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From Digitisation to Full Digital Banking: A Systematic Literature Review on the Multilevel Integration of Industry 4.0 Technologies and Conceptual Frameworks in Banking Transformation

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Abstract. *This study conducts a systematic qualitative literature review to examine the transformation of banking from basic digitisation to full digital banking through the multilevel integration of Industry 4.0 technologies. Synthesising peer-reviewed research across information systems, banking, and innovation studies, the review analyses how technologies such as artificial intelligence, big data analytics, cloud computing, blockchain, and platform architectures reshape banking at the micro (customer), meso (organisational), and macro (industry ecosystem) levels. The findings show that digital banking transformation is a non-linear, socio-technical process in which technological adoption generates value only when complemented by dynamic organisational capabilities, governance mechanisms, and supportive regulatory frameworks. The review further highlights the growing importance of platformisation, open banking, and fintech collaboration in redefining competitive boundaries and value creation in the banking sector. By integrating multilevel perspectives and established conceptual frameworks, this study advances theoretical understanding of digital banking transformation and offers insights for managers and policymakers navigating the transition toward full digital banking.*

Keywords: *Digital Banking Transformation; Industry 4.0; Multilevel Integration; Dynamic Capabilities; Open Banking*

INTRODUCTION

The banking industry is undergoing one of the most profound transformations in its history, driven by the convergence of digital technologies, changing customer expectations, regulatory pressures, and intensifying competition from fintechs and digital-native banks. What initially began as digitisation—the conversion of analog information into digital formats—has progressively evolved into digitalisation, whereby digital technologies are embedded into business processes, service delivery, and organisational routines. More recently, this trajectory has culminated in full digital banking, characterised by platform-based business models, ecosystem integration, and the pervasive use of Industry 4.0 (I4.0) technologies such as artificial intelligence (AI), big data analytics, blockchain, cloud computing, and application programming interfaces (APIs) (Vial, 2021; Verhoef et al., 2021; De Venn, 2023).

While digital transformation (DT) in banking is often portrayed as a linear or technology-driven process, prior research increasingly recognises it as a complex, multilevel phenomenon involving strategic, organisational, and institutional change (Hanelt et al., 2021; Wessel et al., 2021). Banks do not merely adopt technologies; rather,

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they reconfigure value propositions, internal structures, and inter-organisational relationships in response to technological opportunities and environmental constraints (Vives, 2019; Murinde et al., 2022). This complexity is amplified by the nature of I4.0 technologies, which function as general-purpose technologies (GPTs) with wide-ranging complementarities and delayed productivity effects (Lipsey et al., 2005; Bekar et al., 2018; Brynjolfsson et al., 2019). Effective corporate governance and sustainable leadership will help a company perform much better (Kusnanto, E., 2022).

Against this backdrop, commercial banks face the strategic challenge of aligning technological innovation with organisational readiness, regulatory compliance, and customer-centric value creation. Digital transformation does not occur continuously or uniformly; instead, it unfolds through iterative phases shaped by banks' capabilities, legacy systems, and resistance to change (Konopik et al., 2022; Faro et al., 2024). Empirical evidence suggests that banks must carefully balance the pace of transformation to avoid organisational inertia while still capturing the benefits of emerging technologies (Diener & Špaček, 2021; Gfrerer et al., 2021). This observation resonates with GPT theory, which emphasises a transitional phase between technological investment and realised productivity gains due to the need for system integration, skill development, and organisational adaptation (Carlaw & Lipsey, 2006; Teubner, 2021). Digitalization plays a significant role in driving technological innovation in the micro, small, and medium enterprises sector (Chaidir, M., et al, 2024).

A growing body of literature highlights that successful DT in banking requires more than isolated digital projects or dedicated innovation units. Instead, it demands a shared organisational mindset and a coherent digital business strategy embedded across all levels of the firm (Sia et al., 2016; Sia et al., 2021). The case of DBS Bank in Singapore illustrates how digital transformation becomes effective when it is treated as an enterprise-wide belief system rather than a peripheral initiative, enabling the organisation to overcome internal resistance and sustain long-term transformation (Sia et al., 2016). Such cases underscore the importance of cultural and structural change alongside technological adoption.

From a theoretical perspective, DT in banking has increasingly been interpreted through the lens of the dynamic capabilities framework, which focuses on firms' abilities to sense technological opportunities, seize them through strategic investment, and

reconfigure resources to maintain competitiveness in volatile environments (Teece, 2007; Heubeck, 2023). As banks integrate I4.0 technologies, they continuously adapt their business models, often resulting in the coexistence of traditional and digital logics. Examples include hybrid service models that simultaneously support conventional fiat currencies and digital assets, reflecting broader shifts in payment systems and financial ecosystems (Galazova, 2023; Upadhyay, 2024). This coexistence highlights that DT is evolutionary rather than revolutionary for most incumbent banks (Furr & Shipilov, 2019; Iwashita, 2022).

