

The Impact of Digital Inclusive Finance on Financing Constraints of Small and Medium-sized Enterprises: Examining the Moderating Effect of Regional Financial Ecosystem

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Abstract. Small and medium-sized enterprises (SMEs) play a crucial role in driving economic growth, fostering technological innovation, and expanding employment. However, they have long faced structural financing constraints, including information asymmetry, limited credit history, and exclusion from traditional financial systems. Conventional financial institutions often fail to meet the financing needs of high-growth, asset-light SMEs—particularly those classified as "specialized, refined, differentiated, and innovative" (SRDI)—due to their reliance on hard information and collateral-based risk control. In response, digital inclusive finance, empowered by big data, artificial intelligence, and blockchain technologies, is reshaping credit assessment and risk pricing systems, thereby expanding the accessibility and precision of financial services for SMEs. This paper focuses on the causal logic between digital inclusive finance and SME financing constraints, systematically reviewing the direct and indirect mechanisms through which digital finance alleviates financing barriers, including credit reconstruction, dynamic pricing, and supply chain finance integration. Furthermore, the study incorporates the regional financial ecological environment as a moderating variable, examining how institutional quality, financial infrastructure, and governance capacity influence the effectiveness of digital finance mechanisms. The findings reveal that digital finance exhibits a substitution effect in regions with strong institutional support, and a complementary effect in underdeveloped areas. The interactive effects between firm-level and regional heterogeneity further amplify the differentiated outcomes, with SRDI enterprises benefiting most significantly.

Keywords: Digital inclusive finance, SME financing constraints, financial ecological environment, resource allocation efficiency.

1. Introduction

Small and medium-sized enterprises (SMEs) serve as critical drivers of economic growth, job creation, and industrial innovation. However, their development has long been constrained by structural financing difficulties, particularly for start-ups and technology-intensive "specialized, sophisticated, distinctive, and innovative" (SSDI) firms. The traditional financial system often fails to effectively serve such entities due to issues such as information asymmetry, high costs of credit evaluation, and lack of collateral, resulting in inefficient capital allocation and hampering both enterprise potential and balanced regional development. In recent years, digital technologies—represented by big data, artificial intelligence, and blockchain—have profoundly reshaped financial service paradigms. The rise of digital inclusive finance has introduced a novel financial supply mechanism, with its technological empowerment significantly improving the accessibility and precision of financial services. It also breaks the boundaries of traditional financial systems in key areas such as credit reconstruction, risk pricing, and supply chain finance, offering new financing channels for SMEs, especially those with light assets and high growth potential.

Although a growing body of literature acknowledges the positive role of digital inclusive finance in improving SMEs' access to financing, most studies primarily focus on its direct effects. There remains a lack of systematic identification of the specific mechanisms through which it alleviates financing constraints and the regional conditions under which its effects are most pronounced. Particularly in the context of China's uneven regional development and diverse institutional environments, the effectiveness of digital inclusive finance is influenced by multiple external factors,

including institutional constraints, market depth, and disparities in information infrastructure. The regional financial ecological environment—comprising institutional governance, market structure, and financial infrastructure—has increasingly become a key external variable in explaining the effectiveness of financial services. The interaction between this environment and digital inclusive finance warrants deeper investigation. Existing research has shown that in regions with well-developed institutions and market environments, digital inclusive finance tends to function as a complement or substitute for traditional finance. In contrast, in areas with weak ecological foundations, its functioning relies more heavily on policy support and data governance capabilities, resulting in a nonlinear moderating effect [1, 2].

