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-RESEARCH ARTICLE-

LEVERAGING E-COMMERCE FOR TRANSNATIONAL SALES-MARKETING OF RURAL AGRICULTURAL PRODUCTS: THE IMPACT OF DIGITAL PLATFORMS AND CROSS-BORDER LOGISTICS

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─Abstract─

This study examines the influence of digital platform adoption and cross-border logistics integration on transnational sales volume (TSV) within rural agriculture. It seeks to explore how these factors, along with their mediating effects on market accessibility and operational efficiency, affect market performance and sustainability in global agricultural trade. A quantitative research design was adopted, utilising a sample of 340 rural agricultural producers in China. Data were collected through electronically distributed structured questionnaires, focusing on perceptions of digital platform utilisation, logistics integration, and sales volume. Statistical analyses, including correlation analysis and regression modelling using SPSS, were performed to investigate the relationships and mediating effects. The study revealed that both digital platform adoption and logistics integration have a significant positive impact on TSV. Market accessibility and operational efficiency were identified as key mediators in these relationships, underscoring their critical roles in improving market performance for rural agricultural producers. This research provides empirical evidence on the impact of digital platforms and logistics integration on TSV in rural agriculture. It addresses gaps in the existing literature by specifically exploring these relationships and highlights the practical implications for policymakers, agricultural managers, and stakeholders in promoting sustainable economic development and enhancing global market competitiveness within the agricultural sector.

Keywords: Digital Platform Adoption, Cross Border Logistic Integration, Transnational Sales Volume, Market Accessibility, Operational Efficiency.

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INTRODUCTION

In recent decades, agricultural globalisation has posed significant challenges for rural producers worldwide. Farmers face the dual challenge of seizing global opportunities while contending with difficulties in domestic and regional sales. This transformation is driven by increased agricultural demand, advancements in transportation and communication technologies, and shifting global consumer trends (Contzen & Häberli, 2021). Rural farmers seek to meet global demand to boost sales, and TSV serves as a critical metric for assessing the global competitiveness and long-term sustainability of rural agricultural enterprises. TSV evaluates factors such as export performance, economic sustainability, and readiness for international markets. A high TSV enables rural agricultural producers to better navigate climate and geopolitical uncertainties, enhance profitability, and mitigate risks associated with local market fluctuations. Digital platforms and international logistics play a pivotal role in supporting agricultural growth (Murdeshwar et al., 2019). While acknowledging both the advantages and challenges of globalisation, legislation has increasingly focused on facilitating these processes. Online trading platforms and e-commerce marketplaces empower rural producers to engage directly with international customers, providing access to global consumer markets. These platforms help producers market their products more effectively, reducing reliance on traditional distribution networks and enhancing brand visibility (Zhou et al., 2023).

Integrated cross-border logistics streamline the global transportation of agricultural commodities by improving supply chains, transportation, and customs procedures, thereby enabling quicker and more cost-effective delivery. Efficient logistics management allows rural agricultural producers to lower transportation costs, enhance product quality, and meet international market delivery timelines (Wang & Sup, 2020). For rural farmers to compete effectively in global markets, the adoption of digital platforms and efficient cross-border logistics is essential. This initiative aims to gather data that will enhance both the theoretical understanding and practical application of strategies to improve the competitiveness and sustainability of rural agricultural markets. It seeks to explore the intricate relationships between these factors and their impact on global sales performance, providing insights into how digital and logistical integration can drive long-term success in international agricultural trade.

Since the dawn of civilisation, agricultural commerce has been a driving force behind global industry, with agriculture significantly contributing to both the economy and culture. The evolution of the economy, communication, and transportation has had a profound impact on agricultural trade. International trade has been closely tied to agriculture since the era of European colonialism and the globalisation of the Silk Road (Herrera & Garcia-Bertrand, 2018), which contributed to advancements in global culture and economic systems. While traditional agricultural commerce remains vital,

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rural farmers face numerous challenges in accessing global markets. Barriers such as limited market knowledge, inadequate infrastructure, geographic isolation, and regulatory complexities hinder their ability to compete internationally. The transportation of perishable goods from remote, underdeveloped regions is especially challenging due to export regulations and the need to meet international standards (Li, 2020).To overcome these obstacles, rural farmers increasingly rely on digital platforms and logistics integration to access global markets. Digital platforms enable widespread product promotion, eliminating intermediaries and connecting producers directly with international clients. This facilitates greater market knowledge, enhanced transparency, and encourages the internationalisation of rural producers, fostering fairer competition (Ni, 2022).

The integration of logistics systems further enhances the reliability and efficiency of transnational agricultural supply chains. By optimising transportation networks, incorporating advanced monitoring technologies, and streamlining customs procedures, integrated logistics systems enable the movement of agricultural products from production sites to global markets. Logistics integration helps rural producers meet the demands of international markets by accelerating delivery times, reducing transportation costs, and preserving product quality. The combined use of logistics and digital technologies has revolutionised the ability of rural agricultural producers to engage in global markets (Van Asch et al., 2020). This integration offers easier market access, more efficient business operations, reduced international trade risks, and supports long-term agricultural sustainability. Through digital platforms and integrated logistics solutions, rural producers can expand their customer base, increase global sales, and contribute to local economic growth.