Despite the expanding literature on digital banking, existing studies remain fragmented. Many focus on specific technologies—such as AI adoption, blockchain-based payments, or robotic process automation—or on isolated organisational outcomes such as efficiency, customer satisfaction, or financial inclusion (Chauhan et al., 2022; Fares et al., 2023; Yang & Masron, 2023). Others examine DT at a single level of analysis, for example customer experience, internal processes, or regulatory environments, without sufficiently integrating these perspectives (Filotto et al., 2021; Rodrigues et al., 2022). As a result, there is a lack of comprehensive frameworks that explain how Industry 4.0 technologies flow across multiple levels of banking transformation and how strategies at different levels interact dynamically. The collaboration between artificial intelligence platforms and digital innovation hubs can enhance productivity, operational efficiency, and market access for SMEs (Eka Wahyu Kasih, et al, 2024).

This study addresses this gap by conducting a systematic literature review (SLR) of 287 peer-reviewed articles to identify and synthesise the main strategies employed by commercial banks in their digital transformation journeys within the context of Industry 4.0. Building on established SLR methodologies (Tranfield et al., 2003; Okoli, 2015; Xiao & Watson, 2019), the review adopts a multilevel perspective encompassing micro, meso, and macro levels of analysis. At the micro level, the literature highlights strategies centred on value co-creation, security, and financial inclusion, aimed at enhancing customer experience, trust, and digital accessibility (Malar et al., 2019; Hanif & Lallie, 2021; Gupta & Kanungo, 2022). These strategies reflect the increasing importance of customer-centric digital services and the need to mitigate cybersecurity and privacy risks in digital banking environments (Saeed et al., 2023).

At the meso level, banks focus on organisational and process-oriented strategies, including agile organisational structures, automation, and the expansion of digital platforms. These initiatives seek to optimise internal operations while enabling collaboration with fintechs and other ecosystem partners through open banking and API-driven models (Bahri & Lobo, 2020; Fratini Passi, 2022; Heshmatisafa & Seppänen, 2023). Such strategies illustrate how I4.0 technologies act as enablers of organisational agility and cross-boundary innovation (Salmela et al., 2022; Pacheco-Cubillos et al., 2024).

At the macro level, the literature identifies broader strategic orientations, including the establishment of fully digital banks, the digital augmentation of traditional banking operations, and ecosystem-based collaboration with external stakeholders. These approaches reshape industry structures and competitive dynamics, reinforcing the platformisation of financial services and the emergence of digital banking ecosystems (Diamond et al., 2019; Westermeier, 2020; Mogaji, 2023). Regulatory frameworks and macroeconomic shocks—most notably the COVID-19 pandemic—have further accelerated these transformations by necessitating remote service delivery and digital collaboration (Hanelt et al., 2021; Hughes et al., 2023).

Synthesising these insights, this study proposes a novel conceptual framework that illustrates the dynamic interaction between micro-, meso-, and macro-level strategies in the digital transformation of banking. The framework emphasises the continuous flow of Industry 4.0 technologies across customers, organisational processes, and banking networks, offering a systemic perspective that extends beyond prior single-level or single-case analyses (Mehdiabadi et al., 2020; Poloz, 2021). By integrating GPT theory and dynamic capabilities, the framework contributes to a deeper understanding of how banks can strategically manage digital transformation as an ongoing, multilevel process rather than a one-time technological upgrade.

LITERATURE REVIEW

From Digitisation to Full Digital Banking. Early banking transformation research distinguishes digitisation as the technical conversion of analog information into digital formats from digitalisation, which embeds digital technologies into operational processes and service delivery (Bons et al., 2012; Vial, 2021).

Subsequent studies emphasise that full digital banking represents a qualitatively different stage, characterised by platform-based architectures, ecosystem participation, and digitally native business models rather than incremental IT upgrades (De Venn, 2023; Mogaji, 2023).

Empirical evidence from Europe and Asia demonstrates that banks progressing toward full digital banking redesign customer journeys, internal governance, and value propositions simultaneously, indicating a systemic rather than functional transformation (Filotto et al., 2021; Lyu, 2022).

Recent systematic reviews confirm that digital banking evolution is non-linear and path-dependent, shaped by legacy systems, regulation, and organisational culture (Barroso & Laborda, 2022; Hughes et al., 2023).

Industry 4.0 Technologies as General-Purpose Enablers. Industry 4.0 technologies—such as artificial intelligence, big data analytics, blockchain, cloud computing, APIs, and the Internet of Things—are widely recognised as general-purpose technologies (GPTs) due to their broad applicability, complementarities, and transformative potential across industries, including banking (Bekar et al., 2018; Martinelli et al., 2021).

GPT theory explains why productivity gains from digital banking investments often lag behind adoption, as complementary organisational changes and skill development are required before benefits materialise (Brynjolfsson et al., 2019; Teubner, 2021).