Meanwhile, different types of enterprises exhibit varying degrees of responsiveness to digital inclusive finance. SSDI SMEs, characterized by technological intensity, high proportions of intangible assets, and uncertain development cycles, differ fundamentally from conventional SMEs in terms of credit formation and financing risk structures. These distinctions make their adaptability to financial tools more sensitive. Moreover, regional-level factors such as government governance capacity and data-sharing mechanisms further influence the risk identification and resource allocation efficiency of digital finance platforms. Consequently, a single-mechanism analysis is insufficient to explain the heterogeneous outcomes of digital inclusive finance across different regions and enterprise structures. In response to these challenges, this study constructs a three-dimensional analytical framework comprising “mechanism pathway – moderating structure – response heterogeneity.” It systematically reviews the mechanisms through which digital inclusive finance affects SMEs’ financing constraints, incorporating the regional financial ecological environment as a moderating variable. By identifying its marginal moderating effects under varying institutional and market conditions, this paper aims to provide theoretical insights and practical guidance for alleviating SME financing difficulties, improving the efficiency of digital finance resource allocation, and enhancing regional financial ecosystems.

2. The Impact of Digital Inclusive Finance on Alleviating SMEs’ Financing Constraints

The extensive application of digital inclusive finance is reshaping the financing ecosystem of SMEs through technology as an intermediary. Its influence is not only reflected in the improvement of financing accessibility and the reduction of transaction costs, but more importantly, in its deep involvement in the entire financing lifecycle through mechanisms such as data-driven modeling, platform-based matchmaking, and intelligent algorithms. These mechanisms together construct a multi-channel, systematized framework of financial support. Against the backdrop of an institutional and traditional financial logic that has difficulty fully covering light-asset SMEs—especially “specialized, sophisticated, distinctive, and innovative” (SSDI) enterprises—digital inclusive finance introduces three key alleviation mechanisms through institutional innovation: the restructuring of credit evaluation systems, the optimization of dynamic risk pricing, and the integration of supply chain financial resources. These pathways significantly enhance the accessibility, precision, and sustainability of SME financing.

2.1. Restructuring of Credit Evaluation Systems

The restructuring of credit evaluation systems provides a feasible path for resolving the financing difficulties of SMEs lacking historical credit records or collateralizable assets. Traditional financial institutions primarily rely on “hard information” such as financial statements, collateral, and operational history for credit evaluation. However, such data is often unavailable or unstandardized in SMEs—particularly those that are light-asset and high-growth SSDI enterprises—leading to missing or distorted credit assessments [3]. In contrast, digital inclusive finance platforms leverage big data to rebuild the credit evaluation framework by incorporating “soft information” such as transaction records, tax filings, social media reviews, logistics performance, intellectual property

filings, and third-party platform ratings into credit scoring systems. This multi-dimensional and dynamic depiction of enterprise credit not only expands the boundaries of traditional credit evaluation but also enables previously excluded SMEs to become visible to financial institutions. Credit scoring models have evolved from static ratings to real-time learning systems, no longer reliant on manual offline assessments. Instead, machine learning algorithms adaptively assess enterprise performance and credit risk, improving both informational interpretability and risk control efficiency. This transformation lays the foundation for addressing information asymmetry and provides the technical assurance for financial institutions to “lend with confidence” and “lend willingly.”

2.2. Optimization of Dynamic Risk Pricing Mechanisms

Dynamic risk pricing mechanisms effectively address the structural problem of risk overestimation and excessive pricing in SME financing. Traditional pricing models often apply uniform interest rates based on industry category, firm size, or historical default rates, ignoring credit differences across individual firms. This results in significant mismatches between the financing costs and risk levels of high-quality enterprises [4]. Digital inclusive finance platforms, by leveraging real-time monitoring data and high-frequency interactions, build algorithmic pricing frameworks based on “behavioral scoring plus model prediction,” forming a closed-loop system with dynamic pre-loan rating, mid-loan rate adjustment, and post-loan risk response [5]. For instance, some platforms integrate indicators such as fulfillment rates of online orders, customer complaint ratios, and logistics timeliness to create individualized risk profiles. These profiles inform differentiated interest rates and credit limits, allowing high-quality enterprises to access lower-cost and more flexible financing. At the same time, “credit return mechanisms” based on data feedback incentivize enterprises to enhance information disclosure and operational compliance, forming a positive feedback loop [6]. The intelligent evolution of risk pricing not only improves the accuracy of financing decisions but also enables the effective reallocation of financial resources from high-risk entities to high-quality firms, contributing to optimized financing structures.