There is limited research on how digital platforms and cross-border logistics affect the sales volume of rural agricultural farmers in international markets, despite the growing importance of these commodities in the global agricultural economy (Forman & Van Zeebroeck, 2019). While many studies examine the impact of digital technology and logistics on corporate profitability, few focus on rural agricultural sales volume. Small enterprises often lack technology and global market access, which are crucial for their survival and competitiveness. Digital platforms reduce transaction costs and increase visibility, potentially boosting TSV (Runck et al., 2022). Logistics integration enhances supply chain efficiency and reduces costs. However, further research is needed to understand how rural locations affect agricultural product values (Hackfort, 2021). This study suggests that digital platforms and logistics integration can enhance TSV for rural agriculture and address information gaps. Rural farmers need this data to compete globally, invest in digital infrastructure, and advocate for appropriate legislation, essential for poverty reduction, economic growth, and food security (Zhao et al., 2022). However, market accessibility and operational efficiency may limit the global sales volume benefits of these technologies. The objectives of this study are as follows:

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1. To examine the correlation between digital platform usage and TSV.
2. To assess the relationship between cross-border logistics integration and TSV.
3. To investigate the impact of market accessibility on the relationship between digital platform adoption and TSV.
4. To evaluate operational efficiency as a mediator in the connection between cross-border logistics integration and TSV.
5. To provide empirical insights that contribute to theoretical knowledge and practical strategies for enhancing the competitiveness and sustainability of rural agricultural markets.

This outcome has significant implications for agricultural economics theory and the development of rural agriculture. The empirical study explores how cross-border logistics integration and digital platforms influence transnational sales volume. The project aims to advance international trade and agricultural economics. Operational efficiency and market accessibility play crucial roles in technology adoption, logistics integration, and market performance. These insights will inform the creation of theoretical frameworks that incorporate technology, supply chain management, and market access within the context of rural agriculture. The report outlines strategies to enhance the competitiveness and sustainability of rural agriculture, targeting development organisations and policymakers. Improvements in transportation efficiency and digital technology can support these goals. The findings suggest that agricultural managers and producers can enhance operations and international sales by adopting relevant technologies and developing market access strategies. Increasing rural sales volume can drive job creation and poverty reduction. The study also highlights the importance of environmental sustainability and innovations in the supply chain for global food security and sustainable agriculture. A better understanding of digital platforms and logistics systems within agricultural enterprises can improve international trade agreements, benefiting both importers and exporters through enhanced global competitiveness of rural agricultural products.

LITERATURE REVIEW

Digital Platform Adoption and Transnational Sales Volume

Digital platform technology has reduced market barriers in agricultural trade, enabling global connections between producers and customers. Platforms like e-commerce websites and apps allow remote farmers to reach broader markets, overcoming geographical and knowledge gaps (Bolfe et al., 2020). They enhance market reach and awareness, attracting buyers seeking diverse products (Smidt & Jokonya, 2022). By eliminating intermediaries, farmers can increase earnings, while secure payment systems and transparent transactions foster trust, encouraging repeat purchases (Gabriel & Gandorfer, 2023). Data analytics on consumer behaviour helps farmers optimise pricing, market expansion, and product offerings (Borrero & Mariscal, 2022). Examples

such as Kenyan farmers using mobile platforms for international sales demonstrate the benefits of digital platforms (Runck et al., 2022). However, challenges like regulatory hurdles, digital literacy, and inadequate infrastructure hinder small-scale producers in developing countries (Han et al., 2022). To fully integrate digital platforms in global agricultural trade, improved infrastructure, skills development, and streamlined regulations are necessary.

Cross-border Logistic Integration and Transnational Sales Volume

Efficient integration of cross-border logistics is crucial for the swift delivery of high-quality agricultural products, ensuring competitiveness in global markets (Niu et al., 2023). It reduces delays and spoilage through seamless coordination of delivery, customs clearance, storage, and transport. Studies show that effective logistics improve supply chain reliability, boosting customer trust and repeat business (Liang et al., 2021). For perishable goods, reliable logistics are essential for global sales. Case studies, such as Chile's fruit exports and Kenya's flower shipments, demonstrate the positive impact of logistics integration on export volumes and profits (Lee & Shen, 2020; Ren et al., 2020). However, challenges in developing nations, such as inadequate logistics and infrastructure, require investment from governments, businesses, and international organisations to enhance global competitiveness (Niu et al., 2022).

Digital Platform Adoption and Market Accessibility

Internet platforms provide underserved farmers with access to global markets. The different studies suggest that Indian farmers can utilise digital platforms, such as agricultural marketplaces, mobile apps, and e-commerce websites, to expand their market reach. These platforms enable producers to sell internationally without transaction fees and bypass physical market barriers (Shen et al., 2024). Small enterprises require enhanced logistics and information systems to access larger, more profitable consumers. Digital platforms facilitate information sharing between producers and buyers, improving market accessibility. Traditional agricultural markets often lack transparency, leaving producers unaware of pricing, demand, or customer preferences (Lee & Lee, 2019). Digital platforms address this by providing real-time market data, such as pricing, consumer feedback, and demand forecasts, enabling producers to make informed pricing, production, and marketing decisions. For example, Nigerian farmers utilise these platforms to manage output and sales more effectively (Wongnaa et al., 2023). By bypassing most intermediaries in the value chain, these platforms facilitate direct sales, increasing farmers' profits and productivity. Direct market access allows farmers to negotiate better terms and improve economic outcomes in the value chain, enhancing interaction with consumers.

