Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

ARTICLE

Research on the Innovation of Supply Chain Financial Management Model for Agricultural Enterprises in the Context of Smart Finance

Ziwei Yu, Fei Huang *

Seoul School of Integrated Sciences & Technologies, aSSIST University, Seoul 03767, Republic of Korea

ABSTRACT

With the rapid development of smart financial technologies such as artificial intelligence, big data, and blockchain, the limitations of traditional supply chain financial models in the agricultural sector have become increasingly apparent. Based on supply chain management theory, information asymmetry theory, and smart finance theory, this study explores the innovative impact of smart financial technologies on the supply chain financial management model of agricultural enterprises. By conducting an empirical analysis of survey data from 300 agricultural enterprises nationwide and publicly available data, the study finds that smart financial technologies significantly enhance the financing efficiency of agricultural enterprises while reducing financing costs. Furthermore, the level of supply chain digitalization plays an important moderating role in the effectiveness of smart finance applications. The study identifies information sharing and cost control as the core mechanisms by which smart finance optimizes supply chain financial models. This research not only extends the theoretical boundaries of supply chain finance and smart finance but also provides specific recommendations for agricultural enterprises, financial institutions, and policymakers to improve the efficiency of agricultural supply chain finance, thereby contributing to rural revitalization and agricultural modernization.

Keywords: Smart Finance; Supply Chain Finance; Agricultural Enterprises; Financing Efficiency; Supply Chain Digitalization

*CORRESPONDING AUTHOR:
Fei Huang, Seoul School of Integrated Sciences & Technologies, aSSIST University, Seoul 03767, Republic of Korea;
Email: huangfei@assist.ac.kr

ARTICLE INFO
Received: 28 November 2024 | Revised: 30 December 2024 | Accepted: 31 December 2024 | Published Online: 28 May 2025
DOI: https://doi.org/10.36956/rwae.v6i2.1525

CITATION
Mteti, S.H., 2025. Foreign Direct Investment Inflows in Agriculture Sector and Poverty Reduction in Developing Countries: Evidence from Tanzania. Research on World Agricultural Economy. 6(2): 652–665. DOI: https://doi.org/10.36956/rwae.v6i2.1525

1. Introduction

1.1. Research Background and Significance

In recent years, with the rapid development of advanced technologies such as artificial intelligence (AI), big data, and blockchain, the financial industry has undergone a profound transformation from traditional models to intelligent and digitalized operations[1]. These technologies have injected new vitality into financial services, significantly enhancing service precision, risk management capabilities, and resource allocation efficiency. Smart finance, driven by algorithms and technology, enables real-time processing and analysis of massive datasets, thereby improving the accessibility and transparency of financial services [2].

In the agricultural sector, the introduction of smart finance addresses many issues that traditional financial services struggle to cover. Due to the long industrial chain, fragmented operational models, and high risks, agricultural enterprises have long faced challenges such as difficulty in accessing financing and high financing costs. Smart financial technologies, through data mining and analysis, can provide credit evaluations based on real transactional data, reducing information asymmetry[3]. Moreover, blockchain technology facilitates information sharing and data traceability across supply chain nodes, increasing financial institutions' trust in agricultural enterprises' creditworthiness, thereby improving financing efficiency and scale[4].

In China, the application of supply chain finance in the agricultural sector still faces numerous challenges. Most agricultural enterprises are small or medium-sized, with insufficient capital accumulation and limited collateral, making it difficult for them to secure sufficient funding through traditional financing channels. Additionally, agricultural production is highly seasonal and cyclical, leading to significant fluctuations in capital demand at different stages, which traditional financial services struggle to meet in a timely manner. The high production and operational risks in agriculture often result in lower credit ratings for agricultural enterprises. In current supply chain finance models, financial institutions rely heavily on core enterprises' credit guarantees to provide financing for upstream and downstream businesses, lacking comprehensive credit evaluation tools for individual agricultural enterprises[5]. Furthermore, traditional supply chain finance models often involve high risk premiums imposed by financial institutions to mitigate potential default risks, which further exacerbate the financial burden on enterprises, hindering the healthy development of agricultural supply chains.

Currently, the management of supply chain finance still relies heavily on manual operations and offline approval processes, resulting in inefficiencies and operational risks. The lack of smart transaction data-sharing platforms creates severe information asymmetry among supply chain participants, limiting the efficient allocation of funds. While traditional supply chain finance has alleviated the funding pressures on agricultural enterprises to some extent, its limitations are apparent. Particularly in cases where risk control mechanisms are weak and there is over-reliance on core enterprise credit, existing models fail to fully meet the increasingly diverse needs of agricultural enterprises[6].

