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Digital Financial Inclusion, Operational Efficiency, and Sustainable Growth: A Systematic Review from an Enterprise Service and Operations Perspective

Guangqin Kang, Roziana Baharin*,

Faculty of Economics and Management, Universiti Kebangsaan Malaysia, Bangi, Malaysia
roziana.baharin@ukm.edu.my (Corresponding author)

Abstract. Digital Financial Inclusion (DFI) has emerged as a critical enabler of enterprise development in the digital economy, particularly for small and medium-sized enterprises (SMEs). While existing studies widely acknowledge the positive association between DFI and Sustainable Growth (SG), the operational mechanisms through which digital financial access is transformed into sustained enterprise-level outcomes remain insufficiently clarified. Drawing on service science, informatics, and operations management perspectives, this study conducts a systematic literature review of 89 peer-reviewed articles following the PRISMA protocol to examine the role of Operational Efficiency (OE) as the core mediating mechanism linking DFI and SG. The review reveals substantial conceptual fragmentation and measurement inconsistency across studies, as well as pronounced regional and contextual imbalances, particularly in SME-focused research from developing economies. Synthesizing evidence from the DFI–OE, OE–SG, and DFI–SG research streams, this study advances an integrated enterprise-level framework grounded in the Resource-Based View and Dynamic Capabilities Theory. We argue that OE represents the central transformation hub through which digital financial resources and information infrastructures are converted into sustainable growth outcomes via process optimization, enhanced information flows, and improved operational decision-making. By explicitly positioning DFI as a digital service and information infrastructure that reshapes enterprise operations, this review contributes to the logistics, informatics, and service science literature by clarifying the micro-level mechanisms of digital transformation and identifying priority directions for future empirical research on SMEs and service-oriented enterprises.

Keywords: Digital Financial Inclusion; Operational Efficiency; Enterprise Service Systems; Sustainable Growth; SMEs; Digital Transformation

1. Introduction

Digital Financial Inclusion (DFI)—leveraging digital technologies to broaden financial access—has gained prominence for its role in promoting equitable financial services and empowering underserved groups in a digitalizing world (Xi & Wang, 2023). This technological shift has reshaped the financial landscape, creating new avenues for accessing digital financial services (DFS) (Lee & Tang, 2023).

As a catalyst for inclusive growth, DFI aligns with the sustainable development agenda (Tlemsani et al., 2023). Its transformative potential is particularly significant for small and medium enterprises (SMEs), which often face barriers in traditional financial systems (Kame Babilla, 2023).

Despite their substantial economic contribution, SMEs' growth is frequently hampered by inherent resource constraints and broader market inefficiencies (Bhattacharyya et al., 2023).

Simultaneously, achieving higher operational efficiency (OE) is critical for SMEs to remain competitive and resilient in dynamic markets. OE, as an enterprise's ability to maximize resource utilization while minimizing waste, has been identified as a crucial factor linking financial inclusion and performance outcomes (Shu & Yang, 2024). Studies on the relationship between DFI, OE, and sustainable growth (SG) have experienced rapid development, especially as digital technologies permeate financial and business ecosystems. The theoretical foundations primarily draw from classical economics and resource-based perspectives, with Resource-Based View (RBV) underscoring the importance of firm-specific resources and capabilities in achieving sustainable competitive advantage and Dynamic Capabilities theory (DCT) highlighting the need for enterprises to adapt and innovate in response to the evolving digital landscape (Barney, 1991; Li et al., 2021; Marozau et al., 2024). Despite the progress, understanding how DFI fosters SG through OE remains fragmented, regionally skewed, and conceptually inconsistent.

Existing literature has primarily focused on the direct impacts of DFI on SG or OE independently (Lin & Xie, 2023; Yang & Zhang, 2020), while the mediating role of OE between DFI and SG has received limited attention (Santos-Jaén et al., 2023), with some studies adopting the perspective of financial service providers rather than enterprises (Anton & Nucu, 2024; Binaluyo et al., 2024), resulting in fewer SME-focused investigations. In addition, although significant progress has been made in developing DFI indices and OE measurement techniques, inconsistencies in definitions and methodologies persist. For example, studies vary in how they conceptualize DFI—ranging from indicators considering either demand or supply side of DFS to comprehensive indices incorporating financial and digital access, literacy, and socioeconomic factors (Banik & Roy, 2023; Johri et al., 2024; Kouladoum et al., 2022; Li et al., 2024). OE measurement also ranges from single indicators to input-output system design, with metrics evolving from solely operational expenses and revenues to including intangible assets and knowledge outputs (Santos-Jaén et al., 2023; Wang et al., 2024; Zheng & Luo, 2023). Similarly, the definition and measurement of SG often oscillate between financial performance proxies and broader, multidimensional sustainability metrics (Li et al., 2024; Zopounidis & Lemonakis, 2024). These inconsistencies hinder the ability to draw generalizable conclusions across contexts, particularly for SMEs operating in diverse economic and digital environments.

Nonetheless, a lack of integrated understanding regarding the mediating role of OE between DFI and SG persists. The existing literature has not adequately addressed the contextual variations in DFI development, such as differing levels of financial and digital infrastructure, financial literacy, and regulatory environment (Aryani et al., 2020; Binaluyo et al., 2024; Zopounidis & Lemonakis, 2024). Moreover, studies often overlook region-specific indicators and the non-linear dynamics that may exist between DFI and SG, influenced by varying stages of digital transformation (Santos-Jaén et al., 2023). To date, no systematic literature review has comprehensively examined these relationships, uncovered existing issues, and provided a structured agenda for future research.

Thus, the research questions are as follows: At the enterprise level, particularly for SMEs, through what specific mechanisms does access to digital financial services (DFI) enhance operational efficiency

(OE)? And how does this improved OE, in turn, translate into sustainable growth (SG) outcomes? Furthermore, what are the key contextual factors (e.g., firm capabilities, institutional environment) that moderate the strength of this DFI → OE → SG pathway?

Therefore, this study moves beyond the traditional review's focus on summarizing and categorizing literature, aiming to construct a theoretical framework with operational efficiency (OE) as the core mediating mechanism to systematically explain 'how' and 'why' digital financial inclusion (DFI) can drive sustainable growth (SG) for enterprises, especially SMEs. We posit that OE is not merely one among many potential parallel mediators but is the central conversion hub that transforms external digital-financial resources into sustainable endogenous growth capabilities. This core argument is grounded in the following integrated theoretical logic: The Resource-Based View (RBV) posits that sustainable competitive advantage stems from the effective allocation and utilization of scarce, valuable, inimitable, and non-substitutable heterogeneous resources. DFI provides enterprises (particularly resource-constrained SMEs) with two key types of resources: a) financial resources, alleviating financing constraints and enabling investment in technology, human capital, and innovation; and b) digital resources and channels, reducing transaction costs, enhancing information transparency, and expanding market reach. These resources possess value and, in many contexts, scarcity. However, resource possession does not directly equate to competitive advantage. Dynamic Capabilities Theory (DCT) further elucidates that enterprises require 'dynamic capabilities' to effectively configure and leverage resources. OE—the optimization of input-output ratios and enhancement of process efficacy—is precisely the operationalized outcome and concentrated manifestation of such dynamic capabilities at the level of internal operational processes. It reflects the transformation efficacy through which an enterprise converts acquired financial and digital resources (inputs) into products, services, market performance, and long-term value (outputs) via 'capability application,' such as process re-engineering, cost innovation, and agile decision-making. Without this efficient internal transformation mechanism, digital-financial resources may lie idle, be misallocated, or fail to generate sustained benefits. Consequently, the core theoretical proposition of this review is that: Operational efficiency is an indispensable and dominant mediating mechanism linking digital financial resource access (DFI) to sustainable growth outcomes (SG). Subsequent analysis will focus on verifying and deepening this proposition and exploring the contextual boundaries of its effectiveness.

While Digital Financial Inclusion (DFI) is often discussed within frameworks of finance or development economics, it is fundamentally a comprehensive service ecosystem driven by digital technologies. It profoundly reshapes the service interfaces, information channels, and decision-making foundations through which enterprises exchange resources with their external environment. Consequently, this study aims to systematically examine the mechanisms of DFI from the intersecting perspectives of service science, informatics, and operations management. Specifically, we investigate: how DFI, as a digital service infrastructure, affects service process efficiency, information processing capability, and real-time operational decision-making within enterprises by improving the accessibility, flow, and quality of funds and information; and how this ultimately drives sustainable growth (SG) through the core transformation hub of operational efficiency (OE). This analytical framework not only enriches research on the micro-mechanisms of financial inclusion but also directly contributes to the core issues in logistics and supply chain , service science , and information systems.

Therefore, this study goes beyond the summary and categorisation of the literature in traditional reviews and aims to achieve the following objectives through systematic integration: (1) to construct a theoretical framework with operational efficiency as the central mediating mechanism to systematically explain "how" and 'why' ; (2) to critically sort out the existing measures of the main constructs and their inconsistencies; and (3) to propose a prioritised agenda for future research based on the above sorting. It is important to emphasise that the framework and propositions put forward in this paper originate from the logical integration and theoretical extrapolation of the existing literature, and their validity

(especially the OE as a core mediator) needs to be urgently examined by rigorous empirical research in the future.

The paper is structured as follows: Section 2 defines the core concepts and theoretical foundations of DFI, OE and SG, laying the conceptual foundation for the mechanism analysis. Section 3 details the methodology of the systematic review, focusing on how the three relational pathways - DFI-OE, OE-SG and DFI-SG - are explored through literature screening and thematic categorisation, and Section 4 integrates the evidence from the literature to analyse the measurement and impact of developmental finance interventions, the mediating role of organisational effectiveness and the transmission mechanisms among the three constructs in turn. transmission mechanisms between the constructs. Section 5 summarises the core findings, responds directly to the research questions, and proposes an integrative theoretical framework and directions for future research.

2. Conceptual background

This section presents the key concepts and theories underpinning DFI, OE, and SG individually and collectively, exploring how DFI leverages digital technologies to promote FI, the evolving role of OE in enterprise performance, and the broader dimensions encompassed by SG.

2.1 Digital Financial Inclusion

FI—the strategic provision of access to financial services for formerly underserved populations (Banik & Roy, 2023)—has long been recognized as a policy priority for sustainable development (Ozili, 2022), especially in developing countries (Binaluyo et al., 2024). The advent and proliferation of digital technologies has further catalyzed the evolution into DFI, which aims to achieve the goals of FI by leveraging these technologies to reduce the costs of financial services and expand the coverage of customers (Xi & Wang, 2023). This transformation has gained considerable momentum, with the Covid-19 pandemic accelerating the development and amplifying the significance of digital finance (Nandru et al., 2024; Nepal et al., 2025; Tay et al., 2022).

Early established theories exploring approaches to achieve FI focused on enhancing financial literacy and targeting the most financially vulnerable (Ozili et al., 2020). On this basis, the Diffusion of Innovation theory merges the concepts of digital finance and FI, examining the adoption and usage of digital technologies from the perspective of how financial institutions diffuse DFS in the market (Kouladoum et al., 2022). This theory has been employed extensively alongside the Technology Acceptance theory to analyze the factors influencing customers' attitudes and intentions towards DFI (Fersi et al., 2023). These innovation and acceptance theories are particularly pertinent to understanding the technology-driven dynamics of DFI (Abd Elghany, 2025).

The conceptualization of DFI in the literature reflects its diverse dimensions (as shown in Table 1), which are mostly captured by building on traditional FI indicators with digital metrics, acknowledging DFI as an extension and enhancement of FI through technology (Li et al., 2024). Some recent conceptualizations attempt to develop metrics derived from text-based analysis of corporate reporting, identifying the use of advanced technologies by enterprises. But such metrics are often biased and may not accurately reflect actual technology implementation (Shen et al., 2025).

Table 1. DFI: conceptual proxies

Proxy	Source
Comprehensive DFI Index = Traditional FI indicators + Digital metrics (+Literacy)	(Anton & Nucu, 2024; Banik & Roy, 2023; Johri et al., 2024; Kame Babilla, 2023; Kouladoum et al., 2022; Li et al., 2024; Shen et al., 2025; Ugwuanyi et al., 2022; Wang et al., 2024; Yang & Zhang, 2020; Zheng & Luo, 2023)
Provision of Fintech services (mobile phone and Internet services)	(Fersi et al., 2023; Li et al., 2024; Zhou et al., 2025)
Usage of DFS (online banking intensity and digital payments)	(Johri et al., 2024; Nandru et al., 2024; Zhou et al., 2025)
Degree of digital transformation (text-based analysis, i.e. AI, digital financial, cloud computing, etc.)	(Belas et al., 2025; Lin & Xie, 2023; Shen et al., 2025; Wang et al., 2024)

From a service system perspective, the dimensions measured by DFI indices—coverage breadth, usage depth, and digitalization level—essentially characterize the maturity of an ecosystem in a country or region that supports efficient, low-cost digital service interactions and information exchange for enterprises, especially SMEs.