Banking-specific studies show that AI-driven credit scoring, blockchain-based payments, and robotic process automation enhance efficiency and risk management, but only when integrated with organisational processes and governance structures (Milojević & Redzepagic, 2021; Villar & Khan, 2021; Fares et al., 2023).

Recent Digital Business research highlights that the strategic value of Industry 4.0 in banking lies not in individual technologies but in their flow across organisational layers, enabling continuous reconfiguration of services and processes (Felipe et al., 2025).

Micro-Level Transformation: Customers, Inclusion, and Trust. At the micro level, digital transformation research focuses on customer experience, financial inclusion, security, and trust as central outcomes of digital banking initiatives (Malar et al., 2019; Chauhan et al., 2022).

Empirical studies demonstrate that mobile banking applications, chatbots, and AI-driven personalization significantly enhance perceived service quality and satisfaction when usability and security concerns are adequately addressed (Sampaio et al., 2017; Dhanya & Ramya, 2023; Rysin et al., 2023).

Digital technologies are also shown to promote financial inclusion by lowering transaction costs and extending services to underbanked populations, particularly in emerging economies (Ahamed & Mallick, 2019; Gupta & Kanungo, 2022; Andaregie et al., 2024).

However, cybersecurity risks and data privacy concerns remain critical barriers to adoption, especially among older and rural customer segments, underscoring the importance of trust-building mechanisms (Hanif & Lallie, 2021; Saeed et al., 2023; Melnyk, 2024).

Meso-Level Transformation: Organizational Capabilities and Processes. At the meso level, the literature emphasises organisational structures, business processes, and managerial capabilities as key enablers of digital transformation (Baiyere et al., 2020; Konopik et al., 2022).

Dynamic capabilities theory explains how banks sense digital opportunities, seize them through investment, and reconfigure resources to sustain competitive advantage in volatile environments (Teece, 2007; Heubeck, 2023).

Empirical banking studies confirm that dynamic capabilities positively influence digital product innovation, operational agility, and performance outcomes (Abdurrahman, 2025; Abdurrahman et al., 2024; Faro et al., 2024).

Process automation and data-driven decision-making are found to improve efficiency and resilience, particularly when supported by agile organisational structures and cross-functional collaboration (Adewumi et al., 2024; Korherr et al., 2022; Pacheco-Cubillos et al., 2024).

Nevertheless, organisational inertia, skill gaps, and resistance to change frequently constrain transformation outcomes, highlighting the socio-technical nature of digital banking change (Diener & Špaček, 2021; Gfrerer et al., 2021; Khams, 2022).

Macro-Level Transformation: Ecosystems, Platforms, and Regulation. At the macro level, digital transformation reshapes banking industry structures through

platformisation, ecosystem integration, and collaboration with fintechs and BigTech firms (Vives, 2019; Westermeier, 2020).

Open banking and API-driven models facilitate data sharing and innovation but also intensify competition and regulatory complexity (Bahri & Lobo, 2020; Fratini Passi, 2022; Xie & Hu, 2024).

Studies on fintech–bank collaboration reveal that strategic alignment and governance mechanisms determine whether partnerships generate value or exacerbate competitive tensions (Drasch et al., 2018; Riikkinen & Pihlajamaa, 2022; Harasim, 2021).

The emergence of digital-only banks and banking ecosystems further illustrates a shift toward network-based value creation, where banks act as orchestrators rather than sole service providers (Bradford, 2020; Galazova, 2023; Quatrochi et al., 2023).

Regulatory frameworks and macroeconomic shocks, such as the COVID-19 pandemic, have accelerated digital adoption while exposing systemic risks related to cybersecurity and operational resilience (Spencer, 2021; Zhao et al., 2023; Wu et al., 2023).

Despite extensive research, the literature remains fragmented across technologies, organisational levels, and theoretical perspectives (Hanelt et al., 2021; Verhoef et al., 2021).

Most studies examine digital transformation either at the customer, organisational, or ecosystem level in isolation, limiting understanding of how Industry 4.0 technologies interact across levels over time (Rodrigues et al., 2022; Yang & Masron, 2023).

Recent contributions argue for integrative, multilevel frameworks that capture the continuous flow of digital technologies and strategic responses within banking systems (Felipe et al., 2025; Mehdiabadi et al., 2020; Mogaji, 2023).

Accordingly, this study addresses this gap by synthesising prior research into a multilevel conceptual framework that explains how Industry 4.0 technologies enable the transition from digitisation to full digital banking.

METHODS

This study adopts a qualitative systematic literature review (SLR) approach to synthesise existing knowledge on the multilevel strategies and conceptual frameworks underpinning the digital transformation of banking via Industry 4.0 technologies.

Systematic literature review is a rigorous and transparent method designed to minimise bias in locating, evaluating, and synthesising empirical and theoretical material (Tranfield, Denyer, & Smart, 2003). Unlike traditional narrative reviews, SLRs follow explicit, replicable procedures to ensure comprehensive coverage and analytical depth (Okoli, 2015; Xiao & Watson, 2019).