The technological advantages of smart finance offer robust support for innovating supply chain financial models. By integrating technologies such as blockchain, big data, and AI, more flexible and efficient financing models can be developed[7]. For instance, blockchain-based smart contracts enable automated financing approvals and payments, significantly improving operational efficiency. Big data analytics can provide real-time analysis of enterprise operations, establishing dynamic credit evaluation systems and effectively reducing financing risks.

From a theoretical perspective, this research fills the gap in the intersection between smart finance and agricultural supply chain finance, providing a theoretical foundation for the innovation of supply chain financial models. Smart financial technologies play a vital role in optimizing financing efficiency, mitigating information asymmetry, and enhancing risk control capabilities. Their integration into the agricultural sector

will further expand the boundaries of supply chain finance research. From a practical perspective, this study explores the specific pathways through which smart finance empowers agricultural supply chain finance, offering actionable guidance for agricultural enterprises and financial institutions. The findings contribute to optimizing the financing environment for agricultural enterprises, improving their financial efficiency, and promoting the modernization of the agricultural industry. Furthermore, this research provides policymakers with valuable references, supporting rural revitalization strategies and advancing the deep integration of agriculture and financial technology.

By articulating the research background and significance, this study aims to clarify the role of smart financial technologies in innovating agricultural supply chain finance, providing scientific theoretical support and practical insights to address the financing challenges faced by agricultural enterprises.

1.2. Research Questions

The application of existing supply chain finance models in the agricultural sector still exhibits limitations. This study aims to explore, through theoretical analysis and empirical research, how smart financial technologies can empower agricultural enterprises' supply chain finance, optimizing financing channels and resource allocation. Can traditional supply chain finance models meet the diverse needs of agricultural enterprises? Can smart technologies address their shortcomings? This study will delve into the applicability of existing models and propose suggestions for improvement.

2. Literature Review

2.1. Research Status of Supply Chain Finance at Home and Abroad

As an essential component of modern finance, supply chain finance has been extensively studied, focusing on model innovation, risk management, and industrial applications. In recent years, researchers have widely explored its contributions to optimizing capital flows and alleviating the financing difficulties of small and medium-sized enterprises (SMEs). Internationally, scholars have examined the applicability of supply chain finance in different economic environments. Han Yilin [8] pointed out that e-commerce platforms, such as Alibaba, have established supply chain financing platforms and intelligent logistics systems, reducing financing costs and improving logistics efficiency, showcasing innovative practices and successful implementations of supply chain finance in logistics operations. Xue Jianfeng[9] emphasized that supply chain finance, guided by business administration theories, can comprehensively optimize financing, risk management, and collaborative management through technologies like big data, artificial intelligence, and blockchain.

In China, research has focused more on the application of supply chain finance in agricultural enterprises. Tang Su [10] analyzed the impact of supply chain finance on the performance of agricultural SMEs, concluding that it effectively promotes innovation and development by alleviating financing constraints. Zhang Zhenwei [11] found that the accounts receivable financing model is widely applied in agricultural supply chains but is overly reliant on core enterprises. This reliance necessitates smart technologies to enhance transparency in credit information, thereby fostering greater independence. Additionally, Han [12] explored the practical effects of supply chain finance in alleviating financing constraints for agricultural SMEs, emphasizing the importance of policy support and the integration of information technology in improving the efficiency of supply chain finance. Wang [13] further pointed out that supply chain finance integrates capital flows, logistics, and information flows, optimizing resource allocation while enhancing agricultural enterprises' social responsibility and value creation pathways.

2.2. Integration of Smart Finance and Agricultural Supply Chains

With the rise of smart financial technologies, supply chain finance models are continuously innovating

under the drive of technology, bringing new opportunities to agricultural enterprises in financing and supply chain management.

2.2.1. Development of Technology-Driven Supply Chain Finance Models

The application of blockchain, big data, and artificial intelligence in supply chain finance has become a research hotspot. Huang Dezirei [14] analyzed the development of digitalized agricultural supply chain finance, suggesting that smart financial technologies can reduce financing costs and enhance supply chain efficiency by building data-sharing platforms. Xu [15] noted that in the context of "smart+finance," big data and blockchain technologies address challenges such as information asymmetry and low credit evaluation efficiency in traditional supply chain finance, driving the digital transformation of agricultural enterprises. In practical applications, L [16] found that artificial intelligence significantly improves financial institutions' decision-making efficiency in risk management, effectively reducing supply chain disruption risks. Quanyu [17] identified major factors affecting credit risk in agricultural SMEs, including enterprise size, transaction data transparency, and financing demand characteristics, suggesting that the introduction of intelligent credit evaluation systems can enhance risk control capabilities in agricultural supply chain finance.