2.2 Operational efficiency

The concept of efficiency, broadly referring to the optimal use of resources to achieve desired outcomes, has historical roots in economic theories focused on maximizing productivity and societal welfare (Borza, 2014; Pareto, 2014). In the context of enterprise, OE is more precisely conceptualized as an internal capability reflecting the effectiveness with which an enterprise transforms its inputs into outputs, thereby creating value and enhancing its market competitiveness (Shu & Yang, 2024; Zheng & Luo, 2023). It's distinct from, though often a contributor to, overall financial performance (Wang et al., 2023; Bae et al., 2024).

From a theoretical standpoint, the RBV provides a prominent lens for understanding OE, positing that an enterprise's ability to allocate and utilize resources is central to its performance (Li et al., 2021). Therefore, the pathways to enhancing OE involve strategic resource allocation towards technological upgrades, operational diversification, and effective scaling of activities (Jang et al., 2022; Xie et al., 2024). While RBV emphasizes internal strengths, a critical perspective acknowledges that OE is also shaped by the enterprise's ability to adapt these internal processes in response to its dynamic external environment (Lin & Xie, 2023; Shen et al., 2025).

Within the framework of this paper, operational efficiency (OE) refers not only to traditional resource conversion efficiency but also emphasizes the agility of internal processes (e.g., logistics, customer service processes), the effectiveness of information integration and utilization, and the quality and speed of operational decision-making based on real-time data, after an enterprise engages with the digital service ecosystem.

2.3 Sustainable growth

Research on SG is a continuous process that requires contextualization based on the study sample (Mavlutova et al., 2022), often relying on proxies tailored to specific research contexts (as illustrated in Table 2). Prior studies see profitability as the key driver of long-term growth, therefore equating SG with sustained profitability and using financial indicators as primary proxies (Li et al., 2024; Yang & Zhang, 2020). While these metrics offer insights into an enterprise's financial health, they

predominantly reflect short-term financial outcomes and may not fully capture the broader dimensions of scalability and resilience (Ta et al., 2022).

Recognizing these limitations, more sophisticated financial perspectives on SG have emerged, focusing on an enterprise's capacity for enduring and manageable growth. These frameworks extend to consider long-term financial equilibrium and resource management (Higgins, 2015; Van Horne & Wachowicz, 2001). While still rooted in financial data, they offer more dynamic and structured methods for assessing sustainable growth (Fonseka et al., 2012) by analyzing the dynamics of internal resource investment, financial strategies, and financial structure maintenance (Wang et al., 2024; Yang & Zhang, 2020).

Broader conceptualization of SG emphasizes the generation of long-lasting, multi-dimensional value, integrating economic viability with social responsibility and environmental coherence (Thathsarani & Jianguo, 2022; Yang et al., 2022). Along with a third stream of proxies addressing macro sustainability that focuses on improvements in long-term well-being and systemic shifts towards more sustainable paradigms, these perspectives advance the academic discourse, however, their practical application in empirical research remains challenging, mainly encountering difficulties in obtaining robust, reliable and standardized quantitative measurements, limiting research to theoretical analyses (Mick et al., 2024).

Table 2. SG: conceptual proxies

Proxy	Source
Financial sustainability	
Financial performance (profitability indicators)	(Handoyo et al., 2023; Kabaciński et al., 2020; Li et al., 2024; Yang & Zhang, 2020)
Sustainable growth (rate of growth measured by Higgins/ Van Horne model)	(Wang et al., 2024; Yang & Zhang, 2020)
Integrated Sustainability	
Composite sustainable performance (financial + non-financial indicators)	(Cui, 2021; Li et al., 2020; Li et al., 2023; Santos-Jaén et al., 2023; Ta et al., 2022; Thathsarani & Jianguo, 2022)
Sustainability (generate long-lasting value considering economic, social, and environmental consequences)	(Aryani et al., 2020; Elmi et al., 2025; Thathsarani & Jianguo, 2022; Yang et al., 2022; Zhou et al., 2025)
Economic sustainability	
Sustainable development (growth that meets current need without compromising future capacity)	(Al Yami & Ajmal, 2019; Mick et al., 2024)
De-prioritization of GDP goals (macro-policy that transit from rapid growth to sustainable development)	(Cheng et al., 2024)
Productivity growth (high-quality development)	(Kame Babilla, 2023; Lee et al., 2023)

2.4 Conceptual Demarcation: The Hierarchical Relationship among OE, Financial Performance, and SG

To avoid conceptual confusion and establish a clear analytical foundation, this section explicitly defines the theoretical hierarchy and boundaries among OE, Financial Performance, and SG.

Operational Efficiency (OE): A process- and capability-oriented construct. Its core lies in "transformation efficacy," i.e., the relative efficiency and productivity of the internal processes through which a firm converts inputs (e.g., labor, capital, technology, raw materials) into outputs (e.g., products, services, revenue). It is an intermediate process variable, focusing on "how to produce more economically and agilely." Financial metrics (e.g., ROA, TAT) are often used as its proxy variables, but this is an indirect and incomplete measurement, as these metrics are also influenced by non-efficiency factors like pricing and market power.

Financial Performance: A short-term, outcome-oriented construct. It primarily refers to the financial results achieved by a firm through market exchange within a specific accounting period. Typical indicators include profitability ratios (ROS, ROA), earnings growth, and shareholder return (ROE). It is one of the key direct outcomes that OE may produce, but not the only one (e.g., efficiency improvements can also lead to quality enhancements or faster delivery—non-financial outcomes).

Sustainable Growth (SG): A long-term, multi-dimensional, strategy-oriented construct. It transcends short-term financial results, emphasizing a firm's balanced and long-term viability across economic (sustained profitability and growth capability), social (employee and community well-being), and environmental (resource utilization, ecological impact) dimensions. Financial sustainability (e.g., sustainable growth rate calculated using the Higgins model) is an important sub-dimension or prerequisite of SG, but the connotation of SG is far broader than financial performance.

Core Relationship Demarcation:

1. OE is an important antecedent of Financial Performance, but not the only one. Market opportunities, monopolistic positions, etc., can also drive financial performance.
2. Financial Performance is a necessary but insufficient condition for SG. A firm can be profitable yet unsustainable (e.g., at the expense of the environment or employee welfare).
3. Thus, the three form a progressive causal chain and conceptual expansion: Efficient internal operations (OE) → Good short-term market performance (Financial Performance) → Long-term, responsible multi-dimensional development (SG). The core "mediating" mechanism (OE) emphasized in this review is precisely located at the initial, critical link of this chain.

Consistent with our refined research focus, the conceptual analysis and subsequent synthesis in this review will be primarily anchored at the enterprise level, especially concerning SMEs. We are interested in DFI as an external resource and information environment accessible to individual firms, OE as the firm's internal capability to transform these inputs, and SG as the firm-level outcome of sustained competitive advantage. While acknowledging broader macro-level impacts, our primary objective is to disentangle the internal black-box process through which external digital-financial resources are converted into sustainable performance.

Based on the above definition, this review will consciously, in subsequent analyses: 1) when exploring the measurement of OE, prioritise the examination and discussion of indicators that reflect process, innovation and information dimensions (e.g., process cycle time, degree of digital adoption, level of data integration); 2) when analysing the impact of DFIs on OE, focus on how they contribute to the innovation of service models, the reengineering of business processes, and the enhancement of information processing capability rather than just easing financing constraints; 3) when demonstrating the contribution of OE to SG, incorporate its support for non-financial sustainability dimensions such as operational resilience, service quality and innovation agility.

2.5 Digital financial inclusion, Operational efficiency, and Sustainable growth

The transformative potential of DFI in fostering SG is increasingly recognized, yet the specific micro-level mechanisms driving this relationship, particularly for SMEs, warrant deeper investigation. While much of the existing literature examines DFI's impact at a macro-economic level (Chinoda & Kapingura, 2024) or highlights the environmental aspect of sustainability (Zhang et al., 2024; Zhu et al., 2023), the pathway through which DFI translates into holistic SG for enterprises remains less clear, especially in resource-constrained developing countries (Thathsarani & Jianguo, 2022; Xie et al., 2024). This is a critical yet valuable gap as SMEs are arguably the prime candidates to benefit from DFI to break traditional financial constraints (Kame Babilla, 2023; Santos-Jaén et al., 2023) and lower financing costs (Li et al., 2024).

Theoretically, the RBV and DCT, integrated with FI theories, explain the internal and external factors that drive efficient and sustainable outcomes for enterprises, emphasizing on access to finance and digital capabilities as part of the value chain to gain competitive advantages (Santos-Jaén et al., 2023) and recognizing the adaptation of business models to technological disruptions and regulatory changes to create new forms of value in digital markets (Marozau et al., 2024).

This leads to the role of OE, an efficient internal transformation that can translate the financial and digital resources provided by DFI into sustainable outcomes. Empirically, in few studies that posit OE in between DFI and SG, Financial Resource Dependence and Affordance theory are incorporated to address the importance of digital innovation in overcoming financing gaps, producing higher OE, and promoting SG (Cheng et al., 2024; Liu et al., 2023).

In summary, while DFI and SG's direct relationship is increasingly studied, the conceptual argument for OE as a key mediating mechanism for SMEs is compelling. This review, therefore, focuses on clarifying this pivotal role of OE in the DFI-SG pathway for SMEs.

2.6 Clarifying the Causal Logic and Boundary Conditions of OE as the Core Mediator

To address the reviewer's comment and deepen the theoretical contribution, this section integrates the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to explicitly propose the theoretical rationale, causal chain, and boundary conditions for OE's role as the core mediator in the DFI-SG pathway.

(1) Core Causal Logic: From Resource Acquisition to Capability Transformation, to Sustained Advantage

DFI as Key Resource Provision: According to RBV, DFI provides enterprises (especially SMEs) with two key resource types: a) Financial resources, easing financing constraints and allowing investment in technology, human capital, and innovation. b) Digital resources and channels, lowering transaction costs, improving information transparency, and expanding market access. These resources are valuable and, in many contexts, scarce.

OE as the Operational Manifestation of Dynamic Capabilities: However, resource ownership does not automatically translate to competitive advantage. DCT emphasizes that enterprises need "dynamic capabilities" to effectively configure and utilize resources. OE—optimizing input-output ratios and enhancing process efficiency—is the result of applying dynamic capabilities (e.g., process reconfiguration, technology integration, supply chain optimization) at the operational level. It is the key process that 'activates' and 'internalizes' acquired DFI resources into the firm's operational system.

SG as the Outcome of Sustainable Competitive Advantage: The cost advantages, efficiency gains, flexibility, and innovation speed achieved through OE enhancement form the foundation for short-term financial robustness and long-term adaptability (resilience), ultimately leading to sustainable growth (SG). This pathway embodies the complete chain from "resources" (DFI) to "capabilities" (dynamic capabilities manifested in OE) to "sustained performance" (SG).

(2) Why is OE "Core" and Not Just "Another" Mediator? — A Theoretical Comparison

Compared to other potential mediators (e.g., simple "technology innovation adoption" or "market expansion"), the centrality of OE lies in its:

Comprehensiveness: OE improvement encompasses technological innovation, process management, resource allocation optimization, etc., representing the combined efficacy of various improvement activities.

Foundational Nature: Efficient operations provide the financial and operational foundation for any form of innovation, social responsibility, or environmental challenge response. Without efficiency gains, other activities may become unsustainable due to resource depletion.

Measurability: Compared to some abstract dynamic capability constructs, OE is more readily measured using relatively objective financial or production data, facilitating empirical testing.

(3) Preliminary Theoretical Discussion of Boundary Conditions

The strength of OE's mediating effect may be moderated by the following contextual factors (future research should focus on testing these):

Firm Absorptive Capacity: A firm's knowledge base and learning culture influence the efficiency with which it transforms DFI resources into OE improvements.

External Institutional Environment: The quality of digital infrastructure, financial regulatory policies, data security laws, etc., constitute external "enablers" or "constraints" for DFI resources to be effective and for OE improvements to be implemented.

Industry Characteristics: The pathways and strength of the DFI → OE → SG linkage may differ between capital-intensive and labor-intensive industries.

Firm Life Cycle Stage: Enterprises in start-up, growth, and maturity stages may have different types of DFI needs and foci for OE improvement.