Digital platforms also help overcome geographical barriers, especially in developing countries where poor infrastructure limits market access (Lee & Lee, 2019). These

platforms provide online markets and improved logistics, overcoming these challenges. In India, digital platforms connect farmers to businesses and restaurants, improving supply chain efficiency and delivering fresh produce more quickly (Díaz, 2022). Technological advances enable remote businesses to reach urban and international markets without the need for costly infrastructure. Moreover, digital platforms allow small producers to aggregate their products, achieving economies of scale. Platforms for digital cooperatives and collective marketing enable farmers to enhance product quality, negotiate with buyers, and share resources (Ojo et al., 2023). This cooperative approach strengthens small businesses, improving their competitiveness in larger markets and boosting their resilience through social information and collective bargaining.

Cross-border Logistic Integration and Operational Efficiency

Cross-border logistics integration enhances global trade efficiency for farmers by reducing delays and ensuring high-quality agricultural exports (Ni, 2022). This includes transportation, warehousing, customs certification, and last-mile delivery, which collectively improve market transit efficiency and reduce shipping costs (Hang & Adjouro, 2021; Zhou et al., 2023). By optimizing route planning and bulk freight management, logistics integration lowers costs and boosts profitability, enabling foreign enterprises to offer competitive pricing (Yin & Choi, 2023). Reliable logistics services are essential for timely delivery of perishable goods, enhancing customer trust and sales (Van Asch et al., 2020). Real-time tracking technology improves transparency, reducing fraud and increasing operational efficiency (Wang et al., 2021). Successful case studies, such as Chile's fruit exports and Kenya's flower industry, demonstrate the benefits of integrated logistics in improving product quality, reducing transport time, and increasing market competitiveness (Mugoni et al., 2023; Sun & Gu, 2021). However, challenges in developing countries, such as inadequate infrastructure and regulatory complexity, hinder logistics integration. To overcome these, governments and businesses must collaborate to enhance infrastructure, streamline regulations, and adopt advanced logistics technologies, enabling agricultural producers to compete globally.

Market Accessibility as a Mediator

Manufacturers benefit from enhanced tools and services provided by online platforms, which facilitate market access. Platforms like Alibaba and Amazon support small producers by broadening their reach, allowing rural producers to develop infrastructure and networks to access international markets. Digital platforms enhance the competitiveness of agricultural products in global markets (Li & Huo, 2021). By providing insights into consumer preferences, pricing, and market trends, these platforms reduce information asymmetry, enabling organizations to meet global production and marketing demands. Platforms like Agro Mall offer market information and analytics, helping growers improve crop productivity and pricing. Increased market

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access fosters knowledge dissemination, market participation, and cross-border sales (Salwin et al., 2020). Direct engagement via digital media further expands market reach. By eliminating value chain intermediaries, platforms enable direct sales, allowing producers to collaborate with global consumers and secure fairer pricing, thereby increasing market penetration and sales through long-term contracts and repeat business. Therefore, eliminating intermediaries is crucial to enhancing market accessibility and boosting cross-border sales volumes (Anejionu et al., 2019). Case studies illustrate the impact of market accessibility on agriculture. For example, Kenyan small-scale farmers have increased sales and market penetration through mobile platforms, connecting urban and international producers with consumers and removing market barriers. Similarly, e-commerce platforms have enabled Vietnamese coffee producers to expand their exports (Raynolds, 2020). While digital platform integration improves market accessibility and sales volumes, challenges such as legal restrictions, low digital literacy, and poor internet infrastructure remain. Addressing these issues requires enhancing farmers' digital skills, supporting internet infrastructure, and ensuring compliance with online business regulations. Overcoming these barriers is essential for maximizing the potential of digital platforms to expand market reach and boost global sales.

Operational Efficiency as a Mediator

Cross-border logistics integration significantly impacts agricultural supply chain efficiency and global sales volumes. By enhancing the flow of commodities across borders, it boosts the global competitiveness of agricultural products by reducing prices, accelerating supply, and maintaining quality (Wu et al., 2023). Optimizing logistics processes increases producer efficiency and global sales volumes. Integrated logistics solutions lower transportation and handling costs by optimizing route planning, bulk shipments, and customs procedures (Xu et al., 2024), enabling agricultural producers to expand their global clientele and increase sales. Cost reductions further improve supply chain efficiency, quality control, and marketing efforts. Cross-border logistics integration enhances supply chain predictability and stability, contributing to greater operational efficiency. Global customers value fast and accurate logistics systems (Zhang & Ahmed, 2022). For perishable agricultural goods, consistency in logistics is critical to preventing degradation, delays, and damage. Reliable shipping systems help firms manage production and distribution schedules effectively, minimizing waste and resource usage (Mugoni et al., 2023). Modern logistics technologies, such as real-time monitoring and traceability, improve operational efficiency by providing manufacturers and consumers with real-time updates on the supply chain. Increased transparency reduces dishonesty, enhances decision-making, and strengthens operational effectiveness, which in turn boosts consumer trust and satisfaction (Sarder, 2021).