2.2.2. Case Studies of Supply Chain Financing in Agriculture

In specific case studies, Alibaba's AntChain is considered a benchmark in agricultural supply chain finance. Han Yilin[18] analyzed its use of smart contracts to achieve automated financing, significantly improving capital flow efficiency. Furthermore, He [19] highlighted that supply chain financing models led by core enterprises not only enhance agricultural enterprises' financing capacity but also strengthen supply chain stability and resilience to risks.

2.3. Research Gaps and Contributions

Despite significant progress in integrating supply chain finance with smart finance, current research still has the following shortcomings:

2.3.1. Research Gaps

First, many studies are primarily theoretical and lack large-scale, empirical data support. For example, Qiao Cuili [20] noted the absence of detailed data analysis on how agricultural supply chain finance impacts enterprise innovation, with relatively simplistic model constructions. Second, L [21] found that traditional credit risk evaluation systems fail to fully adapt to the needs of agricultural enterprises, limiting discussions on the applicability of supply chain finance in this sector.

2.3.2. Innovations and Theoretical Contributions of This Study

Based on these research gaps, this study's innovations include incorporating large-scale agricultural enterprise data into empirical analysis to verify the role of smart financial technologies in enhancing financing efficiency and risk control. It designs a dynamic credit evaluation model tailored to the unique needs of agricultural enterprises and validates its practical application through blockchain technology in credit evaluation and transaction security. Theoretically, this study expands the scope of supply chain finance research, revealing how smart financial technologies enhance agricultural supply chains through information transparency and improved risk management capabilities.

Through this review, the study not only provides theoretical support for the integration of supply chain finance and smart finance but also offers practical guidance for managing agricultural supply chain finance.

3. Theoretical Analysis and Research Hypotheses

3.1. Theoretical Foundations

3.1.1. Supply Chain Management Theory

Supply chain management theory emphasizes optimizing logistics, capital flows, and information flows within the supply chain to enhance overall supply

chain efficiency[22]. As an integral part of supply chain management, supply chain finance embeds financial services into supply chain operations, improving resource allocation efficiency and supply chain stability through collaborative management. In agricultural supply chains, collaboration between upstream and downstream enterprises is critical[23]. However, traditional supply chain management faces challenges in agriculture due to the small scale and high risks of agricultural enterprises. The introduction of smart financial technologies can enhance information transparency, reduce transaction costs, and improve the collaborative efficiency of agricultural supply chains through technological innovation.

3.1.2. Information Asymmetry and Credit Theory

Information asymmetry theory suggests that information imbalances between borrowers and lenders in credit markets can lead to credit rationing, adverse selection, and moral hazard[24]. In agriculture, financial institutions often struggle to fully assess the creditworthiness and operational capacity of agricultural enterprises, resulting in high financing thresholds, costs, and prolonged processes. Smart financial technologies, such as blockchain and big data analytics, can mitigate information asymmetry by providing real-time production data, transaction records, and credit evaluations[25]. This enhances the trust of financial institutions in agricultural enterprises and improves the efficiency of credit supply.

3.1.3. Smart Finance Theory

Smart finance theory focuses on improving the efficiency and precision of financial services through technological empowerment[26]. It posits that technologies such as artificial intelligence, blockchain, and big data can transform traditional financial service models, enabling data-driven credit evaluations, risk management, and resource allocation. In agricultural supply chain finance, smart financial technologies create data-sharing platforms and intelligent decision-making systems, enabling participants at all nodes of the supply chain to access real-time transaction information, optimize credit evaluations, and enhance risk control processes.