3. Methodology

To address the research questions, a systematic literature review is conducted to critically assess the relationship between DFI and SG using OE as a mediating mechanism. Since this review attempts to bring together three groups of knowledge, examine their relationships and underlying mechanism, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Haddaway et al., 2022) was utilized to provide guidance in identifying, screening and selecting eligible literature to analyze and synthesize existing knowledge on DFI, OE, and SG. The method is divided into five phases: identification, screening, eligibility, included, and present.

3.1 Search strategy

The primary databases searched were SCOPUS and Web of Science (WOS) due to their extensive indexing of peer-reviewed journals, supplemented by the relevant literature searched in Google Scholar (GS), which has a more permissive keyword search mechanism that can capture some articles that may have been missed by the first two databases, but requires more work to screen. The searches were last updated on September 13th, 2025.

In the identification stage, the keywords determined were “digital financial inclusion” or “digital inclusive finance”, “operational efficiency”, “sustainable growth”, “SME*” or “small and medium enterprise*”. To obtain more relevant literature, the search string is extended to include “financial inclusion” or “inclusive finance”, “digital*”, “operating efficiency”, and “sustainab*”.

In the screening stage, English articles published within the last ten years were included to capture the development in research regarding DFI and enterprises’ performance and growth. Three restricted criteria were set in the screening process, as shown in Table 3.

Table 3. Restriction criteria

Criteria	Eligibility	Exclusion
Document type	Article	Conference paper/ review, Book Chapter, Book, Note
Language	English	Other language
Time period	2015-2025	Earlier than 2015

In the eligibility stage, manual effort was involved in reading titles and abstracts to assess if the remaining literature is closely related to the discussion of the topic. Meanwhile, literature that cannot be retrieved in full text was excluded.

In the included stage, to ensure a systematic and comprehensive review of the literature, the search process was further divided into several focused segments. First, the search targeted literature on building a comprehensive DFI index, emphasizing studies that discussed dimensions and indicators for constructing composite indices. Second, the search focused on OE of enterprises, aiming to capture its various dimensions and measurements used in existing studies. Third, the relationship between DFI and OE was investigated, with an initial focus on SMEs. However, due to limited literature specific to SMEs, the scope expanded to include other types of organizations. Fourth, the connection between DFI and SMEs' SG was explored, seeking to understand how DFI impacts long-term performance and sustainability. Lastly, the relationship between OE and SG was examined. This search initially focused on SMEs but expanded to include all sizes of enterprises to address the scarcity of relevant studies.

Upon completion of the above process, the study presents 89 literatures in total that are found closely related to the discussion of DFI, OE, and SG. The complete process and corresponding result are shown in Fig. 1.

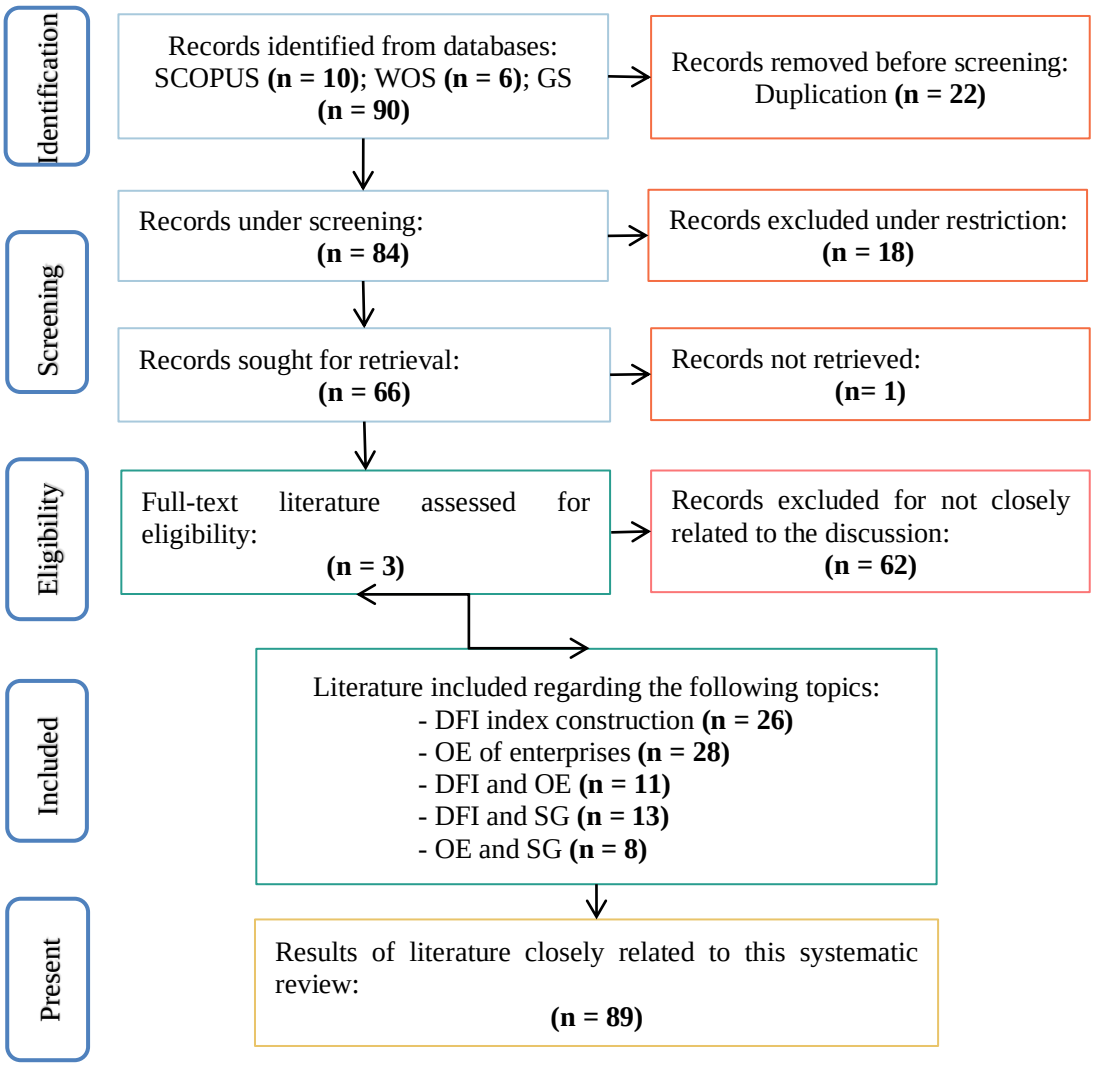

Fig. 1: PRISMA: the flow chart Source.

3.2 Critical analysis

To address our refined research question focusing on enterprise-level mechanisms, the screened literature was critically analyzed with an explicit firm-centric lens. We prioritized evidence and insights pertaining directly to how individual enterprises or SMEs experience and utilize DFI, how such usage affects their internal operations and processes (OE), and how these operational changes link to their long-term growth and sustainability (SG). Studies focusing solely on macroeconomic outcomes, financial system stability, or policy-level analysis were synthesized only insofar as they provided context or foundational understanding for the enterprise-level phenomena of primary interest.

To systematically address the core question of "how DFI promotes SG through OE," the screened literature is categorized into three relationship groups for critical synthesis:

1) The relationship between DFI and OE (corresponding to "how DFI affects OE" in the research question);

2) The relationship between OE and SG (corresponding to "how OE affects SG");

3) The relationship between DFI and SG (serving as the context for the total effect).

By separately reviewing the evidence and discrepancies within these relationships, this paper then synthesizes inferences regarding the mediating mechanism of OE and its boundary conditions.

Based on the extracted articles, this critical analysis focuses on the conceptualization, measurement and relationships among DFI, OE and SG, aiming to identify gaps and inconsistencies within the current literature and provide a foundation for advancing the future research agenda. A risk of bias assessment was conducted using the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018). Two reviewers independently evaluated each study, and all included studies demonstrated methodological quality with clear objectives and appropriate research approaches.

In addition to the risk assessment of individual study quality, this review also examines the selected literature holistically from the perspective of causal inference validity. A prominent commonality is that the vast majority of studies (especially quantitative ones) are based on cross-sectional data or short panel data. While such designs can effectively reveal associations between variables, they severely limit the ability to draw definitive causal conclusions. Specifically: (a) Ambiguity in Causal Direction: Cross-sectional data makes it difficult to determine whether improvements in DFI lead to enhancements in OE and SG, or whether more operationally efficient and sustainably growing firms are more willing and able to adopt digital financial services (reverse causality); (b) Inability to Control Unobserved Heterogeneity: Unobserved inherent differences between firms (e.g., management quality, corporate culture) may simultaneously influence their DFI adoption level, OE, and SG outcomes, leading to estimation bias; (c) Neglect of Dynamic Processes: The influences among DFI, OE, and SG may be reciprocal, lagged, or evolving over time, which cross-sectional designs cannot capture. Therefore, while the relational patterns synthesized in this review are insightful, the causal claims implicitly contained within must be treated with caution. It is recognized that enhancing causal inference validity is a critical bottleneck urgently needing breakthrough in the empirical research of this field.

The selected studies were categorized based on their focus on DFI, OE, and SG to enable a targeted examination. Particular attention was given to how DFI contributes to SMEs' SG by enhancing their OE, therefore, this involved analyzing not only the direct relationship between DFI and SG, but also the connections between DFI and OE, as well as OE and SG.

Based on the critical analysis of the aforementioned relationships, this study adopted a 'proposition derivation' approach to formalize the integrated framework. Specifically: (a) From the three sets of empirical findings on DFI-OE, OE-SG, and DFI-SG, we inductively identified the foundation for significant associations (corresponding to the basis for propositions PA1, PA2, and PB1); (b) Through theoretical deduction (based on RBV and DCT), we established the logical rationale for OE as the core transformation mechanism (corresponding to propositions PB1 and PB2); (c) By identifying contradictory or variable results in the literature (e.g., non-significant effects of DFI on OE or SG in some studies), we deduced key contextual factors that might explain this variance (corresponding to propositions PC1-PC3). This process ensures that the proposed framework is both grounded in empirical evidence and possesses theoretical depth and clear structure.

4. Results and Discussion

In this section, the synthesized results offer insights into the relationships between DFI, OE, and SG. Begin with measuring these key constructs, highlighting variations across literature and addressing the need for clarity. Then delve into the relationships between them respectively.

4.1 Understanding Digital Financial Inclusion

4.1.1 DFI: Leveraging technology to promote financial inclusion

The conceptualization of an inclusive digital economy, and by extension DFI, is inherently context-specific, shaped by regional socio-economic conditions and infrastructure development. Consequently, much of the early discourse and empirical evidence on DFI concentrated on developing economies such as China (notable in Fig.2). These nations not only present significant opportunities for financial deepening due to large unbanked or underbanked populations but also often showcase rapid

"leapfrogging" potential, where digital solutions can bypass the physical barriers of traditional financial infrastructure.

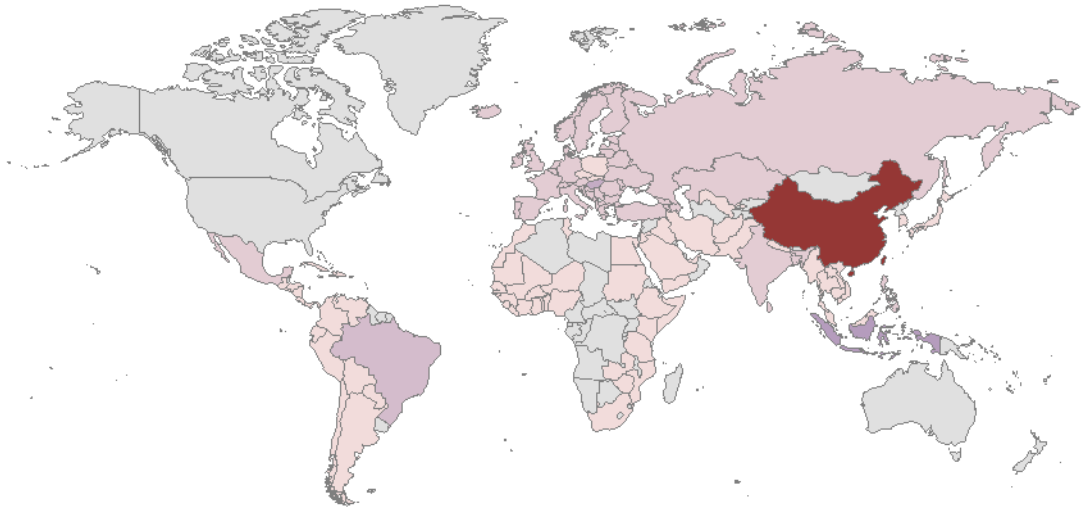

Fig. 2: Geographical distribution of DFI related studies

As shown in Figure 2, the geographical distribution of existing DFI-related research is highly uneven, exhibiting a pronounced 'China-centric' phenomenon, with significant under-representation of many developing economies in dire need of digital financial solutions (e.g., most of Sub-Saharan Africa, parts of Latin America). This is not merely a simple description of publication volume; it profoundly reveals a geographical 'research-need' mismatch and potential theoretical blind spots in the field.