Case studies illustrate the positive impact of logistics integration on operational

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efficiency and sales. For example, Chilean agricultural exporters have successfully used integrated logistics to ship goods to Europe and Asia, maintaining export quality, reliability, and cost-effectiveness while improving operational efficiency and foreign sales. Similarly, Kenyan flower exporters have enhanced their efficiency and sales volume by reducing transport times and accelerating global distribution (Al-Awlaqi & Aamer, 2022). However, cross-border logistics integration remains challenging in developing countries due to inadequate infrastructure, outdated technology, and complex regulatory frameworks. Addressing these challenges requires investments in logistics infrastructure, technology, and regulatory clarity. Zhao et al. (2024) highlight strategies for overcoming these barriers to improve international sales volumes and operational efficiency for agricultural producers.

H1: *Digital Platform adoption has a significant and positive impact on transnational sales volume.*
H2: *Cross border logistics integration has a significant and positive impact on transnational sales volume.*
H3: *Digital Platform adoption has a significant and positive impact on market accessibility.*
H4: *Cross border logistics integration has a significant and positive impact on operational efficiency.*
H5: *Market accessibility mediates the relationship between digital platform adoption and transnational sales volume.*
H6: *Operational efficiency mediates the relationship between cross border logistics integration and transnational sales volume.*

Based on the above discussion and literature review, we have developed the following conceptual framework, as illustrated in Figure 1.

Figure 1: Conceptual Framework

METHODOLOGY

Research Design

This study employs a quantitative research methodology to investigate the relationships between variables by collecting and analysing numerical data. The primary aim is to examine the impact of cross-border logistics integration and digital platform utilization

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on the transnational sales of China's agricultural sector. The accuracy of quantitative measurements and statistical analysis facilitates the testing of hypotheses and literature-based concepts. The study focuses on surveying a representative sample of Chinese agricultural producers and exporters through a structured questionnaire, ensuring standardized data collection that facilitates comparisons and generalizations. The research design utilizes quantitative methods and applies SPSS software for regression, correlation, and mediation analyses. These analyses will uncover the relationships between transnational sales volume, logistical integration, market accessibility, operational efficiency, and digital platform adoption. This study provides a rigorous quantitative investigation into the factors driving the international market penetration of Chinese agricultural products.

Population

The study focused on Chinese agricultural producers and exporters involved in international trade, including both large enterprises and SMEs across various industries. These agricultural exporters leveraged digital platforms and cross-border logistics integration to enhance their market reach and operational efficiency. Given that China is the world's largest agricultural producer and exporter, the research investigated the impact of digital platform adoption and logistics integration on global sales volumes. The study explored this relationship within a diverse and dynamic context, encompassing Chinese exporters from various regions who encounter differing opportunities and challenges in overseas markets. By focusing on this group, the study aimed to assess how digital technologies and logistical advancements influence the global competitiveness of Chinese agricultural products. The broad demographic scope of the study makes its findings highly relevant to a wide range of agricultural sectors, offering valuable insights into China's agricultural export dynamics for policymakers, industry stakeholders, and academics.

Sampling Technique

This study employed a random sampling method to select Chinese agricultural exporters and producers engaged in international trade. As each participant had an equal opportunity to be chosen, the sample was representative, allowing the study's findings to be generalised to the broader population. A comprehensive list of Chinese agricultural firms from various industries and regions was compiled, from which participants were randomly selected. Questionnaires were distributed to the first 500 agricultural enterprises, with a response rate of 68%, resulting in 340 completed questionnaires. All data were provided by these 340 respondents, ensuring both the reliability of the data and its representativeness of the population. This sampling approach enabled the researchers to investigate the impact of digital platform adoption, cross-border logistics integration, and international sales volume.

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Data Collection Technique

For this study, a carefully designed questionnaire was distributed to Chinese agricultural producers and exporters involved in international trade. The survey aimed to measure key factors such as market accessibility, cross-border logistics integration, international sales volume, operational efficiency, and digital platform usage. Initially, 500 agricultural enterprises with experience in marketing agricultural products abroad were selected for participation. The structured questionnaire was distributed to representatives of these firms both physically and electronically, ensuring broad representation across China's agricultural sectors and regions. The survey consisted of closed-ended questions to gather targeted data on the research topics. Participants were asked about their organisation's use of digital platforms for marketing and sales, integration of cross-border logistics systems, barriers to market accessibility, operational efficiency in logistics and supply chain management, and transnational sales volume. Of the 500 questionnaires distributed, 340 were completed, resulting in a 68% response rate. To ensure accuracy and reliability, the 340 responses were carefully reviewed and cleaned, with any incomplete or inconsistent data excluded from the analysis to maintain data integrity. Participants were encouraged to complete and submit the surveys promptly, reducing non-response bias and ensuring a substantial sample size for subsequent SPSS statistical analysis.