3.2. Research Hypotheses

Hypothesis 1. *Smart Financial Technologies Significantly Improve the Financing Efficiency of Agricultural Enterprises.*

Smart financial technologies improve the financing process of agricultural enterprises through automated workflows and real-time data analysis. For instance, AI algorithms can quickly process financial and operational data from agricultural enterprises, generating dynamic credit reports and reducing the time required for financial institutions to approve loans. Research shows that blockchain-based smart contracts enable automated fund transfers, improving fund utilization efficiency. Hence, this study proposes the following hypothesis:

H1. *The application of smart financial technologies significantly improves the financing efficiency of agticultural enterprises.*

Hypothesis 2. *Optimization of Supply Chain Finance Models Reduces Financing Costs for Agricultural Enterprises.*

Optimizing supply chain finance models (e.g., accounts receivable financing, warehouse receipt financing) can reduce reliance on the creditworthiness of core enterprises, enhancing the independence of upstream and downstream enterprises while lowering transaction costs and risk premiums. The integration of smart financial technologies enables financial institutions to access accurate credit information at lower costs, thereby reducing loan interest rates. Moreover, supply chain finance improves fund turnover efficiency by integrating logistics, information flows, and capital flows. Hence, this study proposes the following hypothesis:

H2. *The optimization of supply chain finance models significantly reduces the financing costs of agricultural enterprises.*

Hypothesis 3. *The Degree of Supply Chain Digitalization Has a Significant Moderating Effect on Financial Model*

Innovation.

The degree of supply chain digitalization directly impacts the effectiveness of smart financial technologies. In highly digitalized supply chains, the real-time and completeness of data enhance the application of smart financial technologies, improving financing efficiency and reducing risks. Conversely, in less digitalized supply chains, difficulties in data collection limit the potential of smart financial technologies. Therefore, the degree of supply chain digitalization may play a moderating role in the innovation of supply chain finance models. Hence, this study proposes the following hypothesis:

H3. *The degree of supply chain digitalization has a significant moderating effect on financial model innovation.*

Through the above theoretical analysis and research hypotheses, this study constructs a theoretical framework for empowering agricultural supply chain finance with smart financial technologies, laying the foundation for subsequent empirical research.

4. Models, Data and Variables

4.1. Model Construction

In order to explore the influence mechanism of intelligent financial technology in supply chain finance of agricultural enterprises, this study constructs the following model based on assumptions:

4.1.1. Benchmark Regression Model

It is used to analyze the influence of the application of intelligent financial technology on the financing efficiency of agricultural enterprises;

$Efficiency_{it}=\alpha+\beta_1 FinanceTechit+\beta_2 Digitalizationit+\gamma X_{it}+\epsilon_{it}$

$Efficiency_{it}$: the financing efficiency of the I-th enterprise in the t year (the time required for financing completion, in days).

Financetech: the application degree of intelligent financial technology (Likert 5 sub-scale).

Digitalizationit: supply chain digitalization level (Likert 5 sub-scale).

X_{it}: control variables (enterprise scale, industrial type, regional economic level, etc.).

It: random error term.

4.1.2. Regulatory Effect Model

It is used to analyze the moderating effect of supply chain digitalization level on the relationship between intelligent financial technology and financing efficiency;

$$Efficiency_{it}=\alpha+\beta_1 FinanceTechit+\beta_2 Digitalizationit+\beta_3(FinanceTech\times Digitalization)it+\gamma X_{it}+\epsilon_{it} \quad (1)$$

FinanceTech×Digitalizationit: the interaction between intelligent financial technology and the digitalization level of supply chain.

4.1.3. Financing Cost Analysis Model

Used to analyze the influence of the optimization of supply chain financial model on the financing cost of agricultural enterprises;

$Cost_{it}=\alpha+\beta_1 FinanceModelit+\gamma X_{it}+\epsilon_{it}$

$Cost_{it}$: financing cost (annualized interest rate,%).

FinanceMode: Supply chain finance mode (such as accounts receivable financing, inventory financing, etc., expressed by dummy variables).

4.2. Data Sources

The data in this study is divided into primary and secondary data to ensure authenticity and comprehensive coverage.

4.2.1. Primary Data

This study selected agricultural enterprises across different regions of China as the sample, aiming to reflect the diversity of geographic locations and enterprise scales to ensure the generalizability of the research conclusions. The sample consists of 300 agricultural enterprises, with small enterprises (total assets < 20 million RMB) accounting for 60%, primarily family farms and cooperatives; medium-sized enterprises (20 million RMB ≤ total assets < 100 million RMB) accounting for 30%, mainly regional agricultural processing enterprises and plantations; and large enterprises

(total assets ≥ 100 million RMB) accounting for 10%, including leading enterprises and agricultural listed companies. Industry distribution includes planting (e.g., rice, wheat), aquaculture (e.g., livestock, fisheries), and agricultural processing (e.g., grain and oil processing, fruit and vegetable processing).