Cognitive Bias from Research Centralization: The excessive focus on China (which has a unique digital finance ecosystem dominated by platforms like Alipay/WeChat Pay) may lead to research conclusions (e.g., on DFI drivers or policy effectiveness) lacking generalizability, making them difficult to directly apply to other developing regions with vastly different financial infrastructure, regulatory environments, or cultural contexts.

Neglected Research Frontiers: The areas appearing as "blank" or "light-colored" on the map are precisely the critical natural laboratories for testing the boundaries of DFI theory and discovering unique mediating or moderating mechanisms (e.g., DFI models under extreme resource constraints or within informal economies). Future research must consciously expand geographical coverage to discern the common mechanisms and context-specificities of DFI's role through comparative studies.

Indeed, many developing countries face persistent challenges in insufficient physical infrastructures and high costs of traditional banking systems that hinder the delivery of financial services. These operational inefficiencies disproportionately affect marginalized populations, often rendering traditional financial inclusion efforts inadequate. Nevertheless, by leveraging mobile technology, internet connectivity, and innovative platforms, DFI offers a transformative alternative to reduce transaction costs, expand reach, and deliver tailored financial products—from digital payments and online credit to savings and insurance. The rapid adoption of mobile payments in parts of Africa, for instance, demonstrates this potential to improve financial access and continues to gain traction in other emerging economies.

However, the promise of DFI comes with hurdles, which can be slowed by factors such as digital financial literacy gaps, fragmented initiatives, insufficient digital infrastructure, and data security concerns. Consequently, realizing the full potential of DFI—to truly deliver affordable, accessible, and inclusive financial services to traditionally excluded groups—requires a multi-stakeholder engagement, including targeted digital and financial literacy programs, adaptive regulatory environments, continued

investment in digital infrastructure, and the proactive development of user-centric solutions by financial institutions.

Ultimately, DFI is more than providing access but about empowering individuals and enterprises to actively participate in the economy, manage financial risks, and contribute to sustainable growth.

4.1.2 Beyond Description: Institutional Roots and Theoretical Implications of Regional Differences

The 'China-centric' phenomenon and the research gaps in many developing countries revealed in Figure 2 is not only a bibliometric fact, but also a profound reflection of the structural correlation between 'institutional environment-technology adoption-research output'. A systematic explanation of regional differences is the key to understanding the boundary conditions of DFI's mechanism of action.

(1) How Institutional Framework and Regulatory Environment Shape the Form and Effectiveness of DFIs

The uniqueness and insights of the Chinese case: The explosive growth and highly concentrated research on DFIs in China is rooted in its unique 'state-led digital ecosystem' model (e.g., platform giants and strong policy synergies). This has given rise to DFI models centred on payment facilitation and platform credit, whose findings (e.g., the direct impact of platform data on credit) may have limited applicability in decentralised regulatory countries (e.g., many in Latin America and Africa) that lack similarly strongly integrated digital ecosystems.

Regulatory sandbox vs. innovation licensing: In regions with formal 'regulatory sandbox' mechanisms (e.g., some Southeast Asian and East African countries), DFI innovations may penetrate the formal financial system earlier, and the pathway to impacting firms' OE may be more focused on the integration of compliant technologies; whereas in regions with lagging regulatory frameworks, DFIs may exist for a prolonged period of time in informal or quasi-formal forms, and their OE uplift may be more limited. formal forms, and their OE-enhancing effect relies more on digital substitution of informal financial processes.

(2) How the Level of Digital Infrastructure Development Moderates the Efficiency of DFI→OE Transmission

Infrastructure acts as a 'capacity threshold': in regions with high broadband coverage and low mobile internet tariffs (e.g., parts of East Asia), DFI tools (e.g., cloud ERP, real-time payments) can be seamlessly accessed by firms to directly optimise processes (OE). In regions with weak infrastructure, the main role of DFI may only be at the primary stage of replacing cash transactions, and its empowerment of deeper operational processes (e.g., supply chain management, data analytics) is hampered by the 'digital connectivity gap,' resulting in insignificant or lagging effects on OE.

Compound inequality: Research gaps (e.g., most countries in Sub-Saharan Africa) are often characterised by both institutional fragility and infrastructure deficits. This leads to "double binds" for DFI interventions, which may have very different mechanisms of action, such as mobile money systems that rely more on community trust networks (rather than formal institutions). Ignoring these areas deprives us of valuable knowledge to understand how DFIs operate under extreme constraints.

(3) Implications for theory and future research

Analyses of regional differences suggest that there is no single 'DFI → OE → SG' pathway. Future research must extract theory from contextualised comparisons:

Theory building: A weighting framework of 'institutional-infrastructural fit' should be developed to predict the contexts in which DFI resources are more likely to translate into measurable OE improvements.

Research design: Cross-country comparative studies are strongly advocated, especially systematic comparisons of "deep cases" such as China with under-represented regions, in order to identify universal and context-specific mechanisms.

Measurement practices: In cross-regional studies, DFI and OE measures need to be adapted to the maturity of the local digital ecosystem, e.g., in areas dominated by the informal economy, measures of informal digital transaction tools need to be included.

4.1.3 Comprehensive DFI Index: the measurement

Building on the conceptualization of DFI as a multifaceted concept discussed in section 2.3, Table 4 presents a diverse array of dimensions and specific indicators involved in the construction of a comprehensive DFI index, which is a choice that significantly influences research across varied contexts. Analysis of the 26 selected articles reveals that the most included dimensions are accessibility and coverage (representing the supply-side), usage (reflecting the demand-side), and digitalization (capturing the technological advancement):

Accessibility and coverage are frequently measured through metrics such as the density of physical access points (e.g., ATMs, bank branches (Xi & Wang, 2023)) and, increasingly, the penetration of digital enablers such as mobile money account ownership (Nandru et al., 2024; Ugwuanyi et al., 2022). While they effectively map the potential reach of financial services, whether high density or ownership rates automatically translate to equitable inclusion is questioned, especially if barriers to actual use persist.

Usage is commonly assessed via metrics such as the prevalence of savings and borrowings activities in formal financial institutions, alongside the volume of mobile money transactions and online credit uptake (Shen et al., 2022), providing valuable insights into active engagement with traditional and digital financial services.

Digitalization is typically captured by digital infrastructure and adoption rates, such as Internet and mobile phone subscriptions or digital payment levels (Ugwuanyi et al., 2022), which are crucial for understanding the enabling environment for DFI.

Other dimensions appear less frequently but are gaining attention, as scholars begin to recognize the importance of awareness and gender disparity in the pursuit of FI (Banik & Roy, 2023; Duvendack et al., 2023; Shen et al., 2022).

The influence of a mature and standardized index is notable. Of the 26 articles, a significant portion (11 articles) adopted or cited the DFI index from Peking University Digital Finance Center and Ant Financial Group. This index, with its emphasis on digitalization, usage, and coverage through 33 indicators, reflecting the rapid digital transformation and pivotal role of Fintech in reshaping financial inclusion landscape (Guo et al., 2020). The adoption of such comprehensive indices can foster comparability but must be adapted to vital context-specific DFI dynamics.

Table 4. DFI measurement metrics

Dimensions	Indicators	Examples
Accessibility and Coverage	-ATM, bank branches, mobile money agents' density -Debit/credit card, mobile money account ownership	(Banna & Alam, 2021; Kouladoum et al., 2022; Liu et al., 2021; Shen et al., 2022; Suhrab et al., 2024; Ugwuanyi et al., 2022; Xi & Wang, 2023; Yang & Zhang, 2020)
Usage	-Adults saving, borrowing at financial institutions -Mobile payments and mobile money transactions -Online loans, credit access, and e-wallet usage	(Banna & Alam, 2021; Liu et al., 2021; Nandru et al., 2024; Shen et al., 2022; Suhrab et al., 2024; Ugwuanyi et al., 2022; Xi & Wang,

		2023; Yang & Zhang, 2020)
Availability and Affordability	-Domestic credit provided by private sector -Broad money growth rate -National interest rates -Cost and convenience of DFS	(Shen et al., 2022; Yang & Zhang, 2020)
Quality	-Disclosure index -Dispute resolution index -Distance to frontier in credit access	(Tay et al., 2022)
Digitalization	-Internet, mobile subscriptions rate -Cable density -Digital payment level	(Johri et al., 2024; Kouladoum et al., 2022; Ugwuanyi et al., 2022; Zhu et al., 2023)
Literacy	-Tertiary education rate -Reliance on savings for emergency funds	(Banik & Roy, 2023; Shen et al., 2022)
Gender Disparity	-DFS usage by women	(Duvendack et al., 2023)

4.2 Digital financial inclusion and Operational efficiency

4.2.1 Measurement of OE

OE is fundamentally about maximizing outputs from a set of inputs, considering an optimal quantity (technical efficiency) and proportion (allocation efficiency) (Borza, 2014). While financial ratios such as return on assets (ROA) (Shu & Yang, 2024) and total asset turnover (TAT) (Shen et al., 2025; Wang et al., 2023) are frequently used as proxies (as indicated in Table 5, where TAT is a notable proxy), providing a clean way to quantify OE, they offer only a partial and financially-centric view, risking oversimplifying the nature of efficiency and may not capture how effectively an enterprise transforms diverse resources into desired outcomes, especially when considering long-term strategic goals. To achieve a more comprehensive assessment, frontier analysis methods---primarily the non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Analysis (SFA)---are predominantly employed (Borza, 2014; Ta et al., 2022). These multivariate techniques allow for the simultaneous consideration of multiple inputs and outputs. However, over-reliance on financial proxies such as ROA and TAT runs the risk of simply equating "operational efficiency" with "financial results", thereby obscuring the DFI's ability to improve efficiency through improved service processes, accelerated information loops or optimised digital collaboration The real mechanisms. Future research needs to adopt more metrics that directly capture process innovation (e.g., degree of process automation), service quality (e.g., error rates, response times), or information processing effectiveness (e.g., ability to analyse data).

Our review reveals a clear preference for Data Envelopment Analysis (DEA) over Stochastic Frontier Analysis (SFA). This likely stems from DEA's flexibility in handling various data types without stringent assumptions about underlying functional forms, making it adaptable to diverse contexts (Li et al., 2020).

However, a critical perspective acknowledges that OE is also shaped by external forces (Cheng et al., 2024). While DEA attributes all deviations from the frontier to inefficiency, potentially overlooking

statistical noise, SFA offers the advantage of distinguishing between random error and genuine inefficiency.

An examination of the specific inputs and outputs used in these frontier analyses (Table 5) reveals a common focus on traditional factors of production and financial outcomes, in which labor and capital are critical inputs to drive OE (Jang et al., 2022; Li et al., 2021), and profitability in operations is most frequently revolved as output. Moreover, it's encouraging to see studies beginning to incorporate intangible assets and R&D investment as inputs and granted patents as an output (Wang et al., 2024; Zheng & Luo, 2023), recognizing that competitive advantages in this evolving digital age are increasingly driven by knowledge, innovation, and intellectual capital (Cheng et al., 2022).

Table 5. OE measurement: Proxy, input and output in DEA and SFA application

Proxy	Example	Input	Example	Output	Example
ROA	(Shu & Yang, 2024)	Total assets	(Xie et al., 2024)	Sales revenue	(Wang et al., 2024)
Return on sales	(Bae et al., 2024)	Fixed assets	(Liu et al., 2023)	Operating income	(Zheng & Luo, 2023)
Δ in current gross margin + Δ in asset turnover	(Li et al., 2023)	Intangible assets	(Wang et al., 2024)	Net profit	(Luo et al., 2017)
TAT	(Wang et al., 2023)	Goodwill	(Liu et al., 2023)	Gross profit margin	(Zhou et al., 2022)
Inventory turnover	(Shen et al., 2025)	Liquid assets	(Luo et al., 2017)	Return on equity	(Yang et al., 2023)
Operating expenses to operating revenues	(Santos-Jaén et al., 2023)	Owner's equity	(Yang et al., 2023)	ROA	(Highfield et al., 2021)
		Capital expenditure	(Chen, 2024)	Inventory turnover	(Zhou et al., 2022)
		Operating costs	(Zheng & Luo, 2023)	Patents	(Zheng & Luo, 2023)
		SG&A expenses	(Jang et al., 2022)	Enterprise value	(Chai et al., 2022)
		COGS	(Chen, 2024)	Taxes to total assets	(Xiang et al., 2022)
		Labor cost	(Li et al., 2020)	Assets liquidity	(Li et al., 2021)
		Number of employees	(Jang et al., 2022)	Management capacity	(Li et al., 2020)
		Net inventory	(Li et al., 2021)	Equipment utilization rate	(Xiang et al., 2022)
		R&D investment	(Zheng & Luo, 2023)	Investment income	(Li et al., 2021)

4.2.2 The relationship between DFI and OE

In examining the relationship between DFI and OE, we focus on evidence demonstrating how specific digital financial tools and services impact the operational processes and resource management within firms, particularly SMEs. The relationship between DFI and OE exhibits context-dependent nuances. While studies focusing on financial institutions (e.g., commercial banks) generally report efficiency

gains from digitalization , evidence from Microfinance Institutions (MFIs) is mixed, sometimes indicating a trade-off between outreach and efficiency. For non-financial enterprises, particularly in emerging economies like China and India, the literature leans towards a positive association, suggesting DFI can alleviate critical financing constraints that hinder operational optimization. This variance underscores the importance of organizational type and mission in shaping DFI's efficiency outcomes.