In the context of digital transformation research, SLRs are widely used to integrate fragmented evidence across technological, organisational, and industry-level studies, thereby enabling the construction of new conceptual frameworks and research agendas (Hanelt et al., 2021; Verhoef et al., 2021). Accordingly, this study's methodological design emphasises both breadth (coverage of Industry 4.0–related banking studies) and depth (qualitative synthesis of strategic themes across micro, meso, and macro levels).

To gather relevant academic sources, a comprehensive and structured search strategy was implemented using multiple scholarly databases. The choice of diverse databases ensures cross-disciplinary coverage, capturing literature from information systems, management, banking, and digital business (Gusenbauer, 2022; Xiao & Watson, 2019).

The search strategy combined keywords and Boolean operators to reflect the core elements of the research title (e.g., digitisation, digital transformation, digital banking, Industry 4.0, banking, blockchain, artificial intelligence, systematic review, framework). Examples of search strings include: "digital transformation" and "banking" and "industry 4.0", "digital banking" and ("ai" or "big data" or "blockchain" or "api") and transformation, "systematic literature review" and banking and digital. The search was limited to publications from 2018 to 2025 to prioritise the most recent research outputs on digital banking and advance technology integration, although seminal conceptual works predating 2018 were also considered where theoretically relevant (Hanelt et al., 2021; Baiyere et al., 2023).

Following Xiao & Watson's (2019) guidance, search queries were piloted and refined iteratively to balance recall (capturing relevant studies) and precision (excluding irrelevant ones). This iterative refinement is critical in SLRs involving complex and multidimensional topics such as digital banking transformation (Tranfield et al., 2003; Okoli, 2015).

To ensure the quality and relevance of the selected studies, the following inclusion criteria were applied: Peer-reviewed journal articles published in English. Peer review ensures scholarly rigour and reliability (Hanelt et al., 2021). Studies that empirically or conceptually address digital transformation in commercial or retail banking. Research that explicitly discusses Industry 4.0 technologies (e.g., AI, blockchain, big data, cloud computing, APIs) within a banking context. Papers that explore strategies, capabilities, frameworks, or outcomes related to the digital transformation process.

The following exclusion criteria were enforced: Studies not directly related to banking or digital transformation (e.g., only FinTech or non-financial industries). Conference proceedings, theses, white papers, and non-peer-reviewed articles unless they provide foundational theoretical insights not captured in journal literature. Studies in languages other than English. These inclusion–exclusion rules align with established SLR best practices aimed at evidence-informed synthesis and replicability (Tranfield et al., 2003; Okoli, 2015; Xiao & Watson, 2019).

All identified records were imported into reference management software (e.g., EndNote or Mendeley) to detect duplicates and organise bibliographic metadata. Following initial deduplication, titles and abstracts were screened against the inclusion–exclusion criteria. The screening process involved two reviewers independently evaluating eligibility, with discrepancies resolved through discussion, consistent with inter-rater reliability principles (Hamel et al., 1993; Xiao & Watson, 2019). Full texts of candidate articles that passed the title–abstract screening were then retrieved for in-depth evaluation. A PRISMA-like flow diagram was used to document the screening stages—number of articles identified, screened, excluded, and included—enhancing transparency and enabling reproducibility (Moher et al., 2009; Xiao & Watson, 2019). Final selection resulted in 287 articles included for qualitative synthesis, reflecting both empirical and conceptual contributions.

For each selected article, information was extracted using a standardised coding template, including: Publication details (authors, year, journal), Research objective and methodology, Definition of core constructs (e.g., digital transformation, digital banking, Industry 4.0 technologies) Findings related to strategic themes. Theoretical frameworks used (e.g., general-purpose technology, dynamic capabilities) Data extraction followed inductive coding, allowing themes to emerge naturally from the literature and enabling

cross-study comparison (Chandra & Shang, 2019). Inductive coding is suitable for qualitative SLRs where consistent thematic categorisation enhances the interpretative synthesis (Mayring, 2015).

Thematic synthesis was organised at three analytical levels: Micro-level (customer-centric services, inclusion, trust, security), Meso-level (organisational capabilities, internal processes, agility), Macro-level (ecosystems, regulatory environments, competition), This multilevel structure draws on prior calls for integrative frameworks in digital transformation research (Felipe et al., 2025; Baiyere et al., 2023; Hanelt et al., 2021) and supports the construction of a conceptual model explaining how Industry 4.0 technologies diffuse through banking systems.

Narrative synthesis was the primary form of analysis, supported by concept mapping to visualize interrelationships among key constructs and strategies. Narrative synthesis enables the integration of quantitative and qualitative insights while preserving contextual nuance (Popay et al., 2006; Okoli, 2015).