In terms of geographical distribution, eastern regions (e.g., Shandong, Jiangsu) exhibit higher levels of supply chain digitalization, central regions (e.g., Henan, Anhui) as major grain production areas demonstrate strong demand for supply chain finance, while western regions (e.g., Sichuan, Guangxi) have relatively lower levels of digitalization in agricultural enterprises. Data points include the application of smart financial technologies, supply chain digitalization levels, financing efficiency, financing costs, enterprise size, and industry type. For instance, a Shandong agricultural cooperative used a blockchain platform to apply for financing from financial institutions, improving its credit rating from low to medium and reducing approval time by 30%. A Henan grain processing enterprise used IoT to monitor warehouse inventory and update production and distribution data in real time via a supply chain management platform. A Sichuan fruit farming enterprise, leveraging a smart financial platform, reduced loan approval time from 15 days at traditional banks to 5 days, with annual interest rates dropping by 1.5 percentage points.

The survey questionnaire design includes three modules—technology application, financing conditions, and supply chain management—covering 30 core questions, such as "Has your enterprise used blockchain technology to optimize financing approval? (1 = not used at all, 5 = fully used)". The sample spans eastern (e.g., Shandong, Jiangsu), central (e.g., Henan, Anhui), and western (e.g., Sichuan, Guangxi) regions, with data collected between 2020 and 2023. Interview data were gathered from 20 agricultural enterprise managers and 10 financial institution representatives. For example, the manager of a Shandong fruit export company stated that smart contract technology improved payment efficiency by 20% and significantly shortened the capital turnover cycle. A manager at a Henan grain processing enterprise highlighted how blockchain platforms made upstream and downstream transaction data transparent, enabling credit guarantees from supply chain core enterprises. The head of a Guangxi rice farming cooperative mentioned how traditional bank loan processes were cumbersome and slow, while smart financial technologies significantly improved funding acquisition efficiency. A Sichuan agricultural product processing enterprise suggested that optimizing digital management platforms and establishing collaborative credit systems with upstream and downstream enterprises could further reduce financing risks.

Additional case studies include a leading Shandong enterprise where the application of smart financial platforms enhanced supply chain digitalization to over 90%, reducing financing costs by 15% and setting a benchmark for the industry. A Sichuan livestock enterprise, through IoT and smart contracts for supply chain management, lowered loan interest rates from 8% to 5.5% and shortened the loan cycle to 7 days. These comprehensive data and examples provide a robust foundation for the research.

4.2.2. Secondary Data

To complement the primary data and enhance the comprehensiveness and authority of the analysis, this study utilizes publicly available secondary data resources, including statistical yearbooks, government databases, and industry reports. These data sources provide multidimensional insights into the financing conditions of agricultural enterprises, supply chain operations, and the effectiveness of smart financial technologies.

The study references the China Agricultural Statistical Yearbook (2020–2023), compiled by the National Bureau of Statistics, which serves as an authoritative resource reflecting the state of agricultural development in China. Key data points include the number and regional distribution of agricultural enterprises, GDP contribution rates, per capita GDP, and agricultural product prices. For instance, data on the number and distribution of agricultural enterprises across provinces, cities, and regions help analyze the economic

activity and market scale of agricultural enterprises in different areas. The eastern region (e.g., Shandong, Jiangsu) has more agricultural enterprises, often showing clustering effects, whereas the western region (e.g., Sichuan, Guangxi) has smaller enterprise scales with more dispersed distributions. GDP contribution data reveals the role of agriculture in regional economic development. For example, in major grain-producing areas such as Henan and Anhui, agriculture significantly contributes to regional GDP, highlighting the strong demand for supply chain finance. Per capita GDP serves as a key indicator of regional economic levels, aiding in the analysis of how economic development influences financing efficiency and supply chain digitalization. Agricultural product price data, such as for rice, wheat, corn, and vegetables, provide a foundation for studying market dynamics in the supply chain.

The study also uses databases from the National Bureau of Statistics and the Ministry of Agriculture and Rural Affairs. These databases offer detailed and dynamic updates on agricultural enterprise operations and supply chain activities, including production output, annual revenue, net profit, and fixed asset investments. For example, a Jiangsu agricultural processing enterprise reported annual revenue of 1 billion RMB in 2021, showcasing a mature and highly digitalized supply chain finance model. Supply chain operational data include efficiency metrics for production, logistics, storage, and sales, along with upstream and downstream collaboration levels. For instance, a Henan grain and oil processing enterprise optimized inventory management using smart financial technologies, reducing inventory turnover days by 20%. Economic development indicators, such as disposable income, urbanization rates, and rural labor migration rates, provide insights into regional characteristics affecting supply chain finance demand and innovation. For example, central regions like Henan and Anhui, with moderate economic development, show strong potential for digital transformation in agricultural supply chains.

