stricter anti-money laundering and counter-terrorist financing compliance measures, are likely to reshape the significance of regulatory compliance, system security, and interoperability in blockchain adoption decisions. Because the DEMATEL approach captures causal relationships at a single point in time, it does not account for these ongoing regulatory shifts or market fluctuations. Future research should adopt longitudinal designs to track how such changes influence blockchain adoption over time. Additionally, combining DEMATEL with methods like system dynamics could enhance adaptability to uncertain regulatory and technological conditions, providing a more dynamic representation of evolving adoption factors. Furthermore, scenario-based modeling could help assess the impact of future regulatory shifts on the feasibility and scalability of blockchain solutions in retail banking. Moreover, future research should investigate real-world examples of banks that have effectively managed regulatory challenges to adopt blockchain technology, focusing on key strategies and their potential for replication.

Additionally, this study deliberately emphasizes the broader industry conditions that influence the feasibility of large-scale blockchain adoption in retail banking, focusing on systemic and external factors rather than firm-specific capabilities such as IT infrastructure or employee skills. Future research could complement this approach by exploring how firms develop internal capabilities once these systemic barriers are addressed. Furthermore, this study does not explicitly address the influence of external macroeconomic and geopolitical factors. Economic downturns, cybersecurity risks, and regulatory shifts may significantly impact blockchain adoption. Future research should incorporate scenario-based modeling to assess these external disruptions, providing financial institutions with more strategic insights. Finally, while this study identifies technology cost as the most significant factor, it does not analyze specific cost components. Future research should conduct a detailed cost-benefit analysis to help financial institutions develop targeted blockchain deployment strategies.

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## Appendix A

**Table A1.** DEMATEL matrices.

| Average Direct Relation Matrix | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Factors** | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** |
| **F1** | | 2.750 | 2.500 | 2.667 | 2.333 | 2.333 | 3.000 |
| **F2** | 2.167 | | 3.083 | 2.833 | 2.583 | 1.833 | 1.583 |
| **F3** | 1.917 | 3.417 | | 2.500 | 1.833 | 1.500 | 1.583 |
| **F4** | 1.667 | 2.750 | 2.583 | | 1.833 | 1.667 | 1.917 |
| **F5** | 3.500 | 3.500 | 2.750 | 3.083 | | 3.583 | 3.417 |
| **F6** | 2.333 | 2.833 | 2.667 | 2.500 | 2.917 | | 2.833 |
| **F7** | 2.583 | 2.833 | 2.750 | 2.250 | 2.583 | 2.727 | |
| **Normalized Direct Relation Matrix** | | | | | | | |
| **Factors** | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** |
| **F1** | 0.000 | 0.139 | 0.126 | 0.134 | 0.118 | 0.118 | 0.151 |
| **F2** | 0.109 | 0.000 | 0.155 | 0.143 | 0.130 | 0.092 | 0.080 |
| **F3** | 0.097 | 0.172 | 0.000 | 0.126 | 0.092 | 0.076 | 0.080 |
| **F4** | 0.084 | 0.139 | 0.130 | 0.000 | 0.092 | 0.084 | 0.097 |
| **F5** | 0.176 | 0.176 | 0.139 | 0.155 | 0.000 | 0.181 | 0.172 |
| **F6** | 0.118 | 0.143 | 0.134 | 0.126 | 0.147 | 0.000 | 0.143 |
| **F7** | 0.130 | 0.143 | 0.139 | 0.113 | 0.130 | 0.138 | 0.000 |
| **Total Relation Matrix** | | | | | | | |
| **Factors** | **F1** | **F2** | **F3** | **F4** | **F5** | **F6** | **F7** |
| **F1** | 0.345 | *0.554* | 0.509 | 0.503 | 0.450 | 0.437 | 0.477 |
| **F2** | 0.411 | 0.394 | 0.495 | 0.476 | 0.427 | 0.385 | 0.388 |
| **F3** | 0.372 | 0.505 | 0.328 | 0.431 | 0.369 | 0.343 | 0.357 |
| **F4** | 0.356 | 0.472 | 0.436 | 0.312 | 0.363 | 0.344 | 0.365 |
| **F5** | *0.581* | *0.688* | *0.615* | *0.613* | 0.430 | *0.568* | *0.579* |
| **F6** | 0.464 | *0.573* | 0.529 | 0.511 | 0.486 | 0.345 | 0.483 |
| **F7** | 0.465 | *0.563* | 0.524 | 0.492 | 0.465 | 0.457 | 0.350 |

Notes: Threshold value = Mean + Standard Deviation = 0.457 + 0.087 = 0.544. Values exceeding this threshold are highlighted in red italics.

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