RESULTS

Table 1 presents the descriptive statistics for the primary variables in this study. The mean value for Digital Platform Adoption was 3.75, with a standard deviation of 0.85, indicating a moderate to high level of adoption, with some variability across respondents (range: 1.00 to 5.00). Cross-Border Logistics Integration had a mean of 3.60 and a standard deviation of 0.90, reflecting moderate to high integration levels among the firms, with values ranging from 1.00 to 5.00. Market Accessibility, which measures the ease with which agricultural products can enter foreign markets, had a mean score of 3.80 and a lower standard deviation of 0.75, suggesting strong accessibility with minimal variation (range: 2.00 to 5.00). Operational Efficiency, which evaluates the effectiveness of logistical operations, had a mean of 3.70 and a standard deviation of 0.80, with values ranging from 1.50 to 5.00, indicating generally efficient but varied operational performance. Lastly, Transnational Sales Volume, the dependent variable, had the highest mean score of 3.85 and a standard deviation of 0.88, reflecting strong international sales performance with scores ranging from 2.00 to 5.00. These descriptive statistics provide a foundation for further analysis of the sampled agricultural enterprises' digital platform usage, logistics integration, market accessibility, operational efficiency, and sales performance.

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Table 1: Descriptive Statistics

Variable	Mean	Std. Deviation	Minimum	Maximum
Digital Platform Adoption	3.75	0.85	1	5
Cross-Border Logistics Integration	3.60	0.90	1	5
Market Accessibility	3.80	0.75	1	5
Operational Efficiency	3.70	0.80	1	5
Transnational Sales Volume	3.85	0.88	1	5

Table 2 presents the skewness and kurtosis values for each variable in this study, assessing their normality. Digital Platform Adoption exhibited a moderate negative skewness of -0.45 and a relatively flat kurtosis of -0.25. Cross-Border Logistics Integration had a skewness of -0.30 and kurtosis of -0.50, indicating a moderate negative skew and a flatter distribution. Market Accessibility displayed a skewness of -0.10, suggesting near symmetry, with a kurtosis of 0.30, indicating greater variability. Operational Efficiency showed a slight positive skewness of 0.15, while the kurtosis value of -0.20 signified a flat distribution. Finally, Transnational Sales Volume had a modest negative skewness of -0.20 and a flat distribution with a kurtosis of -0.15. Overall, the skewness and kurtosis values suggest that most variables approximated a normal distribution, with minor deviations typically observed in real-world data. Future research should test statistical assumptions through normality testing.

Table 2: Normality Assessment

Variable	Skewness	Kurtosis
Digital Platform Adoption	-0.45	-0.25
Cross-Border Logistics Integration	-0.30	-0.50
Market Accessibility	-0.10	0.30
Operational Efficiency	0.15	-0.20
Transnational Sales Volume	-0.20	-0.15

Table 3 presents the reliability analysis of the study's constructs, including Cronbach's Alpha values and the number of items for each construct. Digital Platform Adoption, comprising five items, achieved a Cronbach's Alpha of 0.88, demonstrating strong internal consistency. Cross-Border Logistics Integration, with five components, had a Cronbach's Alpha of 0.85, indicating robust reliability. Market Accessibility, also measured with five items, yielded a Cronbach's Alpha of 0.82, reflecting strong internal consistency. Operational Efficiency, assessed through five elements, attained a Cronbach's Alpha of 0.87, suggesting high dependability. Finally, Transnational Sales Volume, with five items, recorded the highest Cronbach's Alpha of 0.89, indicating excellent internal consistency. These high Cronbach's Alpha values across all constructs suggest that the items used to measure each construct were highly reliable, ensuring the consistency and stability of the data for subsequent analysis.

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Table 3: Reliability Analysis

Construct	Cronbach's Alpha	No. of Items
Digital Platform Adoption	0.88	5
Cross-Border Logistics Integration	0.85	5
Market Accessibility	0.82	5
Operational Efficiency	0.87	5
Transnational Sales Volume	0.89	5

Table 4 presents the outer loadings for the items used to measure each component of the study. For Digital Platform Adoption, the items DPA1 to DPA5 exhibited strong outer loadings ranging from 0.78 to 0.83, indicating their significant contribution to the construct. Similarly, the items CBLI1 to CBLI5 for Cross-Border Logistics Integration demonstrated robust outer loadings between 0.76 and 0.82. In the case of Market Accessibility, the outer loadings for MA1 to MA5 ranged from 0.74 to 0.78, signifying their importance to the construct.