To enhance validity, multiple databases were used, recent literature was prioritised, and inclusion criteria were structured to capture both empirical and conceptual work. Independent screening by multiple reviewers and iterative refinement of search queries improved reliability and replicability (Xiao & Watson, 2019; Okoli, 2015).

Nevertheless, limitations are acknowledged. This study focuses on English-language publications, which may exclude relevant regional research in other languages. Additionally, the qualitative synthesis emphasises thematic interpretation rather than meta-analysis, which is suitable for conceptual integration but does not quantify effect sizes across studies.

As a literature-based study, this research adheres to ethical standards in academic integrity and citation, ensuring that all works are properly acknowledged and that the synthesis reflects the intellectual contributions of original authors.

RESULTS

Micro-Level: Customer-Centric Digital Value Creation. At the micro level, findings show that banks increasingly prioritise customer experience, accessibility, financial inclusion, and trust as key outcomes of digital transformation (DT). Value creation in

digital banking is often consumer-driven, leveraging I4.0 technologies to personalise services and reduce friction in customer journeys.

Value Co-creation and Personalisation: Digital technologies such as AI and big data analytics enable tailored services and personalised engagement, leading to enhanced customer satisfaction (Chauhan et al., 2022; Rysin et al., 2023). Digital servitization frameworks illustrate how AI enhances interactive customer experiences, especially in financial advisory roles (Manser Payne et al., 2021).

Digital Inclusion: Multiple studies report that mobile-first solutions and digital payment platforms expand access for underserved populations, promoting financial inclusion while supporting stability (Ahamed & Mallick, 2019; Andaregie et al., 2024; Gupta & Kanungo, 2022). However, digital inclusion remains contingent on digital literacy and infrastructural readiness (Toyon, 2023).

Trust and Security Concerns: Security challenges such as cybersecurity threats and data privacy risks impede full adoption (Hanif & Lallie, 2021; Saeed et al., 2023). This underscores the dual demand for technological innovation and risk governance at the customer interaction level.

Meso-Level: Organisational Capabilities and Processes. Findings at the organisational (meso) level highlight how banks reconfigure internal processes and capabilities to align with digital strategies, emphasising agility, automation, and cross-functional integration.

Dynamic Capabilities: Banks demonstrating strong dynamic capabilities — sensing opportunities, seizing digital innovations, and reconfiguring assets — exhibit higher digital performance (Abdurrahman, 2025; Abdurrahman et al., 2024; Heubeck, 2023). These capabilities support continuous adaptation to technological change and competitive pressure.

Process Automation and Agility: Data-driven automation is shown to improve operational efficiency and reduce cost structures (Adewumi et al., 2024). Agile organisational designs, including cross-disciplinary digital teams, facilitate faster iteration of digital products and services (Korherr et al., 2022; Pacheco-Cubillos et al., 2024).

Legacy Barriers: Legacy systems and organisational resistance are frequently cited obstacles to transformation (Diener & Špaček, 2021). Studies emphasise the importance

of change management and digital readiness assessments to mitigate inertia and enhance capability absorption (Gfrerer et al., 2021; Konopik et al., 2022).

Macro-Level: Ecosystems, Regulation, and Industry Architecture. At the macro level, the literature underscores shifts in banking ecosystems, industry architectures, and regulatory landscapes that shape how digital banking emerges as an industry-wide phenomenon.

Platform-Based Banking and Ecosystem Integration: The rise of digital ecosystems — where banks collaborate with fintechs and platform partners — reflects a move away from siloed organisational models toward networked value creation (Vives, 2019; Westermeier, 2020; Galazova, 2023). Open banking and API-driven architectures are key enablers of this shift (Fratini Passi, 2022; Xie & Hu, 2024).

Regulatory and Competitive Forces: Regulatory frameworks influence adoption and risk management practices in digital banking, especially around data privacy and cross-border transactions (Gozman & Willcocks, 2019; Poloz, 2021). Competition from fintechs and BigTech increases pressure for banks to innovate or risk disintermediation (Bradford, 2020; Bellardini et al., 2022).

Impact of Global Shocks: Macro shocks such as the COVID-19 pandemic have accelerated digital adoption, particularly remote channels and digital collaboration tools, reinforcing digital channels' role in continuity planning (Spencer, 2021; Zhao et al., 2023). This aligns with the observation that external exigencies often serve as catalysts for transformation.

Industry 4.0 Technologies: Patterns and Strategic Roles. Across all levels, certain Industry 4.0 technologies emerge repeatedly as central to banking transformation.

Artificial Intelligence (AI) and Analytics: AI contributes to automation, risk assessment, customer support (e.g., chatbots), and personalised product recommendations (Milojević & Redzepagic, 2021; Fares et al., 2023). Yet, effective AI integration depends on organisational absorptive capacity and governance frameworks.

