

Research Article

ENHANCING SMALLHOLDER AND RETAILER COMPETITIVENESS THROUGH EFFICIENT AND DYNAMIC VEGETABLE SUPPLY CHAINS IN CAMBODIA

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Article History:

Received: 15 Sept 2026 | **Accepted:** 20 Sept 2026 | **Published:** 27 Sept 2026

DOI: <https://doi.org/10.5281/zenodo.22997202>

*** Related declarations are provided in the final section of this article.*

Abstract

The study examined strategies for improving the competitiveness of smallholder farmers and retailers through efficient and dynamic vegetable supply chains in Cambodia. The study was motivated by persistent challenges relating to fragmented marketing systems, inadequate post-harvest infrastructure, weak governance coordination, and limited market integration, which constrain the performance of the vegetable sector. The study was grounded in Dynamic Capabilities Theory, which explains how organisations and supply-chain actors develop, integrate, and reconfigure resources and capabilities to respond effectively to changing market conditions. The study was conducted using a mixed-methods research design that consisted of a cross-sectional survey of 420 smallholder vegetable producers, 85 key informant interviews, and six focus group discussions. The quantitative data were analysed using descriptive statistics, multiple regression, ANOVA, and Structural Equation Modelling (SEM), while the qualitative data were analysed thematically. The results show that the respondents strongly agreed that efficient supply chains are important in improving competitiveness, household income, and retailer profitability. Supply-chain efficiency and governance coordination explained 66.3% of the variation in competitiveness ($R^2 = 0.663$, $R = 0.814$), according to regression analysis. The regression model was statistically significant ($F = 118.463$; $p < 0.001$). Supply-chain efficiency had the strongest impact on competitiveness ($\beta = 0.603$, $p <$

0.001). Governance coordination improved supply-chain performance significantly ($\beta = 0.384$, $p < 0.001$). The SEM also revealed a significant positive effect of supply-chain efficiency on competitiveness ($\beta = 0.684$, $p < 0.001$) and governance coordination on supply-chain performance ($\beta = 0.592$, $p < 0.001$). The study found that efficient logistics, collaborative governance, digital innovation, market integration, and better post-harvest systems are essential to boost competitiveness. It is recommended that Cambodia develop resilient and sustainable vegetable supply chains through strengthening agricultural cooperatives, expanding cold-chain and storage infrastructure, promoting digital market information systems, improving stakeholder collaboration, and increasing government investment in supportive policies and rural infrastructure.

Keywords: Vegetable supply chains; Smallholder competitiveness; Governance coordination; Dynamic Capabilities Theory; Cambodia.

1. Introduction

Agricultural supply chains are crucial for food security, the economic development of rural areas, and the competitiveness of agricultural stakeholders in developing economies. The vegetable subsector is important for household nutrition, employment, and income diversification for smallholder farmers in Southeast Asia. However, the increasing integration of domestic and international markets has heightened competition, demanding that agricultural supply chains be more efficient, resilient, and responsive to changing consumer preferences. Governments and development organisations have thus increasingly seen supply chain modernisation as a strategic approach to increase agricultural productivity, reduce post-harvest losses, and improve market access for smallholder producers and retailers (Food and Agriculture Organisation [FAO], 2023; World Bank, 2024).

In Cambodia, agriculture remains an important pillar of national economic development and rural livelihoods despite gradual industrialisation. Vegetable production has grown significantly due to increased urbanisation, population growth, and consumer demand for fresh and safe produce. However, the domestic vegetable market is still marked by fragmented production systems, poor storage facilities, inefficient transportation networks, limited market information, and weak coordination among farmers, traders, cooperatives, wholesalers, and retailers. Structural inefficiencies limit the capacity of smallholder farmers and retailers to effectively compete with imported vegetables from neighbouring countries,

leading to reduced profitability and limiting opportunities for sustainable agricultural development (Asian Development Bank, 2024; FAO, 2023).

Efficient and dynamic vegetable supply chains are increasingly acknowledged as important mechanisms to improve competitiveness along agricultural value chains. Supply chain efficiency is the effective coordination of production, harvesting, transportation, storage, processing, and distribution activities to reduce operational costs while maintaining product quality and market responsiveness. Dynamic supply chains also include adaptive, innovative, digitised, collaborative governance and swift responses to evolving market conditions. Such characteristics increase product availability, reduce post-harvest losses, build trust among stakeholders, and improve the overall performance of agricultural markets. Empirical evidence shows that improved governance, market coordination, digital market information systems, and investment in logistics infrastructure can significantly improve the competitiveness and resilience of smallholder agricultural supply chains in developing countries (Organisation for Economic Co-operation and Development [OECD], 2023; World Bank, 2024).