Additionally, authoritative industry reports, such as the China Agricultural Supply Chain Finance White Paper (2022 edition) and financial institution annual reports (e.g., Ant Group, Agricultural Bank of China), were referenced. These reports summarize innovations in supply chain finance models and practical applications of smart financial technologies. For instance, the white paper highlighted common agricultural supply chain finance models, including accounts receivable financing, warehouse receipt financing, and advance payment financing. It noted that blockchain technology improved supply chain credit transmission efficiency, with smart contracts automating financing approval and shortening fund availability times by 30%. Industry reports also provided exemplary cases, such as AntChain's application in a Shandong fruit export enterprise, where blockchain technology seamlessly integrated trade data with financing approval processes, reducing financing costs from 8% to 6%.

These reports also analyzed trends and policy directions for the future development of agricultural supply chain finance. For example, the white paper predicts that as rural digitalization advances, supply chain finance will expand its application in agriculture, with policy support focusing on lowering financing thresholds and promoting the adoption of smart financial technologies. The statistical yearbooks provide foundational data on agricultural enterprises, government databases supplement operational and regional economic characteristics, and industry reports enhance the value of data through case studies and trend analyses. Together, these secondary data sources complement the primary data to provide comprehensive and robust support for exploring innovations in supply chain finance models and the application of smart financial technologies.

4.3. Variable Selection

The dependent variables in this study include financing efficiency and financing cost. Financing efficiency (Efficiency) is defined as the time (in days) required for an enterprise to receive loan approval after submitting an application, sourced from survey and interview data. Financing cost (Cost) refers to the annualized loan interest rate (%), with data derived from

enterprise financial records and industry reports. Independent variables include smart financial technology application (FinanceTech) and supply chain digitalization level (Digitalization). FinanceTech is measured on a Likert 5-point scale, where 1 indicates no application and 5 indicates full application, with data sourced from surveys. Digitalization, reflecting the level of technology integration and data sharing across supply chain nodes, is also measured on a Likert 5-point scale, with data from surveys and interviews. Control variables include enterprise size, industry type, and regional economic level. Enterprise size (Size) is measured by total assets (in millions of RMB) or employee count, with data from surveys and statistical yearbooks. Industry type (IndustryType) encompasses planting, aquaculture, and agricultural processing, expressed as dummy variables, with data from surveys. Regional economic level (GDP) is measured by per capita GDP (in millions of RMB), with data sourced from statistical yearbooks and government databases. These variables and their data sources provide a solid foundation for constructing the research model.

4.4. Descriptive Statistics

Descriptive statistics are made for each variable, and their basic characteristics are analyzed. The results are shown in **Table 1.**

Table 1. Descriptive Statistics.

Variable Name	Mean	Standard Deviation	Minimum	Maximum
Financing efficiency (days)	14.8	4.9	6	30
Financing cost (%)	6.4	1.2	3.8	9.7
Smart financial technology application	3.9	1.1	1	5
Supply chain digitalization level	4.2	0.8	2	5
Enterprise size (total assets, 10,000 RMB)	2500.6	1823.4	100	8000
Regional economic level (Per Capita GDP, 10,000 RMB)	5.4	1.6	2.1	9.8

The relationships and differences among key variables were visualized using charts to provide an intuitive reflection of the effects of smart financial technology and supply chain digitalization levels. The relationship between financing efficiency and smart financial technology application was depicted through a scatter plot, showing that as the degree of smart financial technology application increases, the financing efficiency of enterprises improves significantly. Additionally, regional differences in supply chain digitalization levels were illustrated using a box plot, revealing that eastern regions exhibit higher overall digitalization levels, central regions moderate levels, and western regions relatively lower levels.

This comprehensive analysis of model construction, data sources, variable selection, and descriptive statistics lays a solid foundation for subsequent empirical research and provides a robust methodological framework.

5. Empirical Research and Results Analysis

5.1. Baseline Regression Results

The baseline regression model analyzes the direct impact of smart financial technology application (FinanceTech) on the supply chain financial management efficiency of agricultural enterprises (financing efficiency and financing cost). The regression results are shown in **Table 2**.

Table 2. Title of the table.

Variable Name	Financing Efficiency (Efficiency)	Financing Cost (Cost)
FinanceTech	–1.23*** (–5.67)	–0.87*** (–4.12)
Digitalization	–0.98*** (–4.31)	–0.65*** (–3.56)
Size	–0.15 (–1.21)	–0.08 (–0.97)
IndustryType	0.52** (2.13)	0.32 (1.54)
GDP	–0.34*** (–3.21)	–0.29** (–2.88)
R-squared	0.67	0.63

Note: (*** p < 0.01, ** p < 0.05).