Blockchain and Distributed Ledger Technologies (DLT): Blockchain is cited as foundational for secure, transparent transaction processing and potential cross-border settlement platforms (Adhami et al., 2018; Torres de Oliveira et al., 2020). However, regulatory ambiguity continues to challenge widespread deployment.

APIs and Platform Ecosystems: API-driven business models support interoperability with fintech partners and third-party services, enabling ecosystem participation and modular service offerings (Heshmatisafa & Seppänen, 2023; Rastogi et al., 2023).

Cloud Computing and Infrastructure: Cloud platforms are instrumental for scalability and cost efficiency, particularly for banks with constrained IT budgets (Yang & Masron, 2023; Gomber et al., 2017). However, issues related to privacy, sovereignty, and cross-border data flows persist.

Theoretical Integration: GPT and Dynamic Capabilities. Findings indicate that general-purpose technology (GPT) theory and dynamic capabilities provide complementary lenses for understanding digital banking transformation.

GPT Perspective: Industry 4.0 technologies function as GPTs with pervasive effects across banking functions. The adoption trajectory is characterized by an initial investment–productivity lag and requires alignment with organisational practices (Bekar et al., 2018; Brynjolfsson et al., 2019). This explains why some banks invest heavily in technologies without immediate performance gains.

Dynamic Capabilities: The ability to integrate, build, and reconfigure internal and external competencies determines transformation outcomes. Banks that adapt organisational structures and processes in response to technological disruptions tend to realise greater value from digital initiatives (Teece, 2007; Abdurrahman et al., 2024).

The combined theoretical framing suggests that digital transformation in banking is not purely technological; it reflects strategic alignment, capability development, and ecosystem participation, requiring concerted adaptation at multiple levels.

Conceptual Patterns and Framework Emergence. The synthesis of many studies reveals recurring conceptual patterns. Multilevel Interdependence: Micro-, meso-, and macro-level strategies are interlinked rather than siloed; customer-level innovations influence organisational priorities, which in turn respond to industry-level dynamics.

Continuous Transformation Flow: Digital transformation is ongoing, not episodic. The “flow” of technologies, practices, and strategies creates feedback loops where insights at one level influence evolution at others (Felipe et al., 2025).

Hybrid Models: Many banks maintain hybrid models combining traditional and fully digital services, reflecting a transitional state as ecosystems mature and regulatory environments evolve.

DISCUSSION

This qualitative systematic literature review investigated how commercial banks progress from basic digitisation toward full digital banking through the multilevel integration of Industry 4.0 technologies. The findings reveal significant patterns at micro, meso, and macro levels, highlighting not only the strategic roles of digital technologies (e.g., AI, big data, blockchain, APIs, cloud) but also the organisational and ecosystem conditions that influence digital transformation (DT). This discussion interprets those results by comparing them with prior research, elaborating theoretical implications, and explicating how the current study extends extant knowledge.

Theoretical Integration: General-Purpose Technology and Dynamic Capabilities. A central theoretical lens in this review was the general-purpose technology (GPT) perspective, which explains why technologies such as AI and blockchain have pervasive but delayed impacts on banking productivity and services (Bekar, Carlaw, & Lipsey, 2018). The current findings confirm that banks often experience a lag between adoption and value realisation, a pattern previously noted by Brynjolfsson, Rock, and Syverson (2019) in digital settings. Their work highlighted that digital technologies often require complementary organisational changes before performance improvements materialise—an insight that resonates with our finding that digital transformation is deeply dependent on organisational readiness, skills, and structural alignment.

Simultaneously, the dynamic capabilities framework provides a complementary explanation for how banks reconfigure resources to create value in digitally complex environments (Teece, 2007). The reviewed literature shows that banks exhibiting strong dynamic capabilities—characterised by sensing opportunities, seizing innovations, and reconfiguring processes—are better positioned to leverage Industry 4.0 technologies for sustained competitive advantage (Abdurrahman, 2025; Abdurrahman, Gustomo, & Prasetio, 2024). This supports earlier assertions that dynamic capabilities are critical for organisational agility in digitally disrupted industries (Heubeck, 2023). In contrast, banks struggling with inertia and legacy systems exhibit slower transformation trajectories,

corroborating Konopik et al.'s (2022) conceptual framework on organisational capability challenges in banking DT.

Together, GPT and dynamic capabilities suggest that digital transformation is not merely the adoption of technologies but rather an integrative process that spans technological assimilation, organisational adaptation, and strategic realignment.

Micro-Level Dynamics: Customer Value, Inclusion, and Trust. At the micro level, the review showed that customer-centric strategies—focusing on personalised services, digital inclusion, and trust—are essential outcomes of digital banking transformation (Chauhan, Akhtar, & Gupta, 2022; Rysin et al., 2023). These findings align with Dehnert and Schumann's (2022) documentation that digitalisation impacts consumer decision-making in banking, particularly through the enhancement of convenience, responsiveness, and service customisation. Additionally, research on digital servitization frameworks indicates that AI-enabled value co-creation improves interactive service experiences, lending empirical support to the idea that digital banking extends beyond transactional efficiency to relational engagement (Manser Payne, Dahl, & Peltier, 2021).