The performance of the vegetable supply chain is subject to continuous legislative initiatives to modernise Cambodia's agricultural industry. Access to high-quality inputs, financial services, storage facilities, market knowledge, and organised marketing channels is often restricted for smallholder farmers. In a similar vein, merchants deal with erratic product quality, erratic supply volumes, volatile pricing, and ineffective delivery networks. According to the Asian Development Bank (2024) and the United Nations Development Programme (UNDP) (2023), these limitations impair supply chain integration, lower stakeholder profitability, and compromise long-term competitiveness in both domestic and regional markets.

In light of this, a more thorough study is still required to determine how market dynamics, supply chain efficiency, government coordination, and stakeholder cooperation all affect smallholder farmers' and merchants' ability to compete in Cambodia's vegetable industry. Policymakers, agricultural cooperatives, development partners, and business sector players looking to bolster sustainable vegetable supply chains are anticipated to gain evidence-based insights from such an assessment. In the end, improving dynamic and efficient vegetable supply chains is expected to boost market access, generate more revenue, strengthen the resilience of the food system, and encourage inclusive agricultural growth across Cambodia.

This study examines the influence of supply chain enablers on performance outcomes and their effect on the competitiveness of smallholders and vegetable retailers in Cambodia, considering the moderating effect of contextual factors.

2. Empirical Review of Literature and Theoretical Framework

The study situates itself within current scholarship on vegetable supply chains, smallholder performance, and retail competitiveness through an empirical evaluation of literature and a theoretical framework. This paper presents findings on efficiency, governance, market integration, cooperation, and post-harvest systems based on Dynamic Capabilities Theory. This framework provides an explanation of how adaptive supply chain methods might boost competitiveness and resilience in Cambodia's vegetable sector.

2.1 Supply Chain Efficiency and Competitiveness of Smallholder Farmers and Retailers

According to recent empirical data, vegetable competitiveness is influenced not only by production levels but also by the effectiveness of market connections, quality control, and coordination across the chain. San and Tan (2022) discovered that while cooperative channels performed better because formal contracts and buyer trust reduced linkage problems, smallholder vegetable supply chains in Cambodia were hampered by inconsistent supply, poor post-harvest handling, financial mistrust, and quality degradation. According to Widadie, Wulandari, and Lestari (2024), access to high-value markets required adherence to food safety regulations, better post-harvest handling, and stronger partnerships, while smallholders in traditional vegetable markets captured limited value because of poor vertical and horizontal coordination. Relational aspects are also important, according to regional data. Luoga, Nyangarika, and Mkunda (2026) found that exchange certainty, social organization, and trust greatly enhanced the performance of the vegetable supply chain among smallholders in Northern Tanzania.

The Transforming Agrifood Systems study, which calls for modern cooperatives and better market access while highlighting disjointed supply chains, insufficient cold chains and storage, and ongoing vegetable losses, supports similar conclusions for Cambodia. To better understand shocks, adaptability, and food poverty across holdings, more robust agricultural data systems are required, as the Cambodia Agriculture Survey 2023 emphasizes. The research as a whole suggests that improved relational coordination, effective logistics, and dynamic governance will be necessary for retailer and farmer competitiveness. Nevertheless,

there is still a dearth of empirical research on the combined effects of these variables on merchants and smallholders in Cambodian vegetable chains.

2.2 Governance, Coordination, and Stakeholder Collaboration in Vegetable Supply Chains

Governments, NGOs, traders, and retailers influence sustainability, information flows, and compliance through official and informal coordination mechanisms in vegetable supply chain governance, which is increasingly recognised as a multi-actor process (Siems et al., 2023; Otter & Robinson, 2024). Collaborative short food supply chains are linked to better economic, social, and environmental outcomes as well as joint reflection that supports corrective action, while repeated interaction, mutual learning, and value co-creation generate relational benefits and strengthen resilience in perishable food chains, according to collaboration studies (Stoeva et al., 2024; Mengoni et al., 2025).