Shifting the lens to for-profit enterprises, particularly SMEs, the research is less extensive but points towards a generally positive relationship between DFI and OE. Of the studies reviewed (Table 6), those focusing on enterprises (4 out of 11, with 1 specifically on SMEs) consistently report that DFI initiatives, such as broader digitalization or improved access to financial services through digital technologies, are key antecedents to enhanced OE (Liu et al., 2023). (Lin & Xie, 2023) further argue that low OE in enterprises often stems from inadequate technology management and failure to realize scale effects, suggesting a considerable scope for improvement in innovation, capital utilization and financing. Due to the imbalance between investment demand and capital supply, SMEs face more severe financing constraints, making access to finance a critical factor for their survival and growth (Cheng et al., 2022). (Bhattacharyya et al., 2023) agree on the lack of financial access is detrimental to SMEs' OE, especially in emerging economies with weaker financial systems and infrastructure.

The overall effect of DFI on OE appears positive, though negative and mixed results suggest the need for further investigation. Without a thorough analysis of the unique challenges faced by SMEs in countries with diverse backgrounds, it's premature to draw a conclusion.

In addition to easing financing constraints, DFI's contribution to OE is more evident at the operational level: digital payments simplify the settlement process between enterprises and upstream and downstream, reducing transaction friction; platform-based credit data can be used to optimise inventory management and production planning, reducing resource idleness; and the improved visibility of cash flow brought about by digital financial tools enhances the accuracy of short-term operational decisions. These process and information level optimisations are the deep-seated drivers of OE improvement.

Table 6. Overview of literature on DFI and OE

Sample	Methodology	Framework
(Mavlutova et al., 2022) Financial institutions (EU, Baltic)	Mixed	IV-DFI (+) DV-OE
(Fersi et al., 2023) MFIs (69 developing countries)	Quantitative	IV-DFI (-) DV-OE, Social efficiency OE (-) Social efficiency
(Spilbergs, 2023) Financial institutions (EU)	Mixed	IV-DFI (+) OE
(Mia et al., 2019) MFIs (Bangladesh)	Quantitative	IV-DFI. (+) DV-OE FI outreach (-) OE
(Anton & Nucu, 2024) Banks (81 countries)	Quantitative	IV-DFI (+) DV-Bank stability, OE Traditional FI (+) Bank stability after a threshold
(Jaiswal et al., 2024) Insurance database (Brazil)	Quantitative	IV-DFI (+) DV-OE

(Binaluyo et al., 2024) MFIs (Philippines)	Quantitative	IV-DFI (+) DV-OE
(Wang et al., 2024) Listed enterprises (China)	Quantitative	IV-DFI (+) DV-OE
(Lin & Xie, 2023) Power enterprises (China)	Quantitative	IV-DFI (+) DV-OE
(Bhattacharyya et al., 2023) SMEs (India)	Quantitative	IV-DFI (+) DV-OE
(Shen et al., 2025) Listed enterprises (China)	Quantitative	IV-DFI (+) DV-OE

4.3 Digital Financial Inclusion and Sustainable growth

4.3.1 Measurement of SG

The operationalization of SG in research exhibits complex and context-dependent characteristics, with inherent tensions and trade-offs between financial objectives and broader socio-environmental responsibilities, as exemplified in Table 2. Consequently, the precise definition and appropriate quantification of SG are critical for meaningful research outcomes.

A prevalent approach to measuring SG involves the use of financial indicators, such as ROA and Tobin-Q, primarily to assess the financial sustainability dimension of enterprise growth (Liu et al., 2023; Cheng et al., 2022). This methodological choice is often underpinned by the view that financial health is a fundamental prerequisite for any long-term success (Zopounidis & Lemonakis, 2024), but it conflicts with some studies that use similar indicators to measure OE, highlighting a lack of clear demarcation in between OE, financial performance, and SG. Higgins's and Van Horne's models further provided a structured framework for quantifying the rate of SG through the lens of resource utilization efficiency and reinvestment potential (Fonseka et al., 2012; Yang & Zhang, 2020), with Higgins' model providing a more dynamic perspective that directly links profitability and reinvestment to sustained growth (Fonseka et al., 2012).

Aiming to address the limitations of financial metrics, another stream of research focuses on composite measures that integrate qualitative dimensions, such as organizational integrity and service quality (Santos-Jaén et al., 2023; Thathsarani & Jianguo, 2022) for a richer representation of SG. However, these approaches often struggle to quantify qualitative factors properly and ensure comparability across studies.

4.3.2 The relationship between DFI and SG

Across all 13 selected articles, there's a general consensus that DFI positively contributes to SMEs' SG by addressing the main structural challenge they face---access to finance (Bhattacharyya et al., 2023; Johri et al., 2024; Sun et al., 2025) and that the critical role of digitalization is widely recognized regardless of gender (Belas et al., 2025). However, some findings suggest that the effectiveness of DFI in promoting SG is not uniform and appears highly context-dependent due to underlying challenges and limitations, such as the difficulty of fully leveraging digital finance for SMEs operating in regions with weak financial infrastructure and regulatory support (Aryani et al., 2020; Xie et al., 2024). Furthermore, the conceptualization of both DFI and SG varies considerably across studies (Table 7), leading to inconsistencies in measurement and interpretation that hinder the development of a unified framework.

The current body of research reveals two significant gaps. The first is geographical concentration. A notable portion of studies focuses on specific countries such as China and Indonesia, while many

other emerging economies are also accelerating the process of digitalization and FI agendas with unique socio-economic and institutional contexts. Expanding research into diverse settings is crucial for a more comprehensive understanding of how DFI impacts SMEs under varied conditions. The second gap relates to the exploration of mediating mechanisms. The literature widely recognizes DFI's role in alleviating financing constraints as a key pathway to SG (Lee et al., 2023; Yang & Zhang, 2020), alongside some studies consider mediating factors such as innovation (Kouladoum et al., 2022), technology adoption (Yang et al., 2022), or reduced information asymmetry (Ozili et al., 2020). A fuller exploration of the mechanism that translates DFI to SG for SMEs is yet to be explored. Identifying these intermediate pathways is essential for designing effective initiatives to maximize DFI's contribution to sustainable enterprise development.

Table 7. Overview of mediators in DFI-SG literature

Sample	Methodology	Mediator(s)
(Yang & Zhang, 2020) MSMEs (China)	Quantitative	Financing constraints.
(Kurnia Rahayu et al., 2023) Informal MSMEs (Indonesia)	Qualitative	\
(Aryani et al., 2020) SMEs (Indonesia)	Mixed	\
(Yang et al., 2022) SMEs (China)	Quantitative	Innovation.
(Kame Babilla, 2023) SMEs (West Africa)	Quantitative	\
(Xie et al., 2024) SMEs (China)	Quantitative	Financing constraints, Online market, Information.
(Li et al., 2024) SMEs (China)	Quantitative	Financing scale, Financing costs.
(Lee et al., 2023) Listed enterprises (China)	Quantitative	Financial leverage, Financing constraints.
(Thathsarani & Jianguo, 2022) SMEs (Sri Lanka)	Mixed	Technology acceptance.
(Yu et al., 2023) SMEs (China)	Quantitative	Innovation, Risk-taking ability, Financing cost.
(Zhou et al., 2025) SMEs (Hungary)	Quantitative	\
(Elmi et al., 2025) SMEs (Somalia)	Quantitative	Financial literacy

(Belas et al., 2025) SMEs (V4 countries)	Quantitative	\

4.4 The mediating role of Operational efficiency

4.4.1 The relationship between OE and SG

The core of our synthesis revolves around understanding OE as an enterprise-level mediator. Therefore, we scrutinize studies that explicitly model or discuss how efficiency gains within the firm serve as the critical link between accessing DFI and achieving SG.

The importance of OE for an enterprise' long-term financial performance has been aware, as (Li et al., 2021) addressed, higher OE enables more effective and flexible economic activities, but SG is an integrated examination that includes and extends beyond financial performance (Liu et al., 2023; Kabaciński et al., 2020). Accordingly, a review by (Zopounidis & Lemonakis, 2024) concludes that enterprises are better positioned for long-term growth by prioritizing both OE and broader sustainability in addition to maintaining financial viability. This aligns with findings by (Cheng et al., 2024), who noted that enhanced OE can translate into improved current and future profitability, reduced costs, and increased overall value of the enterprise---all vital components for SG. At this point, a largely supportive view of OE's positive contribution to SG has been established.

However, the relationship between OE and SG is not without its complexities or contradictions. A critical counterpoint is presented by (Liu et al., 2023), who found a negative correlation where expenditures on digital technologies, presumably aimed at boosting OE, adversely affected SG in manufacturing enterprises. This contradiction provides a crucial perspective as it suggests that the heavy investments required for digitalization might strain resources in a way that temporarily or structurally impedes SG, especially for SMEs. Efficiency gains must be strategically managed to translate into sustainable outcomes, which depend on the enterprise's capacity to effectively utilize new resources. Another finding by (Luo et al., 2017) showed that while green loans improved OE and short-term profitability, this didn't lead to long-term SG for energy-saving enterprises, indicating that the type of efficiency gain and the specific dimension of SG measured are crucial.

Beyond its direct impact, the reviewed literature (Table 8) often positions OE as a critical mediating mechanism. In the 8 empirical studies summarized, OE is not the primary independent variable but rather a channel through which other factors---such as digital innovation (Liu et al., 2023), knowledge management (Al Yami & Ajmal, 2019) and corporate social responsibility (Wejesiri et al., 2025), which highlights OE's critical role as a mediator in the transmission of various strategic inputs and firm capabilities to sustainable performance.

Table 8. Overview of literature on OE and SG

Sample	Methodology type	Framework
(Cheng et al., 2022) SMEs (China)	Quantitative	IV-Organizational capital (+) OE (+) DV-SG
(Liu et al., 2023) Manufacturing enterprises (China)	Quantitative	IV-Digital innovation (-) OE (+) DV-SG
(Al Yami & Ajmal, 2019) Public-sector enterprises (UAE)	Quantitative	IV-Knowledge management (+) OE (+) DV-SG.
(Liu et al., 2024) SMEs (18 Asia countries)	Quantitative	IV-Resource efficiency (+) OE (+) DV-SG
(Cheng et al., 2024) Listed enterprises (China)	Quantitative	IV-Career incentives (via disruptive technologies) (+) OE (+) DV-SG
(Handoyo et al., 2023) Manufacturing enterprises (Indonesia)	Quantitative	IV-Business strategy, OE, ownership structure (+) DV-SG

Sample	Methodology type	Framework
(Luo et al., 2017) Energy-saving enterprises (China)	Quantitative	IV-Green loans (+) OE (+) DV-SG
(Wejesiri et al., 2025) MFIs (18 Latin American countries)	Quantitative	IV-CSR (+) OE (+) DV-SG

4.4.2 OE linking DFI and SG

Literature explicitly positioning OE as the mediator in between DFI and SG is scarce yet illuminating. The 3 selected articles collectively emphasize the importance of OE in serving enterprises' SG positively and the potential of DFI as a critical driver of SG. These studies were very newly published within the recent 3 years (as shown in Table 9), indicating the direction and potential for future research.

Critically, the effectiveness of OE in this mediating capacity appears contingent on the nature and maturity of DFI implementation. As suggested by (Santos-Jaén et al., 2023), incomplete digitalization can undermine the positive impact of OE on SG, implying that the depth of integration and the enterprises' ability to leverage digital tools for operational improvements are paramount for OE to channel DFI's benefits towards SG. These studies signal an important and evolving research direction. Understanding OE not just as an outcome but as a dynamic intermediary mechanism is vital.