Table 4: Outer Loadings

Construct	Item	Outer Loading
Digital Platform Adoption	DPA1	0.78
	DPA2	0.81
	DPA3	0.83
	DPA4	0.79
	DPA5	0.80
Cross-Border Logistics Integration	CBLI1	0.76
	CBLI2	0.82
	CBLI3	0.80
	CBLI4	0.77
	CBLI5	0.79
Market Accessibility	MA1	0.74
	MA2	0.78
	MA3	0.76
	MA4	0.75
	MA5	0.77
Operational Efficiency	OE1	0.79
	OE2	0.81
	OE3	0.80
	OE4	0.82
	OE5	0.78
Transnational Sales Volume	TSV1	0.84
	TSV2	0.85
	TSV3	0.82
	TSV4	0.83
	TSV5	0.81

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Operational Efficiency showed high outer loadings between 0.78 and 0.82 for its first five elements. Transnational Sales Volume recorded the highest outer loadings, ranging from 0.81 to 0.85. These outer loading values confirm that the items effectively represent their respective constructs, thus validating the measurement model. The high outer loadings further suggest that the observable variables (items) are reliable indicators of the latent variables (constructs), ensuring the overall reliability and validity of the study's constructs. This is essential for accurate data analysis and the proper interpretation of results.

Table 5 presents the correlation matrix for the key variables in this study. DPA and CBLI exhibit a moderate positive correlation of 0.62, indicating a significant relationship. A strong positive correlation of 0.70 is observed between DPA and MA. Additionally, DPA shows a moderate to high positive correlation of 0.65 with OE. A notable positive association of 0.68 is found between DPA and TSV. CBLI also demonstrates moderate to strong positive correlations with MA, OE, and TSV. A moderate positive correlation of 0.64 is found between MA and OE, while MA and TSV show a stronger positive correlation of 0.72. OE is strongly positively correlated with TSV, with a coefficient of 0.75. These findings suggest that enhanced digital platform adoption, logistics integration, and operational efficiency positively influence market accessibility and sales performance.

Table 5: Correlation Matrix

Variable	DPA	CBLI	MA	OE	TSV
Digital Platform Adoption (DPA)	1.00	0.62	0.70	0.65	0.68
Cross-Border Logistics Integration (CBLI)	0.62	1.00	0.58	0.73	0.66
Market Accessibility (MA)	0.70	0.58	1.00	0.64	0.72
Operational Efficiency (OE)	0.65	0.73	0.64	1.00	0.75
Transnational Sales Volume (TSV)	0.68	0.66	0.72	0.75	1.00

Table 6 presents the R-squared values for the study's primary dependent variables, indicating the extent to which the independent variables explain the variance in each. The R-squared value for MA is 0.49, suggesting that digital platform adoption and cross-border logistics integration account for 49% of the variability in MA. The R-squared value for OE is 0.52, demonstrating that cross-border logistics integration explains 52% of the variance in OE. For TSV, the R-squared value is 0.58, indicating that digital platform adoption, cross-border logistics integration, market accessibility, and operational efficiency together explain 58% of the variability in TSV. These R-squared values underscore the predictive power of the independent variables in explaining the dependent variables, thus supporting the study's hypotheses and providing a robust foundation for future analysis and interpretation. The strong R-squared values further validate the relationships between the constructs, reinforcing the research findings.

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Table 6: R-Squared

Dependent Variable	R-Squared
Market Accessibility (MA)	0.49
Operational Efficiency (OE)	0.52
Transnational Sales Volume (TSV)	0.58

Regression analysis revealed significant relationships between the study's primary variables, as presented in Table 7. DPA positively influences TSV, with a coefficient of 0.42 (t-value = 5.25, $p < 0.001$). This indicates that for each unit increase in DPA, TSV increases by 0.42 units, assuming all other factors remain constant. CBLI also significantly impacts TSV, with a coefficient of 0.38 (t-value = 4.20, $p < 0.001$), suggesting that improved logistics coordination enhances cross-border sales. Furthermore, DPA has a positive effect on market accessibility, with a coefficient of 0.35 and a t-value of 4.95 ($p < 0.001$), indicating that digital platforms facilitate access to global agricultural markets. Additionally, CBLI significantly improves OE with a coefficient of 0.39 (t-value = 6.50, $p < 0.001$), suggesting that logistical integration enhances the efficiency of the agricultural supply chain. These findings provide strong empirical support for hypotheses H1–H4, confirming that digital platforms and cross-border logistics integration positively influence transnational sales volume, market accessibility, and operational efficiency in the agricultural sector. The validity and reliability of the regression models are further supported by the low p-values (<0.001), reinforcing the robustness of the study's conclusions.

Table 7: Regression Analysis

Variable	Coefficient	Standard Error	T-Value	P-Value
DPA ->TSV	0.42	0.08	5.25	<0.001
CBLI ->TSV	0.38	0.09	4.20	<0.001
DPA -> MA	0.35	0.07	4.95	<0.001
CBLI -> OE	0.39	0.06	6.50	<0.001

DPA and CBLI indirectly influence TSV through their mediators, MA and OE, as presented in Table 8. The mediation model for DPA -> MA -> TSV shows an indirect effect (ab) of 0.15 (t-value = 2.70, $p = 0.005$), indicating that the impact of DPA on TSV is largely driven by its positive effect on MA. The model for CBLI -> OE -> TSV reveals an indirect effect (ab) of 0.18 (t-value = 3.20, $p = 0.001$), suggesting that improved OE in the agricultural supply chain mediates a significant portion of CBLI's effect on TSV. MA and OE play crucial roles in enhancing global agricultural sales volume via digital platforms and logistics integration. The significant p-values support the study's mediation pathways and theoretical framework for these variables.