In contrast, cooperative chains backed by formal contracts and buyer trust create more stable incentives for investment; in Cambodia, evidence from the vegetable chain demonstrates that profitability is limited by weak market linkages, financial mistrust, inconsistent quality, and limited post-harvest management (San & Tan, 2022). According to the literature, governance arrangements that coordinate standards, contracts, logistics, and shared information across actors from farm to market are more important for smallholder and retailer competitiveness than isolated production gains (Siems et al., 2023; Otter & Robinson, 2024).

2.3 Market Dynamics, Value Chain Integration, and Competitiveness in Vegetable Supply Chains

In agricultural supply chains, market dynamics and value chain integration are widely acknowledged as key factors that determine competitiveness, especially in the vegetable industry where goods are very perishable, and market conditions change quickly. According to recent research, effective coordination between farmers, traders, wholesalers, retailers, and supporting organisations characterises competitive vegetable supply chains, allowing for prompt market reactions, lower transaction costs, and higher-quality products. Additionally, market-oriented supply chains improve the economic performance of smallholder farmers and merchants by facilitating improved price discovery, increased access to domestic and export markets, and stronger bargaining leverage.

Value chain integration boosts competitiveness by fostering information exchange, contractual ties, coordinated logistics, and adoption of quality standards across the manufacturing and distribution phases, according to recent studies. Integrated value chains increase supply chain resilience against market disruptions, reduce post-harvest losses, and improve operational efficiency. Fresh produce supply chains provide evidence that cooperative integration allows stakeholders to align production with consumer demand, leading to increased profitability and long-term competitive advantage.

Emerging data indicate that the competitiveness of vegetable supply chains in Cambodia is still hampered by disjointed marketing systems, poor post-harvest infrastructure, low-quality standard compliance, and poor market coordination. While some farmers' market involvement has increased as a result of programs supporting value chain development and good agricultural practices, many smallholders still rely on unofficial trade agreements and are poorly integrated into contemporary marketing systems. These structural constraints limit value creation, lower market efficiency, and erode supply chain competitiveness.

As a result, research on how market dynamics and value chain integration affect smallholder farmers' and merchants' competitiveness throughout Cambodia's vegetable supply chains is severely lacking. In order to create evidence-based policies that promote stakeholder integration, boost supply chain efficiency, and increase the long-term competitiveness and sustainability of the nation's vegetable industry, this gap must be filled.

2.4 Cooperative Management, Market Access, and Smallholder Performance

According to the research, organised producer groups can lower transaction costs, increase bargaining power, and enhance access to capital, technology, inputs, and product markets, all of which have a significant impact on smallholder competitiveness (IFC, 2023; Kale et al., 2025). Cooperative efficacy, however, is not a given; performance is still determined by member involvement, leadership calibre, information flows, and the capacity to adjust to shifting market demands. While inadequate support services prevent greater involvement in value-chain activities, recent research indicates that cooperatives positively impact lives where access to information, education, quality control, and structured marketing is available (Christian et al., 2024).

These dynamics are particularly relevant in Cambodia's vegetable supply chains. Value-chain analysis reveals that while cooperative chains with formal contracts, better knowledge sharing, and stronger buyer relationships create more stable market conditions for farmers and

downstream traders, even when price advantages remain modest, informal trading relationships, poor post-harvest handling, and financial mistrust reduce profitability (San & Tan, 2022).

According to IFAD project data, when technical assistance, financial literacy, and institutional coordination are in place, inclusive market interventions can boost sales through producer organisations and enhance farm incomes (IFAD, 2024). The literature as a whole indicates that dynamic and effective vegetable supply chains may enhance the performance of smallholders and retailers. However, there is still little data from Cambodia regarding how cooperative management can be set up to ensure long-term market access and ongoing competition among chain participants.

2.5 Post-Harvest Management, Logistics, and Supply Chain Resilience in Vegetable Marketing

Given that fresh vegetables are highly perishable and vulnerable to quality degradation during harvesting, handling, storage, transportation, and retailing, post-harvest management, logistics, and supply chain resilience have emerged as key factors that determine competitiveness within vegetable value chains. Effective post-harvest procedures reduce physical losses, maintain product quality, increase shelf life, and boost marketability, all of which increase profitability for smallholder farmers and merchants, according to recent research.