2.3. Integration of Supply Chain Financial Resources

The integration of supply chain financial resources plays a pivotal role in mitigating information discontinuity and credit transmission barriers, particularly for midstream SMEs within industrial chains that lack bargaining power. Under traditional financing models, core enterprises often enjoy low-cost financing due to stable operations and strong credit ratings, while upstream and downstream SMEs are constrained by broken credit transmission paths [7]. Digital inclusive finance platforms have introduced “credit penetration along the supply chain,” breaking down data silos between core enterprises, suppliers, and distributors, thereby allowing SME business data to be incorporated into financial institutions’ risk control models and enabling credit sharing and transmission across the supply chain. Based on data flows, invoice flows, and capital flows along the industrial chain, platforms build dynamic credit-granting frameworks rooted in transactional authenticity. This enhances the transparency of risk control and improves the efficiency and flexibility of fund allocation. Moreover, with the aid of blockchain and IoT technologies, some advanced platforms can monitor production nodes, inventory turnover, and contract fulfillment in real time, generating verifiable and traceable credit archives. These developments help transform “accounts receivable” and “order fulfillment” into viable financial assets, facilitating the implementation of structured financial products such as “order loans” and “receivables pools.” By embedding credit within the industrial chain, this model significantly alleviates the constraints of geographic dispersion and information fragmentation, offering a replicable pathway for building a sustainable financial ecosystem for SMEs.

3. The Moderating Mechanisms of Regional Financial Ecological Environments

Although the aforementioned three mechanisms have demonstrated notable advantages in alleviating financing constraints, their actual effectiveness is simultaneously constrained by both regional conditions and firm-level characteristics. At the regional level, in areas where financial infrastructure is well-developed, data interfaces are open, and governmental regulation is sound, platform-based mechanisms tend to operate more smoothly and exhibit stronger effects. Conversely, in regions with weak financial supply, opaque institutional frameworks, and serious data silos, the applicability of credit evaluation and risk control models declines significantly, and platform-based mechanisms may fail to operate effectively. At the enterprise level, SMEs characterized by a high degree of digitalization and standardized business practices—particularly SSDI firms—are more easily identified by platform algorithms and can thus benefit from positive feedback loops. In contrast, early-stage or traditional manufacturing firms, due to limited data accumulation or irregular behaviors, may encounter "technological exclusion". A firm's digital governance capability has become a key variable in determining whether it can successfully integrate into digital financial ecosystems [8].

As a fusion of information technology and financial services, digital inclusive finance does not operate in isolation when alleviating SMEs' financing constraints. Rather, it is deeply embedded within specific institutional structures and market contexts. The regional financial ecological environment, as an external manifestation of institutional supply and financial resource allocation efficiency, not only provides the macro-foundation for SMEs' financing behaviors but also plays a significant moderating role in shaping the operational pathways of digital inclusive finance. Beyond institutional and market mechanisms, firm-level attributes also structurally embed within this moderating relationship. Prior research has indicated that this moderating process often manifests in non-linear, heterogeneous, and context-dependent patterns, which can constrain and reshape the actual effectiveness of digital financial mechanisms—providing a critical explanatory dimension for understanding the logic behind their impacts.

3.1. Moderating Mechanisms of Institutional and Governance Environments

Institutional and governance environments, as vital dimensions of regional financial ecosystems, exert influence primarily through three channels: contractual enforcement, market trust foundations, and financial infrastructure. Regions with efficient governance, sound legal systems, and transparent policy implementation tend to exhibit high financial contract fulfillment rates and efficient dispute resolution processes, which facilitate the stable operation of traditional financial systems. Under such conditions, the marginal effect of digital inclusive finance may be partially suppressed, necessitating differentiated services and technological innovation to complement traditional financial offerings—thereby weakening its "substitutive moderating effect" [9].