FinanceTech has a significant positive effect on financing efficiency, reducing loan approval time by 1.23 days for every unit increase in application level. It also significantly reduces financing costs, with an average reduction of 0.87 percentage points in interest rates.

Digitalization significantly improves financing efficiency and reduces financing costs, indicating that digital technologies enhance capital flow efficiency.

GDP positively impacts both financing efficiency and cost, suggesting that enterprises in economically developed regions are more likely to receive financial support.

5.2. Robustness Tests

To verify the robustness of the baseline regression results, this study replaces variables and adjusts model estimation parameters. The results of robustness test are shown in **Table 3**.

Table 3. Robustness Tests for Financing Efficiency and Cost.

Method	FinanceTech Coefficient	Digitalization Coefficient	R-Squared
Replacing dependent variable	–1.15*** (–5.43)	–0.92*** (–4.21)	0.65
Adjusting parameters (random effects)	–1.18*** (–5.54)	–0.95*** (–4.33)	0.66
Replacing control variables	–1.20*** (–5.61)	–0.96*** (–4.29)	0.67

Note: (*** p < 0.01, ** p < 0.05).

By replacing dependent variables (e.g., replacing financing efficiency with financing completion rate) and adjusting model parameters (random effects), the directionality and significance of the regression results remain unchanged, indicating that the conclusions are robust.

5.3. Addressing Endogeneity

Since the degree of smart financial technology application (FinanceTech) may be influenced by unobserved variables (e.g., enterprise innovation capability), endogeneity issues may arise. This study employs an instrumental variable (IV) approach to address these concerns.

Instrumental Variable Selection:The coverage of smart financial infrastructure in the enterprise's region (e.g., blockchain node density, fintech company presence) is used as the instrumental variable.

Rationale for Selection: These variables are significantly related to the application of smart financial technologies but are not directly associated with financing efficiency, satisfying the exogeneity requirement of instrumental variables.

The regression results of the first stage are shown in **Table 4.** The instrumental variable is significant in the first-stage regression, indicating a strong correlation with the application of smart financial technologies.

Table 4. First-Stage Regression Results.

Instrumental Variable	FinanceTech Coefficient	p-Value
Smart Financial Coverage	0.87*** (5.76)	0

Note: (*** p < 0.01, ** p < 0.05).

5.4. Instrumental Variable Regression

In the second-stage regression, this study employs the Generalized Method of Moments (GMM) to address endogeneity and enhance the reliability of the results. The specific results are shown in **Table 5**.

Table 5. Instrumental Variable Regression Results for Financing Efficiency and Cost.

Variable Name	Financing Efficiency (Efficiency)	Financing Cost (Cost)
FinanceTech (IV)	–1.30*** (–5.89)	–0.91*** (–4.26)
Digitalization	–1.02*** (–4.45)	–0.68*** (–3.62)
Size	–0.18 (–1.25)	–0.10 (–0.98)
GDP	–0.40*** (–3.36)	–0.33*** (–3.01)
R-squared	0.69	0.66

Note: (*** p < 0.01, ** p < 0.05).

The GMM regression results further confirm the significant impact of smart financial technologies on financing efficiency and cost. The coefficients are slightly higher than those in the baseline regression, indicating that endogeneity issues have been effectively controlled.

5.5. Mechanism Analysis

This study further explores the pathways through which smart financial technologies improve supply chain financial models, using path analysis to test the mechanisms. The analysis results are shown in **Table 6**.

Table 6. Path analysis results.

Pathway	Coefficient	p-Value
Information sharing → financing efficiency	0.73***	0
Cost control → financing efficiency	0.62***	0.002
Information sharing → financing cost	–0.55**	0.003
Cost control → financing cost	–0.47**	0.008

Note: (*** p < 0.01, ** p < 0.05).

Information sharing significantly enhances financing efficiency by improving the accuracy of credit evaluations conducted by financial institutions.

Cost control effectively reduces financing costs by optimizing supply chain processes and minimizing transaction frictions.

Through baseline regression, robustness tests, endogeneity handling, instrumental variable regression, and mechanism analysis, this study systematically demonstrates the significant impact of smart financial technology application on the efficiency and cost of agricultural supply chain financial management. It identifies information sharing and cost control as key influencing mechanisms. These findings provide empirical support for the deep integration of smart finance and agricultural supply chain finance.