Appropriate harvesting methods, grading, packaging, cold storage, and temperature-controlled transportation are all components of successful post-harvest systems that lower waste and boost customer satisfaction (Umar et al., 2026; Tort et al., 2022). According to recent research, poor road networks, inadequate cold-chain facilities, poor logistics infrastructure, and a lack of coordination among supply chain participants continue to be major obstacles in developing agricultural economies, leading to significant post-harvest losses and decreased marketing effectiveness (Anand & Barua, 2022; Sanjaya et al., 2022).

Supply chain resilience extends beyond operational efficiency by emphasising the capacity of supply chains to anticipate, endure, adapt to, and recover from shocks such as climate variability, transportation interruptions, market volatility, and infrastructure failures. Robust vegetable supply chains require integrated logistics systems, collaborative governance, digital monitoring technologies, information sharing, and coordinated decision-making among producers, traders, wholesalers, retailers, and policymakers, according to recent research

(Umar et al., 2026; Nguyen et al., 2022). These skills improve responsiveness to unanticipated shocks while maintaining product quality and ensuring market supply continuity.

Vegetable marketing in Cambodia still faces significant post-harvest difficulties because of dispersed distribution networks, poor handling procedures, and inadequate cold-chain infrastructure. Improvements in packing, consolidation, transportation, and coordinated logistics significantly lower product losses while boosting farmers' and retailers' market competitiveness, according to earlier research (Buntong et al., 2022). However, there is no empirical data that thoroughly investigates how supply chain resilience, logistical effectiveness, and post-harvest management all affect Cambodian smallholders' and merchants' ability to compete. This gap warrants more research into integrated approaches that can create dynamic and effective vegetable supply chains that improve long-term market performance.

2.6 Theoretical Framework and Implications for the Study

The Dynamic Capabilities Theory (DCT), which offers a solid theoretical framework for investigating how effective and dynamic vegetable supply chains boost the competitiveness of smallholder farmers and merchants in Cambodia, serves as the foundation for this study. Dynamic Capabilities Theory, which was first developed by Teece, Pisano, and Shuen and has since been further developed in supply chain scholarship, describes how organisations acquire the ability to integrate, construct, and reconfigure internal and external resources in response to quickly shifting market conditions.

Dynamic skills are essential for enhancing supply chain resilience, sustainability, business model innovation, and competitive advantage in increasingly turbulent agricultural markets, according to recent theoretical discoveries (Land et al., 2022). Therefore, the theory is especially pertinent to agricultural value chains that are marked by fragmented production systems, shifting consumer demand, market uncertainty, and climatic unpredictability.

Smallholder farmers and merchants in Cambodia's vegetable industry work in a setting where competitiveness is hampered by production inefficiencies, poor market coordination, poor logistics, post-harvest losses, and a lack of market knowledge. According to the Dynamic Capabilities Theory, these actors may enhance their performance by consistently identifying market possibilities, taking advantage of new business chances through innovation, and modifying current operational procedures to successfully adapt to shifting environmental conditions.

Supply chain partners may embrace better production and marketing technology, enhance coordination, increase information exchange, and build cooperative connections with other value chain actors thanks to these capabilities. As a result, the theory clarifies how supply chain adaptation, flexibility, and learning all work together to support long-term competitive success.

The idea goes on to say that having valuable resources is not the only factor that determines competitiveness, but also the capacity to continually replenish and use those resources in response to changes in the environment. According to recent supply chain research, companies with strong dynamic capabilities outperform those that solely rely on static resource advantages in terms of market performance, operational efficiency, responsiveness, and resilience against supply disruptions (Kalubanga & Gudergan, 2022; Land et al., 2022). This perspective is especially relevant to Cambodia's vegetable supply chains, where competitiveness increasingly depends on quick adaptability to shifting distribution networks, digital market platforms, quality standards, and customer preferences. Additionally, supply chain efficiency, governance, market integration, innovation, logistics, and competitiveness may all be explained through the lens of dynamic capabilities theory. Farmers, merchants, wholesalers, retailers, transportation companies, and supporting organisations must constantly coordinate for supply chains to be effective. According to the theory, supply chain capabilities are strengthened by cooperative learning, information sharing, institutional support, and technological innovation. This increases productivity, lowers transaction costs, minimises post-harvest losses, improves product quality, and opens up new markets. In the end, these enhancements boost retailer competitiveness and farm profitability while fortifying the resilience of the whole vegetable value chain.