However, in areas with weak institutions and limited governance capabilities, traditional financial institutions often exhibit "credit rationing" tendencies due to high risk identification costs and low information transparency, which systematically excludes SMEs. In such scenarios, digital inclusive finance platforms—through advantages in intelligent risk control, blockchain-based data verification, and multi-source data integration—can reconstruct credit evaluation paths without relying on conventional credit histories. This enhances risk identification precision and achieves meaningful breakthroughs in both financing accessibility and targeting. For instance, in certain inland cities with underdeveloped legal environments, credit models built on e-commerce order fulfillment and logistics data have successfully enabled financing for SMEs lacking collateral or credit records. The existence of such mechanisms suggests that the weaker the institutional environment, the greater the marginal gains offered by digital inclusive finance, thereby revealing a "reverse complementary" moderating pattern.

Moreover, institutional and governance environments indirectly define the implementation boundaries of digital inclusive finance by influencing the risk preferences and behavioral logic of financial actors. For example, in regions where local governments exercise significant influence over financial resource allocation, even technologically advanced digital finance platforms may encounter

institutional access barriers and data-sharing constraints. These challenges can render risk identification mechanisms ineffective and reduce the precision of credit models, leading to an “institutional embeddedness dilemma.” Therefore, institutional moderation does not operate linearly but rather through a triple-feedback loop involving “governance capacity, market signaling, and platform adaptability.”

3.2. Moderating Mechanisms of Market and Financial Development Levels

Beyond institutional dimensions, market and financial development levels also serve as important conditions affecting the operational effectiveness of digital inclusive finance [10, 11]. The structure, competition intensity, product coverage, and credit supply elasticity of regional financial institutions directly shape the marginal choice mechanisms of SME financing behavior. In regions with mature financial markets and industrial structures, firms can flexibly select among diversified financing instruments—forming a “multi-source financing ecosystem” that compresses the “marginal operational space” of digital inclusive finance. In such contexts, digital financial platforms must emphasize product differentiation and scenario-based service delivery to extract value, while their roles in addressing structural financing constraints become relatively limited.

In contrast, in areas characterized by unbalanced financial supply and weak market vitality—especially in financially underserved towns and small cities—external intervention by digital finance often brings significant improvements to the structure of financial supply. On one hand, platform-based finance breaks through the spatial limitations of physical bank branches, enhancing SMEs’ access to finance. On the other, by leveraging digital identity authentication, online pre-loan risk controls, and remote post-loan supervision, platforms effectively expand service boundaries. For instance, in some regional credit platforms built on e-commerce and logistics ecosystems, digital inclusive finance has emerged as the primary financing channel following the retreat of traditional financial institutions, offering specialized products like “order-based loans” and “term-based loans” to agro-processing enterprises and small-scale customized manufacturing workshops [12]. Such models illustrate that in regions with low market allocation efficiency, digital inclusive finance possesses stronger “institutional substitution” and “resource activation” capabilities. Its moderating effect primarily manifests as a “promotional enhancement” that drives optimization of the broader financial ecosystem.

Furthermore, market development levels affect the adaptability of pricing mechanisms and service models on digital finance platforms. In regions with mature financial markets, platforms face challenges such as high customer acquisition costs and intense pricing competition, thereby limiting their operational space. In less developed markets, platforms can leverage their “first-mover advantage” to establish credit moats and data barriers, facilitating high-frequency transactions and strong user stickiness. This enhances service penetration and profitability. Therefore, market structure not only influences the intensity of mechanism effectiveness but also determines sustainability and economic viability—providing a theoretical foundation for understanding intra-regional heterogeneity in platform operation [13].

3.3. Firm-Level Heterogeneity in the Nested Moderating Structure

Beyond the dual moderating mechanisms of institutional and market factors, firm-specific characteristics also form a structurally nested layer that conditions the moderating effects of the regional financial ecological environment. In particular, SSDI-type SMEs—characterized by technological intensity, asset-light structures, and high uncertainty in operational cycles—demonstrate significantly varied levels of dependence on digital inclusive finance under different regional ecosystems [14]. argue that such firms tend to face greater exclusion from traditional financial systems in underdeveloped institutional environments, while digital inclusive finance platforms, through technological enablement, can enhance their probability of financing access, resulting in a “compatibility gain” effect.