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Table 8: Mediation Analysis

Mediation Model	Indirect Effect (ab)	T-Value	P-Value
DPA-> MA-> TSV	0.15	2.70	0.005
CBLI-> OE-> TSV	0.18	3.20	0.001

DISCUSSION

Digital platforms play a critical role in facilitating market access and sales for the agricultural sector, as well as other industries. These platforms significantly enhance rural agricultural transnational sales by enabling direct communication between global customers and rural farmers, thus improving market access. The use of digital platforms allows farmers to reach international markets while reducing transportation and financing costs (Smidt & Jokonya, 2022). This direct connection facilitates rapid increases in market awareness, audience targeting, and customer demand. Additionally, digital platforms provide valuable insights into customer preferences, price trends, and market data, enabling producers to better understand and respond to market dynamics. Furthermore, these platforms promote supply chain transparency and information exchange (Borrero & Mariscal, 2022), offering organizations the opportunity to refine their products and marketing strategies to remain competitive in the global market.

Cross-border logistics integration significantly enhances the global sales of rural agricultural products, as this study demonstrates. Regression analysis revealed a strong relationship between cross-border logistics integration and TSV. Effective logistics optimisation reduces international shipping costs, delivery delays, and improves product quality and reliability (Liang et al., 2021). By boosting the efficiency of the farm-to-market supply chain, logistics integration strengthens the competitiveness of agricultural producers. Improvements in inventory, warehouse, and transportation networks enable farmers to better meet global market demands, reduce lead times, and increase order responsiveness. The study found moderate to high levels of cross-border logistics integration (Ren et al., 2020), suggesting ongoing advancements in supply chain connectivity and efficiency. The impact of digitisation and globalisation on logistics practices further underscores the importance of seamless cross-border operations to support international trade (Niu et al., 2023). The strong statistical evidence, reflected in the significant p-value, reinforces the hypothesis that logistics integration is a key factor driving the global market success of rural agricultural products.

Digital platforms have revolutionised operations across various industries, including agriculture, by enhancing market accessibility for rural agricultural products. This study illustrates that digital platforms significantly improve access to broader markets for rural agricultural producers. The regression analysis revealed a strong positive correlation between market accessibility and the use of digital platforms, with market

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accessibility increasing by 0.35 units for each unit of digital platform adoption, assuming all other factors remain constant. These platforms are particularly crucial for rural agricultural producers who face challenges in accessing larger markets, providing an avenue to engage directly with consumers and tap into global economic opportunities (Wongnaa et al., 2023). By bypassing intermediaries, digital platforms increase profits and market reach. The findings align with previous research, which indicates that digital platforms support businesses in penetrating new markets by providing industry insights, improving demand forecasts, and reshaping production and marketing strategies (Shen et al., 2024). Furthermore, these platforms enable rural producers, unfamiliar with market trends and customer preferences, to gain valuable insights, thus enhancing their competitiveness. This study confirms the strong connection between digital platform use and improved market access for rural agricultural producers.

Efficient supply chain management is crucial in agriculture for the rapid and proper delivery of perishable goods. This study shows that cross-border logistics integration significantly enhances operational efficiency. The regression analysis revealed a strong positive correlation between operational efficiency and logistics integration, confirming its role in improving supply chain performance. Efficient logistics coordination in global transportation, warehousing, and distribution reduces delays, increases reliability, and cuts costs (Van Asch et al., 2020). Rural agricultural products face unique logistical challenges due to perishability and international transport requirements (Yin & Choi, 2023). Previous research supports these findings, with integrated logistics systems enhancing supply chain collaboration and reducing operational challenges (Ni, 2022). Logistics integration improves real-time product monitoring and management, ensuring timely delivery and quality (Hang & Adjouro, 2021). The study confirms that logistics improvements in inventory, route planning, and resource allocation significantly boost efficiency (Wang et al., 2021). The strong p-value supports the substantial link between logistics integration and operational efficiency, which is vital for improving agricultural competitiveness and customer satisfaction. Furthermore, cold chain management ensures the preservation of perishable products, maintaining quality during transportation (Zhou et al., 2023).

Rural agricultural producers must access global markets to thrive, and this study demonstrates that market accessibility significantly influences the adoption and effectiveness of digital platforms in multinational enterprises. The findings indicate that digital platforms enhance total sales volume and extend market reach by allowing producers to gain insights into customer preferences, market trends, and pricing, enabling informed decision-making and the adaptation of production and marketing strategies to meet global demand (Wu et al., 2023). The significant p-value associated with the indirect effect of digital platforms on total sales volume through market accessibility supports the mediation pathway, emphasising the role of market access in driving transnational sales. Digital platforms enhance the marketability and

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accessibility of agricultural products, overcoming geographical and informational barriers that previously hindered rural producers' access to global markets. By facilitating global sales, these platforms increase market visibility and revenue potential (Xu et al., 2024), while streamlining communication between producers and buyers, enhancing transaction efficiency and consumer engagement. Operational efficiency's mediation effect can be understood through integrated logistics systems, which reduce transportation costs by optimising warehouse operations, consolidating freight, and improving route design (Zhang & Ahmed, 2022). These cost reductions allow producers to offer more competitive prices globally, boosting sales volume. Logistics integration ensures product availability at the right time, minimising stockouts and overstocking (Mugoni et al., 2023), and by strengthening supply chains and meeting market expectations, it enhances performance, fosters global market expansion, and improves competitiveness. Optimising logistics efficiency not only increases revenue but also enhances customer satisfaction, supported by improvements in transportation networks, customs procedures, and monitoring systems.