The conceptualisation of the independent variables in this study, such as supply chain integration, governance mechanisms, logistics efficiency, market information systems, technological adoption, and stakeholder collaboration, as organisational capabilities that collectively affect the dependent variable of competitiveness, is also supported by the theoretical framework. How these skills translate into better economic performance for smallholder farmers and merchants is explained by the mediating processes of flexibility, coordination, innovation, and resilience.

2.6.1 Implications for the Study

Adopting Dynamic Capabilities Theory has important ramifications for practice and policy. By showing that competition within agricultural supply chains is a dynamic process driven by ongoing competence growth rather than static resource ownership, the framework theoretically expands on current understanding. In order to improve the adaptability of supply chain participants, the framework recommends that government agencies, development partners, agricultural cooperatives, and private sector actors prioritise investments in capacity building, digital market systems, logistics infrastructure, institutional coordination, and innovation. Vegetable farmers and retailers would be able to maintain long-term competitiveness while successfully responding to market uncertainty thanks to such measures. All things considered, Dynamic Capabilities Theory provides a thorough explanation of how effective and dynamic vegetable supply chains give Cambodian smallholder farmers and merchants a competitive edge. As a result, it directly supports the goals and conceptual framework of the current study by offering a cogent theoretical basis for examining the connections between supply chain capabilities, operational efficiency, resilience, market responsiveness, and sustainable competitiveness.

2.6.2 Conceptual Framework

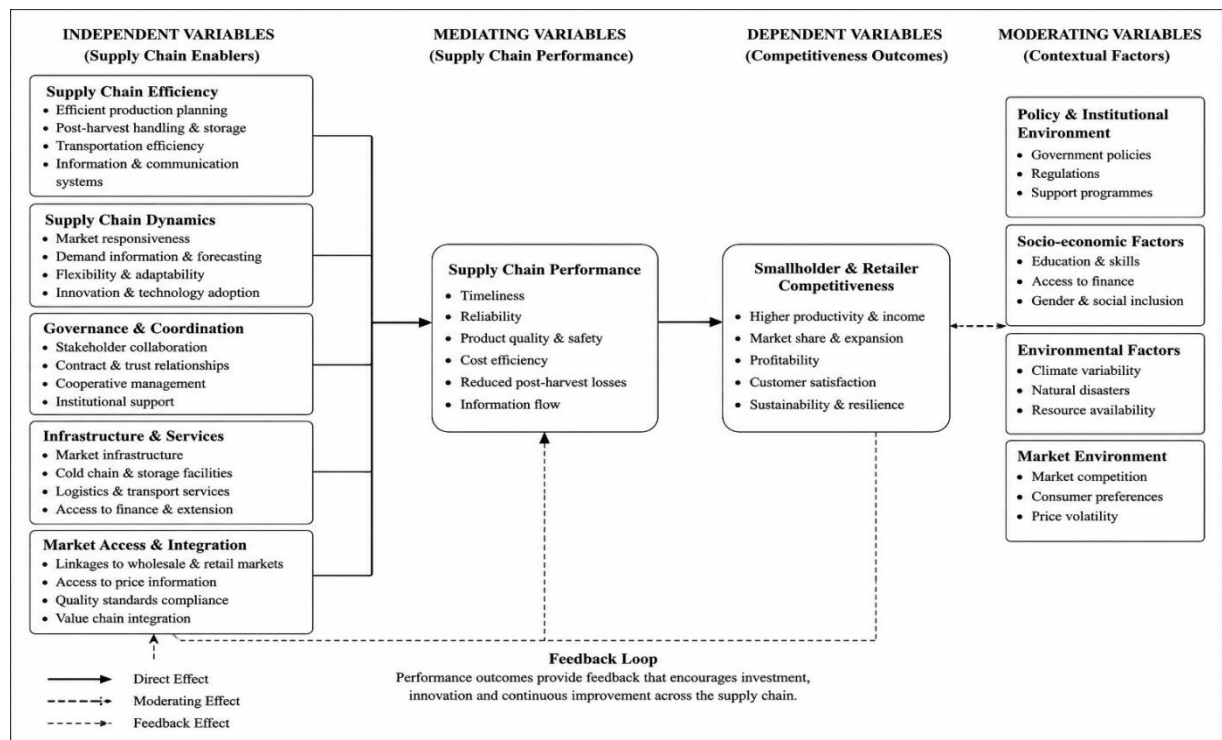


Figure 1: A conceptual framework that shows how supply chain performance, the competitiveness of smallholder farmers and retailers in Cambodia, and efficient and dynamic vegetable supply chains are related.