Table 9. Overview of literature on DFI, OE, and SG

Sample	Year	Methodology	Framework
(Mick et al., 2024) SMEs (Brazil)	2024	Qualitative	DFI (+) OE (+) SG
Wang et al., 2024) Sports enterprises (China)	2024	Quantitative	DFI (+) Technological innovation, OE; (-) Financial constraints (+) SG
(Santos-Jaén et al., 2023) SMEs (Mexico)	2023	Mixed	DFI (+) OE (+) SG, but incomplete DFI (x) SG

4.5 Uncover issues

Based on the above systematic analysis, we identified five major categories of issues that affect the progress of DFI-OE-SG research (Figure 3). In order to optimise the allocation of future research resources and to promote cross-cutting knowledge contributions from the fields of service science, informatics and operations management in particular, we propose a three-tiered prioritisation framework for research:

Priority 1 (foundational challenge): address the fundamental limitations of causal inference and methodology. This is a prerequisite for establishing a reliable knowledge base, without which all correlational findings are difficult to translate into actionable theory.

Priority 2 (Core Mechanism Exploration): Deepen the understanding of the 'process black box' of OE as a mediating mechanism. This is the theoretical core that connects external digital financial resources (DFIs) to sustainable growth outcomes (SGs), and is where service science and operations management research can contribute the most unique value.

Priority 3 (Boundary Expansion and Contextualisation): After consolidating the above foundations, systematically expand the institutional, geographical and sectoral contexts of research to validate theoretical generalisations and boundary conditions, and to focus on neglected groups (e.g. gender differences) and dimensions (e.g. resilience, circular economy).

In this order of prioritisation, the following section discusses each theme and identifies specific high-impact research directions. Finally, the focus shifts from scrutinizing existing knowledge to identifying issues and proposing future agendas. We identified recurring limitations in existing research

on DFI, OE, and SG, and organized them into 5 categories, shown in Fig.3, that represent key areas for future investigation, which we will explore through 4 thematic discussions.

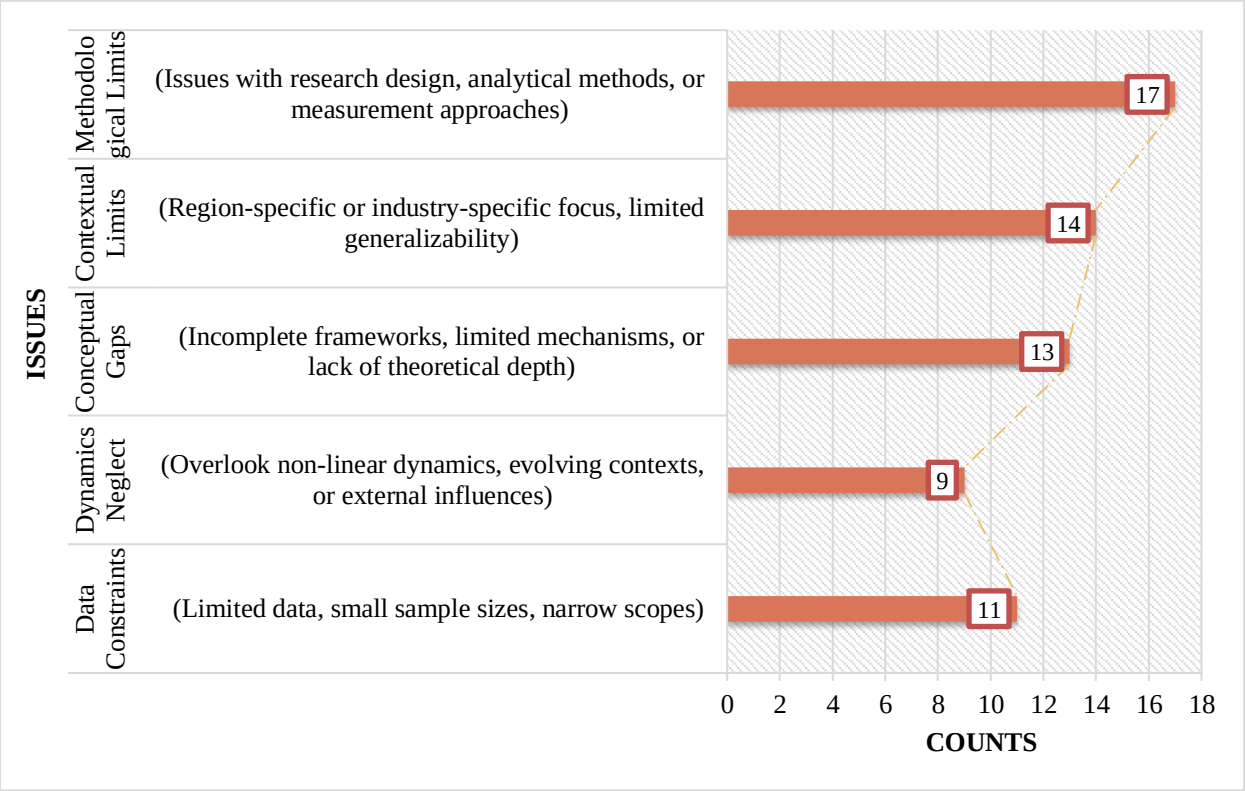

Fig.3: Key issues uncovered

4.5.1 Theme 1: clarifying conceptual ambiguity and measurement deficiencies

A primary challenge identified in the conceptualization and measurement of DFI and SG speaks directly to conceptual gaps and subsequently impacts methodological limits through inconsistent or insufficient measurement.

The inconsistency in the conceptualization of DFI and SG across studies needs to be addressed through developing a comprehensive DFI index that incorporates multiple dimensions of context-specific factors (Anton & Nucu, 2024; Lin & Xie, 2023) and breaks down to city-level or enterprise-level (Li et al., 2024; Yang et al., 2022) to better capture the nuances of digital finance development. Similarly, future work should focus on adopting and validating a multifaceted SG framework that integrates economic, social, and environmental sustainability aspects (Lee et al., 2023; Wang et al., 2024; Yu et al., 2023; Handoyo et al., 2023).

4.5.2 Theme 2: addressing methodological limitations and data constraints

We highlight that several studies are affected by methodological limits, an issue often compounded by underlying data constraints and an insufficient consideration of dynamics neglect in capturing evolving relationships and external influences. Several studies identified their limits in methodology, including issues with research design, analytical methods, and measurement approaches (Binaluyo et al., 2024; Fersi et al., 2023; Kurnia Rahayu et al., 2023; Mia et al., 2019).

To address these frequently identified issues, future research should prioritize more robust designs, for instance, by incorporating larger samples to adequately capture the dynamic relationship between DFI, OE, and SG over time, combining primary and secondary data sources to improve data accuracy, and exploring more advanced analytical techniques to examine the influence of external factors and interdependencies, such as the impact of Covid-19 and carbon taxation policies (Liu et al., 2024; Yang & Zhang, 2020).

4.5.3 Theme 3: overcoming contextual limitations

The reason why it is difficult to generalise the findings of the current study is that institutions and infrastructures constitute the 'foundation' for the DFI effect. Future contextualised research should not be satisfied with adding new geographical cases, but should consciously build a comparative analysis framework based on the following dimensions:

Regulatory models: from highly involved to laissez-faire.

Digital ecological structure: from platform centricity to decentralisation.

Infrastructure penetration: from full coverage to severe shortage.

By analysing these dimensions in combination, a more systematic explanation can be provided as to why the same DFI tool (e.g. digital credit) significantly improves SMEs' inventory turnover (OE) in region A, whereas it mainly exhibits a singular function of relieving financing constraints in region B. A significant portion of the reviewed literature demonstrates clear contextual limits, whereby the generalizability of current findings to diverse economic, social, and regulatory settings is constrained, (Kame Babilla, 2023; Liu et al., 2023; Xie et al., 2024; Yu et al., 2023; Kurnia Rahayu et al., 2023), which also confines the validity and applicability of conclusion. Future research is therefore encouraged to expand the geographical and sectoral scope to include, for example, unlisted SMEs in diverse economic and regulatory environments. It's also vital to investigate region-specific challenges related to factors such as digital literacy (Spilbergs, 2023), financial infrastructure (Xie et al., 2024), and policy frameworks (Mavlutova et al., 2022). Moreover, comparing the effects of DFI on SMEs across different sectors (Mia et al., 2019), ownership structures, and life cycle stages (Wang et al., 2024) will be essential to provide more targeted and contextually relevant solutions.

4.5.4 Theme 4: unpacking OE's mediating role

While OE is recognized as a critical factor in relation to both DFI and SG, its precise role and the intricacies of its influence often suffer from conceptual gaps, particularly concerning the detailed mechanism through which OE operates. Indeed, incomplete consideration of mechanisms is a major issue identified in the literature (Cheng et al., 2024; Lee et al., 2023; Liu et al., 2024; Santos-Jaén et al., 2023; Yang & Zhang, 2020). Furthermore, there's an element of dynamics neglect, as non-linear relationships and evolving contextual factors affecting OE remain underexplored (Kame Babilla, 2023; Thathsarani & Jianguo, 2022).

It's necessary to call for future research to examine the mediating role of OE using in-depth and dynamic methods, and incorporating emerging technologies into the analysis (Jaiswal et al., 2024). Finally, developing and validating tailored input-output systems for OE measurement that reflect industry-specific and enterprise-specific characteristics, particularly taking intangible resources and digital capabilities into consideration (Liu et al., 2023; Wang et al., 2023). A clear understanding of OE's mediating role in the evolving digital landscape will advance the theoretical and practical insights into the pathways through which DFI drives enterprises' SG.

4.5.6 Theme 5: Overcoming Methodological Limitations for Causal Inference

The limitations in causal inference inherent in the research designs underlying the empirical evidence synthesized in this review constitute one of the fundamental obstacles constraining a deeper understanding of the DFI-OE-SG pathway. This transcends measurement or conceptual issues of individual studies and represents a field-level methodological challenge.

Core Limitation: As noted in the Methodology section, the research landscape dominated by cross-sectional data means that current conclusions about DFI promoting OE and OE driving SG remain largely at the level of correlation, making it difficult to establish robust causation.

Potential Threat to Existing Findings: This limitation implies that the observed positive correlations may be overestimated (due to omitted variable bias) or the causal direction misunderstood.

Challenge to Framework Validation: The formalized framework proposed in this paper (Propositions PA1, PA2, PB1, etc.) is essentially a set of causal hypotheses. However, most of the evidence provided by the existing literature is cross-sectional correlational, insufficient for rigorous causal testing of these propositions.

Future Direction: To overcome this limitation, future research must actively adopt research designs with stronger causal inference validity:

1. Longitudinal Panel Data Models: Track changes within the same firms over time, using fixed-effects models to control for time-invariant unobserved heterogeneity, and test for lagged effects between variables.

2. Quasi-Experimental Designs: Identify "natural experiment" contexts, such as the phased rollout of digital financial infrastructure across regions or sudden changes in fintech regulatory policies, to more cleanly identify the causal effect of DFI using methods like difference-in-differences.

3. Mixed-Methods Research: Combine in-depth case studies or process tracing with quantitative analysis. Case studies can deeply reveal the "how" and "why" of mechanisms, providing contextualized explanations and evidence of causal processes for statistical relationships.

Only through methodological innovation can the field advance from 'discovering associations' to 'verifying causation,' thereby providing a more reliable knowledge base for policy and practice.

4.6 Analysis of the impact of methodological choices on research findings

The studies covered in this review are methodologically diverse, mainly including data envelopment analysis (DEA), stochastic frontier analysis (SFA), regression models (e.g., panel regression, structural equation modelling), and qualitative case studies. The choice of these methods not only reflects the different facets of the research problem, but also directly affects the identification and interpretation of mediating mechanisms, dynamic relationships, and nonlinear effects.

(1) Differences in Capturing OE Mediation Mechanisms by Different Methods

Frontier analysis methods such as DEA/SFA: They are good at comprehensively assessing OE from the input-output perspective, but they usually treat it as an overall efficiency score, and it is difficult to decompose the specific operational links (e.g., payment process, inventory management, and information integration) through which the DFI affects the OE, thus blurring the micro-details of the mediating paths.

Structural equation modelling (SEM) or path analysis: It can directly test the path coefficients of 'DFI → OE → SG', which is more suitable for verifying the mediation hypothesis, but the measurement of OE often relies on a single proxy variable (e.g., ROA, TAT), which may simplify the multidimensional connotation of OE.

Qualitative case study: It can deeply reveal the process mechanism of 'how' and 'why', and is especially suitable for exploring the mediation path that has not yet been quantified (e.g., how digital finance reshapes the internal decision-making process of enterprises), but the generalisability of the conclusions is limited.