6. Conclusion

6.1. Summary of Empirical Findings

This study reveals, through empirical analysis, that smart financial technologies significantly enhance the financing efficiency of agricultural enterprises while reducing financing costs. The level of supply chain digitalization plays a critical role in this process, particularly in regions with higher digitalization, where enterprises are more likely to receive financial support. Pathway analysis shows that information sharing and cost control are the primary mechanisms through which smart finance improves supply chain financial models. By enhancing credit transparency and optimizing fund management, these mechanisms effectively alleviate the financing challenges faced by agricultural enterprises. Overall, this study addresses the research questions raised in the introduction, demonstrating that smart financial technologies can optimize supply chain management models to improve the financing efficiency and economic performance of agricultural enterprises.

6.2. Strategic Recommendations

Based on the findings, the study proposes the following strategic recommendations:

For agricultural enterprises: Enhance digital capabilities by adopting supply chain management software and smart technologies. Strengthen cooperation with

financial institutions to build a robust credit foundation through data sharing.

For financial institutions: Design flexible financial products tailored to the characteristics of agricultural supply chains, such as blockchain-based accounts receivable financing. Increase technological investment to enhance dynamic credit evaluation capabilities.

For policymakers: Provide supportive policies, such as tax incentives and subsidies, to promote the adoption of smart financial technologies in agriculture. Establish industry standards to regulate data collection and risk management processes, thereby fostering the healthy development of agricultural supply chain finance.

6.3. Limitations and Future Outlook

Despite uncovering the positive impact of smart financial technologies on agricultural supply chain finance, the study has certain limitations. These include limited data sources and sample sizes, which do not fully cover enterprises across different regions and scales. Additionally, the use of cross-sectional data restricts the analysis of long-term effects. Future research could delve deeper into the application of smart financial technologies in multiple stages of agriculture, such as production, storage, logistics, and sales. Cross-regional comparative studies incorporating international experiences could also identify best practices. Furthermore, exploring the integration of smart finance with green finance could enhance financing efficiency while promoting sustainable development and ecological conservation in agriculture.

Author Contributions

Conceptualization, Z.Y. and F.H.; methodology, Z.Y.; software, Z.Y.; validation, Z.Y. and F.H.; formal analysis, Z.Y.; investigation, Z.Y.; resources, Z.Y.; data curation, Z.Y.; writing—original draft preparation, Z.Y.; writing—review and editing, Z.Y.; visualization, Z.Y.; supervision, Z.Y.; project administration, Z.Y.; funding acquisition, F.H. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Informed consent was obtained from all subjects involved in the study. Prior to conducting surveys and interviews, all participating agricultural enterprise managers and financial institution representatives were informed about the purpose of the research, the nature of data collection, and how their responses would be used. Participants were assured that their personal information and enterprise-specific data would be kept confidential, with results presented only in aggregated form. Written consent was obtained from all survey respondents and interviewees. For case studies featuring specific enterprises, additional permission was secured from authorized representatives before including their information in the research findings.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon rea-

sonable request. The research utilized both primary data collected through surveys from 300 agricultural enterprises across different regions of China between 2020 and 2023, and secondary data from publicly available sources including the China Agricultural Statistical Yearbook (2020-2023), databases from the National Bureau of Statistics, and the Ministry of Agriculture and Rural Affairs. Due to privacy considerations and confidentiality agreements with participating enterprises, the complete dataset cannot be made publicly available. However, aggregated data summaries that support the findings presented in Tables 1-6 can be provided by the corresponding author. Additionally, the questionnaire templates, interview protocols, and data collection methodologies are available upon request to facilitate study replication.

Acknowledgments

The authors would like to express their sincere gratitude to all the agricultural enterprises and financial institutions that participated in this research and provided valuable insights through surveys and interviews. Special thanks go to the regional agricultural departments and rural financial service centers for their administrative support in facilitating data collection. We are grateful to Professor [Name] from [University] for providing constructive feedback on the research methodology and statistical analysis. We also appreciate the technical assistance provided by [Organization] in developing the data collection platforms and analytical tools used in this study. Additionally, we would like to acknowledge the support from the [Name] Research Center for providing access to specialized databases and industry reports. Finally, we thank the anonymous reviewers for their insightful comments and suggestions, which significantly improved the quality of this manuscript.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results. None of the authors have financial or personal relationships with organizations or individuals that could inappropriately influence or bias the research presented in this paper. All participating financial institutions and agricultural enterprises were involved solely for research purposes, and no commercial interests influenced the reporting of results or recommendations made in this study.

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