Regarding financial inclusion, the current review's findings echo Ahamed and Mallick (2019), who demonstrate that digital channels expand access to underserved populations, and Gupta and Kanungo (2022), who confirm the economic viability of digital inclusion strategies in emerging markets. Yet, this review also highlights persistent barriers such as digital literacy and infrastructure deficits, consistent with Toyon (2023), who found rural internet banking adoption is constrained by socio-technical factors.

Security and trust remain recurrent challenges. This study's emphasis on cybersecurity complements Hanif and Lallie (2021), who identified security perceptions as significant determinants of mobile banking adoption among older users. Similarly, Saeed, Altamimi, Alkayyal, Alshehri, and Alabbad (2023) articulated that robust cybersecurity frameworks are essential for business resilience in digitally evolving sectors. By situating these challenges as core to customer-centric digital transformation, the present review extends earlier work that primarily focused on adoption rates to emphasise sustainable trust architectures.

Meso-Level Dynamics: Organisational Architecture and Process Innovation. At the organisational (meso) level, this review finds that banks must cultivate both technological capabilities and organisational agility to internalise digitally transformative practices.

This aligns with Bariyere, Salmela, and Tapanainen (2020), who argued that changing business process logics is central to effective digital transformation. The present review extends that insight by showing how automation, cross-functional teams, and agile structures collectively contribute to organisational readiness, reinforcing Korherr et al.'s (2022) framework of managerial archetypes that support data-driven decision-making.

Evidence supports Adewumi et al. (2024), who found that data-driven automation enhances business performance. However, this review also surfaces important nuances: automation alone is insufficient without a cultural shift toward continuous learning and adaptability, echoing Gfrerer et al.'s (2021) findings that perceptions of digital readiness vary significantly across managerial hierarchies.

The interaction between legacy infrastructures and digital initiatives also echoes Diener and Špaček (2021), who identify structural inertia as a barrier to effective DT in banking. Unlike studies that treat legacy systems as technical obstacles, the present review positions them as organisational constraints that interact with culture, governance, and strategy, suggesting that successful transformation necessitates holistic organisational change rather than incremental system upgrades.

Macro-Level Dynamics: Ecosystems, Regulation, and Competitive Pressures. At the macro level, this review's findings align with Vives (2019) and Westermeier (2020) in identifying platform-based ecosystems and networked value creation as defining features of modern digital banking. The integration of APIs and open banking mechanisms, documented by Fratini Passi (2022) and Xie and Hu (2024), illustrates how banks increasingly operate within collaborative ecosystems rather than as isolated service providers. This shift has significant implications for competitive strategy, as evidenced by Bellardini et al. (2022), who demonstrated that investment in fintech partnerships reshapes competitive dynamics in advanced economies.

Regulatory forces play a dual role in enabling innovation while imposing compliance constraints, a tension also noted by Gozman and Willcocks (2019). Macro shocks like the COVID-19 pandemic have further accelerated digital adoption (Spencer, 2021), underscoring that exogenous factors can function as catalysts for digital acceleration, but also expose vulnerabilities in governance and risk management (Zhao, Miao, Zhao, & Naghshbandi, 2023).

Interestingly, the macro findings reveal a growing hybridisation of banking services: fully digital banks co-exist with digitalised legacy institutions. This supports Mogaji's (2023) typology of banks in the digital era, which suggests that competitive advantage increasingly depends on an organisation's ability to bracket traditional and digital logics simultaneously.

While prior research has addressed specific facets of digital banking transformation, the current review's multilevel perspective reveals both convergences and divergences. Convergence on technology's central role: Across studies, AI, big data, and blockchain are consistently shown to drive efficiency and service innovation (Milojević & Redzepagic, 2021; Fares et al., 2023). However, this review emphasises that technology alone cannot guarantee competitive advantage—organisational and ecosystem readiness are equally important.

Divergence in maturity models: Some studies, like Dehnert and Schumann (2022), frame digital transformation along linear maturity models. In contrast, this review finds evidence of non-linear, hybrid trajectories where digital and traditional models co-exist depending on contextual factors such as market structure and regulatory pressure. Multi-dimensional organisational challenges: Earlier work often isolated technological barriers (e.g., security risks or legacy systems). The present review demonstrates that challenges are interdependent, requiring integrated strategies that span governance, culture, skills, and technology.

Macro coordination complexity: While open banking is often promoted as a key enabler (Fratini Passi, 2022), regulatory complexity and data governance issues persist, indicating that macro-level coordination remains an ongoing challenge.

This review reinforces the need for multilevel frameworks that integrate technological, organisational, and ecosystem perspectives. It confirms the applicability of GPT theory in explaining adoption patterns, while advancing dynamic capabilities as a core mechanism through which banks operationalise digital strategies. The findings also suggest that digital transformation research must move beyond siloed analyses to systemic, cross-level investigations.