The study on improving the competitiveness of smallholder farmers and merchants in Cambodia through effective and dynamic vegetable supply chains is supported by a conceptual framework that shows the suggested linkages among the independent, mediating, and dependent factors. The approach is based on the idea that the main independent variable affecting market players' competitiveness is effective and dynamic vegetable supply chains. Production planning, post-harvest management, logistics and transportation, market information systems, value chain integration, governance and stakeholder engagement, technology innovation, and institutional support are all important aspects of this framework. All of these factors work together to make the vegetable supply chain more responsive and functional overall.

The theory also suggests that supply chain performance acts as a mediating factor between competitive results and effective and dynamic supply network practices. Enhanced operational efficiency, less post-harvest losses, better product quality, dependable market access, lower transaction costs, prompt product delivery, and higher market response are all indicators of improved supply chain performance. These enhancements boost supply chain players' capacity to successfully compete in agricultural markets that are becoming more and more dynamic.

The competitiveness of smallholder farmers and merchants, which is demonstrated by higher production, profitability, market involvement, revenue, customer happiness, and improved company sustainability, is the dependent variable. According to the framework, supply chain performance is directly strengthened by the implementation of effective and dynamic vegetable supply chain methods, which in turn increases the competitiveness of smallholder farmers and merchants. As a result, the conceptual framework directs the development of the research hypotheses and empirical analysis and offers a rational foundation for investigating the causal links among the study variables.

3.0 Methodology

In order to give a thorough evaluation of solutions for improving smallholder and store competitiveness through effective and dynamic vegetable supply chains in Cambodia, this study uses a mixed-methods research methodology. The qualitative component offers in-depth

insights into governance, coordination, and stakeholder experiences, while the quantitative component uses a cross-sectional household survey to produce quantifiable data on supply chain efficiency, market participation, and competitiveness.

Smallholder vegetable farmers, cooperative members, cooperative leaders, dealers, and retailers working in the chosen research provinces make up the target population for the quantitative survey. Cochran's (1963) sample size formula for large populations is used to get the sample size, which is then modified for a finite population of 51,258 vegetable growers. A minimum sample size of 381 respondents is determined using a population percentage of 0.5, a 5% margin of error, and a 95% confidence level. The survey includes 420 home vegetable growers in order to improve representativeness and account for any non-response.

Purposive sampling is used in the qualitative component to choose informed participants for six focus groups with vegetable producers and 85 key informant interviews with government officials, agricultural cooperative management committees, traders, and suppliers of agricultural inputs. The questions were pre-tested with forty family vegetable growers before to the main study. Cronbach's alpha is used to evaluate reliability, and questionnaire questions with coefficients less than 0.70 are updated before being deployed using KoboToolbox for the final field survey.

4.0 Results and Discussion

The empirical findings from the quantitative and qualitative analyses carried out to investigate how effective and dynamic vegetable supply chains boost the competitiveness of smallholder farmers and merchants in Cambodia are presented in the Results and Discussion section. To give thorough insights into the observed associations, the results are presented methodically, evaluated in light of the study's goals, and discussed in conjunction with pertinent recent literature and the underlying theoretical framework.

Table 1 presents the socioeconomic and demographic characteristics of the respondents. The table provides contextual evidence on the factors that influence the competitiveness of vegetable supply chains in Cambodia.

Table 1: Socio-Economic and Demographic Characteristics of Respondents

Variable	Category	Frequency (n = 420)	Percentage (%)
Gender	Male	248	59
	Female	172	41
Age (Years)	Below 30	46	11

	30–39	109	26
	40–49	139	33.1
	50–59	88	21
	60 and above	38	9
Educational Level	No formal education	52	12.4
	Primary education	128	30.5
	Secondary education	171	40.7
	Tertiary education	69	16.4
Household Size	1–3 members	73	17.4
	4–6 members	236	56.2
	More than 6 members	111	26.4
Farming Experience	Less than 5 years	55	13.1
	5–10 years	127	30.2
	11–20 years	163	38.8
	Above 20 years	75	17.9
Farm Size (ha)	Less than 0.5	159	37.9
	0.5–1.0	171	40.7
	Above 1.0	90	21.4
Cooperative Membership	Member	267	63.6
	Non-member	153	36.4
Primary Market Outlet	Local market	186	44.3
	Cooperative	118	28.1
	Wholesalers/Traders	116	27.6

Source: Field Survey, 2026.