(2) The impact of methodological choices on identifying dynamics and non-linearities

Most studies use cross-sectional or short-panel data, which makes it difficult to capture the time-lag effect and bidirectional causality between DFI, OE and SG. Only a few studies using dynamic panel or cross-lag models have begun to touch on this issue, but it is not yet common.

Existing studies mostly assume linear relationships, while the application of moderated effects models or threshold regressions is still relatively rare. For example, the facilitating effect of DFI on OE may be significantly stronger only after the digital infrastructure reaches a certain threshold, and this type of non-linear relationship needs to be tested by more exploratory methods.

(3) Suggestions for future methodological choices

To reveal the mediating role of OE and its boundary conditions more precisely, future studies may consider:

1) Mixed-methods design: combining large-sample panel data (to test 'if' mediation) with multi-case in-depth interviews (to reveal 'how' mediation occurs).

2) Longitudinal studies and experimental designs: tracking the time-series of digital finance adoption and operational change in firms, or using policy shocks as natural experiments to enhance causal inference.

3) Multidimensional OE measurement: Go beyond financial ratios to include operational metrics such as process efficiency, data integration, supply chain collaboration, etc.

5. Conclusion

5.1 Core Findings and Theoretical Contributions

Through a systematic review of 89 articles, this study aimed to answer: How does Digital Financial Inclusion (DFI) promote Sustainable Growth (SG) for enterprises, especially SMEs, through Operational Efficiency (OE). The main conclusions are as follows:

1) For SMEs, DFI primarily enhances OE by alleviating financing constraints, reducing transaction costs, and improving information transparency, thereby providing SMEs with critical digital and financial resources.

2) OE plays a central mediating role between DFI and SG. It transforms the resources accessed through DFI into sustainable growth momentum through mechanisms such as optimizing resource allocation, enhancing process agility, and facilitating data-driven decision-making.

3) The strength of this mediating pathway is moderated by factors including firms' absorptive capacity, digital infrastructure, and the institutional environment. It is significant yet uneven, particularly in developing economies.

These findings confirm the key transformative role of organisational effectiveness (OE) in the digital finance (DFI)-sustainable growth (SG) pathway and provide an empirical basis for the proposed integrated theoretical framework.

This systematic review of 89 articles has examined the evolving progress of DFI and its pathways to SG, with a particular emphasis on the mediating role of OE for SMEs. DFI is increasingly recognized for its potential to overcome traditional financial access barriers, particularly for SMEs. However, a key insight from this review is that the mediating role of OE in the DFI-SG nexus remains significantly underexplored. Furthermore, substantial variations persist in how DFI, OE, and SG are conceptualized and measured across studies (with key thematic clusters visualized in Fig.4).

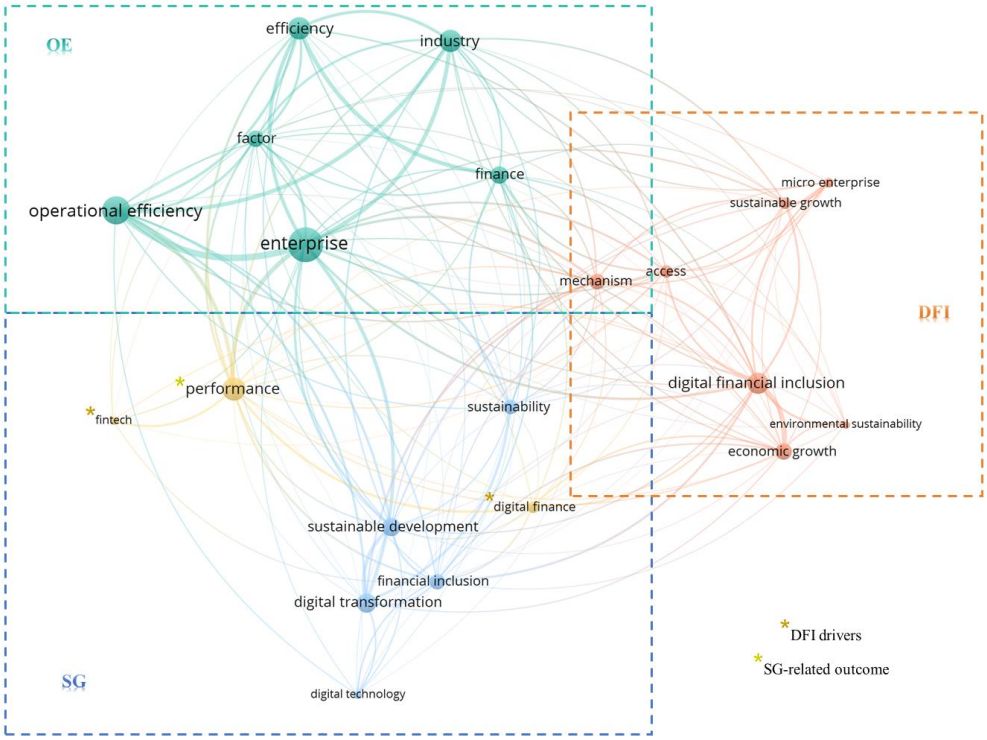

Fig.4: Co-occurrence map of keywords in selected literature

The keyword co-occurrence network in Figure 4 visually confirms the core findings of this review and further reveals the structure and fault lines of research themes.

Core-Periphery Structure Confirms Research Focus: Nodes like 'Digital Financial Inclusion', 'Financial Inclusion', and 'SMEs' are centrally located and densely interconnected, confirming that the DFI-SME nexus focused on in this study is at the heart of current academic discourse. The strong link between 'Sustainable Development' and the core cluster indicates sustainability has been widely incorporated into the discussion framework.

'Weak Ties' of Key Mediator Expose Theoretical Gap: Notably, 'Operational Efficiency' appears, but its connection strength and centrality relative to other core nodes are comparatively weaker. From a bibliometric perspective, this visualizes the core problem identified in this review: OE, as a key mediator, is insufficiently embedded within the existing theoretical discourse network, occupying a relatively peripheral or isolated position, supporting the argument that its role has not been fully explored and theorized.

Neglected Connection Points Hint at Future Directions: Keywords such as 'Gender', 'Resilience', and 'Circular Economy' may appear as smaller nodes on the periphery. Their weaker connection to the core cluster suggests current research may be overlooking the specific pathways through which DFI promotes social inclusion, enhances corporate climate resilience, or drives the green transition. These represent cross-cutting frontier areas where future research can fruitfully expand."

These inconsistencies in operationalizing OE beyond unilateral proxies and SG beyond profitability, complicate comparative analysis and the development of a unified understanding. Despite increasing scholarly attention in the post-pandemic (as shown in Fig.5), the existing research often exhibits fragmented empirical approaches, notable regional disparities in focus, and methodological gaps that highlight the need for more integrated research frameworks.

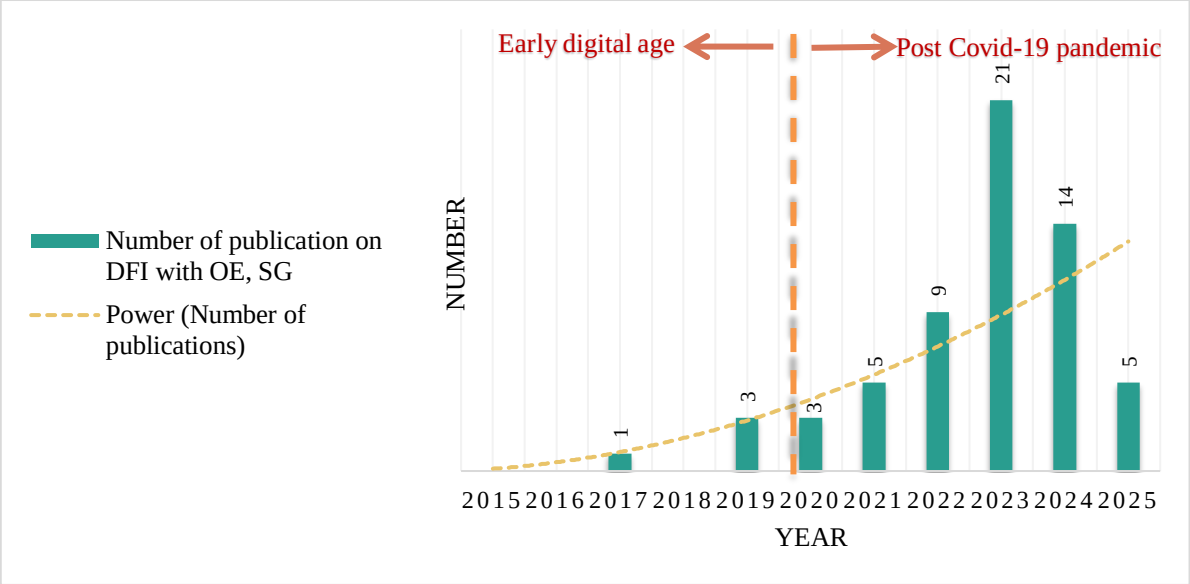

Fig.5: Publication output: DFI with OE, SG focus

The publication trend in Figure 5 not only records the growth of research interest but also reflects the external drivers and internal maturity of the field's evolution.

The Pandemic as a Critical Inflection Point: The marked surge in publication numbers post-2020 visually corroborates how the COVID-19 pandemic acted as an 'accelerator', rapidly pushing DFI from a development agenda to the forefront of policy and academic attention, highlighting its practical value in maintaining economic resilience during crises.

Evolution from Concept Introduction to Mechanism Exploration: Early research (2015-2019) likely focused more on conceptualizing DFI, its macro impacts, or technology adoption itself. The growth in recent years (2020-2025) coincides with the emergence of more literature exploring impact mechanisms and mediating variables (e.g., innovation, financing constraints). However, combined with the analysis of Figure 4, the absolute number of publications specifically focusing on OE as a mediator remains limited, indicating this is still an emerging and unsaturated area for research growth.

Implications for the Future: This growth trend suggests the field is still in an active phase of theoretical deepening and empirical expansion. Future research should not be content with merely replicating validation of DFI's positive correlations. Instead, it should leverage this academic momentum to address more challenging questions of 'how' and 'under what conditions,' which is precisely the direction advocated in this paper.

The main theoretical contribution of this review lies in moving beyond the fragmented discussions in prior literature on the direct DFI-SG link or multiple mediators, to systematically propose and preliminarily argue for an integrated theoretical framework centered on "operational efficiency as the core transformation mechanism through which DFI drives SG." Based on the integrated perspective of RBV and DCT, we have clarified the causal logic chain of "resources (DFI) → capability transformation (OE) → sustained outcomes (SG)."

Accordingly, we propose the following core theoretical propositions, directly testable by future empirical research:

1) Proposition 1 (Mediation Effect Proposition): Operational efficiency plays a significant positive mediating role between digital financial inclusion and enterprise sustainable growth. The positive impact of DFI on SG is largely realized through the enhancement of OE.

2) Proposition 2 (Centrality Proposition): After controlling for other potential mediating variables (e.g., innovation performance, market scope), the mediating effect of OE remains significant and robust, indicating its unique and core explanatory power.

3) Proposition 3 (Boundary Condition Proposition): The strength of OE's mediating effect is moderated by contextual factors. For example, this mediating pathway is more pronounced in firms with strong absorptive capacity, in regions with well-developed digital infrastructure, or in firms in their growth stage.

Future empirical work should strive to rigorously test these propositions using longitudinal data, comparative case studies, or experimental methods, and further refine the boundary conditions.

This review contributes by moving beyond analyses of DFI's direct impacts to emphasize the efficiency dimension, positioning OE as a key explanatory mechanism in the DFI-SG pathway. Unlike much prior research that has viewed FI from macro or supply-side perspectives, this study synthesizes evidence regarding enterprise-level efficiency, offering an integrated understanding of how DFI can foster long-term SG for these vital economic participants. The implications are significant for both academia and practice. For academics, this review emphasizes the need to refine conceptual and measurement approaches for DFI, OE, and SG, and to empirically test the mediating role of OE more rigorously across diverse contexts. For policymakers and practitioners, the findings suggest that initiatives aimed at promoting SG through DFI should not solely focus on expanding access to DFS but pay attention to enhance the OE of SMEs. This involves fostering an enabling environment that supports digital and financial literacy, encourages investment in technology and process innovation, and ensures regulatory frameworks are conducive to efficient operations.

However, this review is constrained by its reliance on English-language publications and may have overlooked insights from grey literature. Future research should prioritize expanding empirical investigations particularly in underrepresented developing regions and across different SME sectors, developing more robust, context-specific DFI impact assessments, and exploring potential non-linear effects or threshold dynamics in the into the DFI-OE-SG linkage. Addressing these areas will enhance understanding of how digital finance can be most effectively leveraged to facilitate sustainable development.