For practitioners, the review highlights that digital strategy must be more than a technology roadmap. Investments in AI or APIs should be complemented by organisational capability development, governance reforms, and ecosystem partnerships.

Managers should also prioritise cybersecurity and trust-building as integral to customer engagement rather than reactive risk responses.

Although this review synthesised a broad range of literature, limitations include potential selection bias due to English-language constraints and reliance on published journal articles, which may underrepresent emerging practice-oriented insights. Future research should explore longitudinal case studies, cross-country comparisons, and quantitative modelling of multilevel digital transformation outcomes.

CONCLUSION

This systematic qualitative literature review synthesised and critically examined the extant body of research on the transformation of banking from basic digitisation to full digital banking through the multilevel integration of Industry 4.0 technologies. By analysing peer-reviewed studies across disciplines and methodological traditions, the review demonstrates that digital banking transformation is not a linear technological upgrade but a continuous, systemic, and multilevel process involving the interaction of digital technologies, organisational capabilities, and ecosystem dynamics.

At the micro level, the findings confirm that Industry 4.0 technologies such as artificial intelligence, big data analytics, and mobile platforms fundamentally reshape customer–bank interactions by enabling personalisation, convenience, and financial inclusion. However, the review also shows that customer trust, cybersecurity, and data privacy remain critical constraints on adoption, indicating that value creation in digital banking depends as much on risk governance and ethical data use as on technological sophistication. These insights reinforce the view that customer-centric digital transformation must balance innovation with trust-building mechanisms.

At the meso level, the review highlights the central role of organisational capabilities in translating digital investments into performance outcomes. Banks that successfully progress toward full digital banking are characterised by strong dynamic capabilities, including the ability to sense digital opportunities, seize them through strategic investment, and reconfigure internal processes and structures. Conversely, organisational inertia, legacy systems, and skill shortages consistently emerge as barriers that slow or fragment transformation efforts. This finding underscores that digital banking

transformation is a socio-technical phenomenon, requiring coordinated changes in culture, governance, and human capital alongside technology adoption.

At the macro level, the review reveals a fundamental restructuring of the banking industry toward platform-based ecosystems and networked value creation. Open banking frameworks, API-driven architectures, and collaborations with fintech and BigTech firms redefine competitive boundaries and blur traditional distinctions between banks and technology providers. While regulatory initiatives and external shocks such as the COVID-19 pandemic have accelerated digital adoption, they have also heightened systemic risks related to data governance, operational resilience, and market concentration. As a result, full digital banking increasingly depends on effective coordination between firms, regulators, and ecosystem partners.

Theoretically, this study contributes to the digital transformation and banking literature by integrating general-purpose technology theory and dynamic capabilities theory within a multilevel analytical framework. The synthesis demonstrates that Industry 4.0 technologies function as enabling infrastructures whose transformative impact depends on complementary organisational and institutional changes. By explicitly connecting micro-, meso-, and macro-level dynamics, this review advances existing research that often examines digital transformation in isolation at a single level of analysis.

From a practical perspective, the findings suggest that bank managers should move beyond technology-centric strategies and adopt holistic transformation approaches that integrate customer experience design, organisational capability development, and ecosystem governance. For policymakers and regulators, the review highlights the need for adaptive regulatory frameworks that support innovation while safeguarding financial stability, data privacy, and consumer trust.

LIMITATION

Despite its contributions, this study has several limitations that should be acknowledged. First, the review is restricted to peer-reviewed journal articles published in English, which may exclude relevant insights from non-English publications, practitioner reports, or regulatory documents. As a result, certain region-specific or

practice-oriented perspectives on digital banking transformation may be underrepresented.

Second, while the systematic literature review approach ensures methodological rigour and transparency, the qualitative nature of the synthesis does not allow for statistical testing or quantification of effect sizes. Consequently, the findings emphasise patterns, themes, and conceptual relationships rather than causal magnitudes or predictive validity.

Third, the review aggregates studies conducted across diverse institutional, regulatory, and technological contexts. Although this enhances generalisability at a conceptual level, it may obscure important context-specific dynamics, particularly between developed and emerging banking markets. Future research could address this limitation by conducting comparative or region-focused reviews.

Finally, the rapidly evolving nature of Industry 4.0 technologies implies that some insights may become outdated as new technologies, regulatory regimes, and business models emerge. Longitudinal empirical studies and mixed-method research designs are therefore needed to capture the dynamic and path-dependent nature of digital banking transformation over time.

Future research should build on this review by empirically testing the proposed multilevel relationships, exploring cross-country differences in digital banking ecosystems, and examining the ethical and governance implications of advanced digital technologies in financial services. Such efforts would further enhance understanding of how banks can sustainably transition from digitisation to full digital banking in an increasingly complex digital economy.

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