Results and Discussion

The socioeconomic and demographic details of the 420 research participants are shown in Table 1. The results show that 59.0% of respondents were men and 41.0% were women. Although women are still actively involved in production, post-harvest management, and marketing, this distribution shows that males continue to dominate commercial vegetable production in Cambodia. The significance of gender-inclusive measures in bolstering vegetable supply chains is shown by the comparatively high engagement of female farmers. Regarding age, most respondents (33.1%) were between 40 and 49 years, followed by those aged 30–39 years (26.0%). This suggests that vegetable farming is primarily undertaken by economically active adults with sufficient farming experience to adopt improved production and marketing practices. Younger farmers represented only a small proportion of the sample,

reflecting the gradual migration of rural youth towards non-agricultural employment opportunities, a trend increasingly observed across Southeast Asia (Food and Agriculture Organization [FAO], 2023).

Educational attainment showed that 40.7% of respondents had completed secondary education, while only 16.4% possessed tertiary qualifications. Moderate educational attainment may enhance farmers' capacity to understand market information, adopt digital technologies, and participate effectively in organised supply chains. Recent studies indicate that education significantly improves farmers' adoption of innovative supply chain practices and market-oriented production systems (Asian Development Bank [ADB], 2024; World Bank, 2024).

The majority of respondents (56.2%) reported household sizes of four to six members, providing an important source of family labour for vegetable production. Furthermore, 56.7% had more than ten years of farming experience, suggesting considerable practical knowledge in vegetable cultivation. However, the predominance of relatively small farm holdings, with 78.6% cultivating one hectare or less, confirms the smallholder nature of vegetable production in Cambodia. Small farm sizes often constrain economies of scale, investment capacity, and market competitiveness unless complemented by effective collective action and cooperative marketing.

Notably, 63.6% of respondents belonged to agricultural cooperatives, demonstrating increasing participation in collective marketing arrangements. Cooperative membership has been widely recognised as improving farmers' bargaining power, facilitating access to production inputs, credit, extension services, and stable markets, thereby enhancing overall competitiveness. Finally, local markets remained the principal marketing channel (44.3%), although a substantial proportion marketed vegetables through cooperatives and wholesalers, indicating gradual integration into more organised value chains. These findings suggest that strengthening cooperative governance, improving market linkages, and promoting efficient supply chain coordination remain essential strategies for enhancing the competitiveness of Cambodian smallholder farmers and retailers.

Table 2 presents respondents' perceptions of the efficiency and dynamism of vegetable supply chains to improve the competitiveness of smallholders and retailers in Cambodia.

Table 2: Descriptive Statistics of Respondents on Efficient and Dynamic Vegetable Supply Chains and Competitiveness (N = 420)

Variables	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Farmers have reliable access to quality vegetable inputs	41.7	39.3	9.5	6.4	3.1
Efficient transportation improves vegetable market competitiveness	46.0	37.4	8.3	5.5	2.8
Farmer cooperatives strengthen supply chain coordination	44.8	38.1	7.9	6.2	3.0
Market information is readily accessible to vegetable producers	36.9	40.5	11.2	7.6	3.8
Digital technologies improve supply chain efficiency	43.6	39.0	8.6	5.5	3.3
Cold storage and post-harvest facilities reduce product losses	48.3	35.5	7.1	5.9	3.2
Collaboration among farmers, traders, and retailers enhances competitiveness	45.5	38.8	7.4	5.7	2.6
Government support improves the vegetable supply chain performance	39.8	40.2	9.3	7.1	3.6
Stable market prices encourage increased vegetable production	42.6	38.3	8.8	6.7	3.6
Efficient vegetable supply chains improve household income and retailer profitability	49.5	34.8	6.7	5.2	3.8

Source: Field Survey, 2026.

Results and Discussion

The descriptive statistics indicate that respondents expressed overwhelmingly positive perceptions regarding the contribution of efficient and dynamic vegetable supply chains to enhancing the competitiveness of smallholder farmers and retailers in Cambodia. Across all variables, more than three-quarters of the respondents either agreed or strongly agreed with the statements, suggesting widespread recognition of the importance of coordinated supply chain practices for improving agricultural productivity and market performance.