Moreover, firms at different stages of their life cycles exhibit differentiated behaviors within platform mechanisms. Startups, often lacking sufficient operational data and historical credit records, may fail to be accurately identified by platform risk control models—even in regions with well-developed institutional frameworks. In contrast, growth-stage firms, which typically possess more comprehensive operational profiles, are better positioned to leverage the advantages of platform-based financial mechanisms across diverse institutional and market contexts. This heterogeneity suggests that the moderating mechanism cannot be adequately explained by a simple “region–platform” dual-variable framework; rather, it must be understood as a three-dimensional nested structure encompassing “region–platform–firm.” Effective system-level identification of such dynamics requires the incorporation of multilayered data and interaction modeling techniques.

In summary, the regional financial ecological environment—through the dual dimensions of institutional governance and market resource allocation—exerts a significant moderating influence on the mechanisms by which digital inclusive finance alleviates SME financing constraints. The more mature the institutions and the more dynamic the market environment, the clearer the operational boundaries of digital finance mechanisms. Conversely, in regions with structural distortions and resource misallocations, digital inclusive finance exhibits a stronger compensatory function. Additionally, firm-level heterogeneity and life cycle stages are further embedded within this moderating structure, shaping the path dependence and response elasticity of mechanism effectiveness. Identifying this multi-layered moderating structure is not only pivotal for advancing theoretical frameworks but also provides a robust foundation for designing empirical models and formulating targeted policy recommendations.

4. Conclusion

Building on the identification of three key mechanism pathways through which digital inclusive finance alleviates SME financing constraints, this study further explores the moderating role of the regional financial ecological environment on the effectiveness of these mechanisms. A logical framework centered on the tripartite relationship of “Mechanism–Moderation–Adaptation” is constructed. The findings indicate that digital inclusive finance opens a technical breakthrough for SME financing by reconstructing credit evaluation systems, optimizing risk pricing models, and integrating supply chain data resources. In particular, among asset-light enterprises such as SSDI-type SMEs that are often underserved by traditional financial institutions, digital finance platforms play a pivotal role in bridging information gaps, screening through algorithmic models, and reallocating financial resources [15].

However, the implementation of these mechanisms is far from homogeneous; their effectiveness is constrained by several regional factors, including the institutional foundation, openness of data systems, and the capacity of financial service provision. In regions with sound institutions, smooth platform access, and transparent regulatory frameworks, digital inclusive finance can partially replace traditional financial functions, thus enabling a more efficient allocation of financial resources. In contrast, in regions with fragile financial ecosystems, digital inclusive finance tends to act as a compensatory tool—supplementing institutional voids and bridging credit gaps through technological intervention [16]. The non-linear nature of regional moderation suggests that digital inclusive finance is not a universal solution; rather, its boundaries must be identified and adapted based on specific local conditions.

These findings underscore the importance of dual-path policy design focused on “regional adaptation” and “platform collaboration.” In regions with robust institutional environments, policy should promote interoperability between government administrative data and platform credit scoring systems, enhancing credit assessment capabilities and the precision of risk pricing. This would guide platform development from “coverage expansion” toward “quality improvement.” In regions with weaker institutions, priority should be given to building foundational digital infrastructure, strengthening regulatory sandbox mechanisms, and lowering platform entry barriers, thereby

improving the integration capacity and service breadth of digital finance. Furthermore, collaboration between financial institutions and technology platforms should be encouraged to jointly develop specialized financial products tailored to intellectual property, R&D activities, and contract performance. This would enable the transformation of “data assets” into “credit capital” and, ultimately, “financing capacity,” thereby channeling financial resources more precisely toward high-potential enterprises [17].

Looking ahead, policy orientation should focus on the dynamic interaction between institutional flexibility and platform evolution. By fostering differentiated financial ecosystems, it is possible to expand the sustainable boundaries of digital inclusive finance and enhance the financing resilience of SMEs under conditions of economic uncertainty.

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