In summary, research in this field should follow the priority path of first consolidating the causal and methodological foundations, then deeply analysing the core mechanisms, and finally systematically expanding the contextual boundaries. Among them, using the theoretical lenses and methodological tools of service science and informatics to deeply analyse how digital finance reshapes the operation process and information capability of enterprises is the most crucial academic task to unlock the sustainable growth effect of DFI.

5.2 A Formalized Integrated Framework: Propositions and Pathways

(1) Core Construct Definitions

Input: Digital Financial Inclusion (DFI): A multi-dimensional construct encompassing the accessibility of digital channels, the usage of financial products, and the supportive level of digitalization (see Table 4).

Mediating Process: Operational Efficiency (OE): The internal transformation efficacy through which a firm converts various resources (e.g., capital, data, technology) into economic outputs. This can be measured via comprehensive frontier analysis methods (e.g., DEA, SFA) or specific combinations of financial ratios (see Table 5).

Outcome: Sustainable Growth (SG): A multi-dimensional outcome encompassing at least two layers: financial sustainability (e.g., sustained profitability, robust growth models) and integrated sustainability (balanced economic, social, and environmental performance) (see Table 2).

(2) Structured Relational Propositions

This framework specifies the following three types of relationships:

Proposition A (Direct Effect Propositions):

PA1: DFI has a direct positive effect on SG. Access to digital financial resources and services can directly alleviate firm financing constraints, providing initial impetus for growth.

PA2: DFI has a direct positive effect on OE. Digital financial tools directly optimize payment, settlement, and financing processes, enhancing the timeliness and accuracy of resource allocation.

Proposition B (Mediation Effect Propositions - Core Pathway):

PB1 (Full/Partial Mediation): OE plays a significant mediating role between DFI and SG. The positive impact of DFI on SG is largely or partially realized through the enhancement of OE. This is the core pathway of the framework (DFI → OE → SG).

PB2 (Transformation Mechanism): DFI primarily enhances OE through the following sub-processes: (i) reducing transaction and financing costs; (ii) improving cash flow management; (iii) facilitating data-driven operational decisions; (iv) enabling supply chain collaboration.

Proposition C (Boundary Condition Propositions – Moderating Effects):

PC1 (Internal Context): A firm's absorptive capacity (e.g., digital skills, learning culture) positively moderates the effect of DFI on OE (i.e., DFI * Absorptive Capacity → OE). The stronger the absorptive capacity, the more pronounced the effect of DFI on OE enhancement.

PC2 (External Context): The external institutional environment (e.g., quality of digital infrastructure, data security regulations, fintech governance) moderates the strength and feasibility of the entire "DFI → OE → SG" pathway.

PC3 (Structural Context): Characteristics of firm size and industry sector may moderate the strength of OE's mediating effect. For instance, the mediating role of OE might be more critical for SMEs or in traditional industries.

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CRediT author contribution statement

Roziana Baharin: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation, Writing–review & editing. **Guangqin Kang:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing–original draft.

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Appendix 1 MMAT Risk of Bias Assessment Summary for Included Studies (n=89)

The methodological quality and risk of bias of the included studies were appraised using MMAT. Two reviewers independently rated each article against the relevant criteria according to its study type, and disagreements were resolved through discussion. Table 10 summarizes the study characteristics and preliminary study-type classification, together with placeholders for recording item-level MMAT judgement and an overall appraisal for each study.

In addition to the study-level MMAT assessments reported, the overall distribution of the methodological quality across study types is summarized in Table 11. After applying the MMAT criteria, most studies were judged to present 95.5% low, 4.5% minor to moderate, and 0% high risk of bias, with variation mainly drive by unclear nonresponse bias and partial reporting or integration issues in a small number of studies.

Table 10 MMAT critical appraisal summary for included studies (n = 89)

No.	Theme	Study	Study type	S1	S2	#1	#2	#3	#4	#5	Overall appraisal
1	DFI	(Shen et al., 2021)	Q3	Yes	Yes			Yes			Low RoB
2	DFI	(Banik & Roy, 2023)	Q4	Yes	Yes				Yes		Low RoB
3	DFI	(Loo, 2019)	Q4	Yes	Yes				Yes		Low RoB
4	DFI	(Kouladoum et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
5	DFI	(Johri et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
6	DFI	(Banna & Alam, 2021)	Q3	Yes	Yes			Yes			Low RoB
7	DFI	(Sefrina, 2024)	Q4	Yes	Yes				Can't tell (1/5)		Minor RoB
8	DFI	(Xi & Wang, 2023)	Q3	Yes	Yes			Yes			Low RoB
9	DFI	(Zhang et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
10	DFI	(Xue et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
11	DFI	(Liu et al., 2021)	Q3	Yes	Yes			Yes			Low RoB
12	DFI	(Sreenu, 2023)	Q3	Yes	Yes			Yes			Low RoB
13	DFI	(Liu et al., 2021)	Q3	Yes	Yes			Yes			Low RoB
14	DFI	(Zhu et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
15	DFI	(Hashemizadeh et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
16	DFI	(Yang & Zhang, 2020)	Q3	Yes	Yes			Yes			Low RoB
17	DFI	(Ozturk & Ullah, 2022)	Q3	Yes	Yes			Yes			Low RoB
18	DFI	(Ahmad et al., 2021)	Q3	Yes	Yes			Yes			Low RoB
19	DFI	(Li et al., 2023)	Q3	Yes	Yes			Yes			Low RoB

20	DFI	(Ugwuanyi et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
21	DFI	(Nandru et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
22	DFI	(Tay et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
23	DFI	(Chinoda & Kapingura, 2024)	Q4	Yes	Yes				Yes		Low RoB
24	DFI	(Suhrab et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
25	DFI	(Duvendack et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
26	DFI	(Zhan et al., 2024)	M (Q1+Q4)	Yes	Yes	Yes		Can't tell (1/5)		Yes	Minor RoB
27	OE	(Shu & Yang, 2024)	Q3	Yes	Yes			Yes			Low RoB
28	OE	(Zheng & Luo, 2023)	Q3	Yes	Yes			Yes			Low RoB
29	OE	(Zhou et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
30	OE	(Qiao & Fei, 2022)	Q4	Yes	Yes				Yes		Low RoB
31	OE	(Xiang et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
32	OE	(Li et al., 2020)	Q4	Yes	Yes				Yes		Low RoB
33	OE	(Ta et al., 2022)	Q4	Yes	Yes				Yes		Low RoB
34	OE	(Zhao et al., 2018)	M (Q1+Q3)	Yes	Yes	Yes		Yes		Yes	Low RoB
35	OE	(Li et al., 2021)	Q4	Yes	Yes				Yes		Low RoB
36	OE	(Akdoğan, 2018)	Q3	Yes	Yes			Yes			Low RoB
37	OE	(Highfield et al., 2021)	Q3	Yes	Yes			Yes			Low RoB
38	OE	(Luo et al., 2020)	Q3	Yes	Yes			Yes			Low RoB
39	OE	(Li et al., 2021)	Q3	Yes	Yes			Yes			Low RoB

40	OE	(Kabaciński et al., 2020)	Q3	Yes	Yes			Yes			Low RoB
41	OE	(Jang et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
42	OE	(Hu et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
43	OE	(Lazarević et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
44	OE	(Xue et al., 2022)	Q4	Yes	Yes				Can't tell (1/5)		Minor RoB
45	OE	(Chai et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
46	OE	(Yang et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
47	OE	(Wang et al., 2023)	Q4	Yes	Yes				Yes		Low RoB
48	OE	(Wang et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
49	OE	(Bae et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
50	OE	(Hua et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
51	OE	(Li & Tong, 2023)	Q3	Yes	Yes			Yes			Low RoB
52	OE	(Dong et al., 2015)	Q3	Yes	Yes			Yes			Low RoB
53	OE	(Xie et al., 2024)	Q4	Yes	Yes				Yes		Low RoB
54	OE	(Mavlutova et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
55	DFI-OE	(Fersi et al., 2023)	M (Q1+Q3)	Yes	Yes	Yes		Yes		Yes	Low RoB
56	DFI-OE	(Spilbergs, 2023)	Q3	Yes	Yes			Yes			Low RoB
57	DFI-OE	(Mia et al., 2019)	M (Q1+Q3)	Yes	Yes	Yes		Yes		Yes	Low RoB

58	DFI-OE	(Anton & Nucu, 2024)	Q3	Yes	Yes			Yes			Low RoB
59	DFI-OE	(Jaiswal et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
60	DFI-OE	(Binaluyo et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
61	DFI-OE	(Wang et al., 2024)	Q4	Yes	Yes				Yes		Low RoB
62	DFI-OE	(Lin & Xie, 2023)	Q3	Yes	Yes			Yes			Low RoB
63	DFI-OE	(Bhattacharyya et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
64	DFI-OE	(Shen et al., 2025)	Q3	Yes	Yes			Yes			Low RoB
65	DFI-OE	(Yang & Zhang, 2020)	Q3	Yes	Yes			Yes			Low RoB
66	DFI-SG	(Kurnia Rahayu et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
67	DFI-SG	(Aryani et al., 2020)	Q1	Yes	Yes	Yes					Low RoB
68	DFI-SG	(Yao & Yang, 2022)	M (Q1+Q4)	Yes	Yes	Yes		Can't tell (1/5)	Can't tell (1/5)	Yes	Moderate RoB
69	DFI-SG	(Kame Babilla, 2023)	Q3	Yes	Yes			Yes			Low RoB

70	DFI-SG	(Xie et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
71	DFI-SG	(Li et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
72	DFI-SG	(Lee et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
73	DFI-SG	(Thathsarani & Jianguo, 2022)	Q3	Yes	Yes			Yes			Low RoB
74	DFI-SG	(Yu et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
75	DFI-SG	(Zhou & Pacala, 2025)	Q3	Yes	Yes			Yes			Low RoB
76	DFI-SG	(Elmi et al., 2025)	Q3	Yes	Yes			Yes			Low RoB
77	DFI-SG	(Belas et al., 2025)	Q3	Yes	Yes			Yes			Low RoB
78	DFI-SG	(Cheng et al., 2022)	Q3	Yes	Yes			Yes			Low RoB
79	OE-SG	(Liu et al., 2023)	Q3	Yes	Yes			Yes			Low RoB
80	OE-SG	(Al Yami & Ajmal, 2019)	Q3	Yes	Yes			Yes			Low RoB
81	OE-SG	(Liu et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
82	OE-SG	(Cheng et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
83	OE-SG	(Handoyo et al., 2023)	Q3	Yes	Yes			Yes			Low RoB

84	OE-SG	(Luo et al., 2017)	Q3	Yes	Yes			Yes			Low RoB
85	OE-SG	(Wejesiri et al., 2025)	Q3	Yes	Yes			Yes			Low RoB
86	OE-SG	(Mick et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
87	DFI-OE-SG	(Wang et al., 2023)	Q1	Yes	Yes	Yes					Low RoB
88	DFI-OE-SG	(Wang et al., 2024)	Q3	Yes	Yes			Yes			Low RoB
89	DFI-OE-SG	(Santos-Jaén et al., 2023)	M(Q1+Q3)	Yes	Yes	Yes		Yes		Yes	Low RoB

Source: Articles in Scopus, WOS, and Google Scholars, reviewed by authors.

Note: #1 = set of five MMAT criteria for qualitative studies (Q1); #2 = set of five MMAT criteria for quantitative randomized studies (Q2); #3 = set of five MMAT criteria for quantitative non-randomized studies (Q3); #4 = set of five MMAT criteria for quantitative descriptive studies (Q4); #5 = set of five MMAT criteria for mixed studies (M). RoB = Risk of Bias.

Table 11 Summary of MMAT ratings by study type

Study type	**Number of studies (n)**	**Low RoB (n)**	**Minor RoB (n)**	**Moderate RoB (n)**	**Comment on recurrent limitations**
Q1	n = [2]	[2]	[0]	[0]	Minor reporting gaps, no major concerns identified.
Q2	n = [0]	[0]	[0]	[0]	No randomized controlled trails were included.
Q3	n = [69]	[69]	[0]	[0]	Occasional residual confounding and limited reporting of robustness checks, but overall acceptable.
Q4	n = [12]	[11]	[1]	[0]	Unclear nonresponse bias identified.
M	n = [6]	[5]	[1]	[1]	Moderate limitations in integration of components and unclear reporting on quantitative exposure timing.
Total	**89**	**[86]**	**[2]**	**[1]**	—

Source: Designed by authors.