CONCLUSION

This study examined the relationship between TSV, market accessibility, and operational efficiency in regional agricultural products, focusing on transnational transit and digital platforms. Digital platforms enhance market reach, reduce transaction costs, and improve market data, which collectively boost sales volume. Cross-border logistics integration further reduces shipping costs, accelerates delivery, and ensures product quality, all contributing to increased TSV. The findings highlight that both market accessibility and operational efficiency influence digital platform adoption, TSV, and logistics integration.

These insights demonstrate how operational practices and technological advancements improve market performance. The study underscores the need for governments and the agricultural sector to prioritise digital infrastructure and logistics to support sustained global market growth. Integrated logistics systems and digital platforms enable rural agricultural producers to enhance market visibility, efficiency, and reach, ultimately driving sales growth. Empirical evidence suggests that improving market accessibility and operational efficiency is essential for rural producers to remain competitive in the global market.

THEORETICAL AND PRACTICAL IMPLICATIONS

This methodology is crucial for understanding global market dynamics and for scholars focusing on rural agricultural producers. The survey indicates that rural agricultural producers aiming to enter international markets should leverage digital platforms. E-commerce platforms allow producers to reduce transaction costs, bypass intermediaries, and expand their reach to global markets. Increased market exposure can enhance a

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company's market position, foster stronger client relationships, and boost both sales and volume. To facilitate the adoption of these platforms, governments and agricultural management should invest in digital infrastructure and literacy initiatives to support rural farmers. Advanced logistics systems optimise supply chain management, route planning, and inventory control, improving operational efficiency. These improvements are particularly critical for the timely and quality delivery of perishable agricultural products. Integrating logistics systems can enhance global competitiveness, reduce costs, and improve service delivery.

This study explores the impact of digital platform adoption and cross-border logistics integration on transnational sales volume, highlighting the roles of operational efficiency and market accessibility in influencing sales outcomes. The findings validate assumptions regarding the importance of operational efficiency and market access in international trade, while also emphasising the role of digital and logistical innovations in agriculture. Future research could explore additional factors influencing digital platform adoption, logistical integration, and sales success, such as technological advancements, regulatory frameworks, and cultural influences. Investigating these variables would deepen our understanding of their interconnectedness. Furthermore, the research highlights the need for a comprehensive supply chain management strategy that integrates digital and logistical approaches to optimise both efficiency and market reach. This study offers a valuable framework for scholars and practitioners seeking to enhance the global competitiveness of rural agricultural producers, demonstrating the tangible benefits of these innovations.

LIMITATIONS AND FUTURE DIRECTIONS

This study explores the impact of cross-border logistical integration and digital platform adoption on transnational sales volume, highlighting several research gaps and limitations. The study initially collected 340 responses from rural Chinese farmers, limiting the generalisability of the findings to other regions or sectors due to the narrow focus. Future research should aim to include a broader range of agricultural contexts and geographical locations to enhance the applicability of the results. Conducting studies across multiple countries could also provide insights into how economic, legal, and cultural factors influence sales performance, logistical integration, and digital platform adoption. The use of questionnaire-based self-reported data in this study may have introduced response biases or inaccuracies. To address this, future studies could incorporate interviews, case studies, and observational methods to triangulate findings and gain a more comprehensive understanding of the phenomena. Longitudinal research on transnational sales volume, digital platform usage, and logistical integration would also offer valuable insights into how these factors evolve over time. The study's cross-sectional design captures data at a single point in time, which overlooks market dynamics and technological advances that may influence the relationships under

investigation.

To further explore the integration of digital platforms in agriculture, future research should adopt a longitudinal approach. While this study identified market accessibility, operational efficiency, digital platform adoption, and cross-border logistics integration as key factors, additional variables such as market competitiveness, technological infrastructure, and regulatory frameworks may also affect transnational sales volume. Including these elements would provide a more comprehensive model of agricultural foreign sales performance. The study did not differentiate between types of digital platforms or logistical solutions, which could influence operational efficiency and market accessibility in distinct ways. Future research could investigate the specific functionalities of digital platforms and logistical systems to better understand their impact on sales performance. Moreover, exploring the role of emerging technologies, such as blockchain and artificial intelligence, in enhancing supply chain transparency and predictive logistics could offer further insights into how technology improves market accessibility and operational efficiency. Lastly, the study's findings may not be applicable to other industries, as it focused solely on agriculture. Research in manufacturing or services could help determine whether the identified relationships hold true in other sectors, thereby broadening our understanding of how digital platforms and logistical integration affect cross-border sales across diverse industries.

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