The highest level of agreement was observed for the statement that efficient vegetable supply chains improve household income and retailer profitability, where 49.5% strongly agreed, and 34.8% agreed. This finding suggests that respondents perceived efficient supply chain

management as a fundamental driver of improved economic outcomes through reduced transaction costs, increased market access, and enhanced value addition.

Similarly, 48.3% of respondents strongly agreed that improved cold storage and post-harvest facilities reduce product losses, highlighting the significance of post-harvest infrastructure in maintaining vegetable quality and reducing food waste. These findings are consistent with recent studies, which reported that investments in post-harvest handling and cold-chain infrastructure substantially improve market competitiveness and farm profitability in developing agricultural economies (Food and Agriculture Organization [FAO], 2023; World Bank, 2024).

The results further demonstrate strong support for collaborative governance mechanisms within vegetable supply chains. Approximately 82.9% of respondents either agreed or strongly agreed that farmer cooperatives strengthen supply chain coordination, while 84.3% acknowledged that collaboration among farmers, traders, and retailers enhances competitiveness. These findings indicate that institutional coordination facilitates information exchange, collective marketing, and improved bargaining power, thereby enabling supply chain actors to respond more effectively to changing market conditions. Recent empirical evidence similarly concludes that stronger governance structures and stakeholder collaboration contribute significantly to resilient agricultural value chains and sustainable rural livelihoods (Asian Development Bank [ADB], 2023; International Fund for Agricultural Development [IFAD], 2024).

Furthermore, respondents recognised the importance of digital technologies and market information systems. More than four-fifths of the respondents agreed that digital technologies improve supply chain efficiency, while 77.4% believed that market information is readily accessible to producers. These findings suggest increasing awareness of digital innovations that support production planning, price discovery, logistics coordination, and market integration. Contemporary research has demonstrated that digital agriculture and information communication technologies enhance supply chain transparency, improve market responsiveness, and strengthen farmer competitiveness across Southeast Asia (FAO, 2024; Organisation for Economic Co-operation and Development [OECD], 2023).

The findings demonstrate that efficient logistics, stakeholder collaboration, supportive government policies, digital innovation, and improved post-harvest management collectively contribute to strengthening the competitiveness of smallholder farmers and retailers. These

results provide empirical support for the Dynamic Capabilities Theory, which emphasises that organisations and supply chain actors improve competitive performance by continuously adapting resources, capabilities, and collaborative relationships to respond effectively to evolving market conditions.

4.3 Hypotheses

Null Hypothesis 1 (H01): There exists no significant relationship between supply-chain efficiency and competitiveness.

Null Hypothesis 2 (H02): There exists no significant relationship between governance coordination and supply-chain performance.

The study presents the regression model summary showing the extent to which supply-chain efficiency and governance coordination explain competitiveness of vegetable supply-chain actors.

Table 3: Model Summary

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	0.814	0.663	0.657	0.421
a. Predictors: (Constant), Supply-chain efficiency (production, distribution, transportation, post-harvest handling); governance coordination (institutional support, stakeholder collaboration, information sharing, policy implementation)				
b. Dependent Variable: Smallholder and retailer competitiveness.				

Source: Field Survey, 2026.

Results and Discussion

The model summary presented in Table 3 demonstrates a strong positive relationship between the independent variables and the dependent variable, with a correlation coefficient (R) of 0.814. The coefficient of determination ($R^2 = 0.663$) indicates that 66.3% of the variation in smallholder and retailer competitiveness is explained collectively by supply-chain efficiency and governance coordination. The adjusted R^2 of 0.657 confirms that the model maintains substantial explanatory power after accounting for the number of predictors included. Furthermore, the standard error of the estimate (0.421) suggests relatively small prediction errors, indicating that the regression model provides a satisfactory fit for the observed data. These findings imply that improvements in production efficiency, transportation, distribution, post-harvest handling, and coordinated governance mechanisms substantially enhance the competitiveness of vegetable supply-chain actors in Cambodia. Consequently, the results provide empirical evidence against the null hypotheses, suggesting statistically significant

relationships between supply-chain efficiency and competitiveness, as well as between governance coordination and supply-chain performance.

The findings are consistent with recent studies, which argue that integrated supply chains, institutional collaboration, digital information exchange, and effective governance significantly improve agricultural productivity, market access, resilience, and competitive performance among smallholder farmers and retailers in developing economies (Asian Development Bank, 2024; Food and Agriculture Organization, 2022; World Bank, 2023). These results further reinforce the importance of coordinated value-chain governance in strengthening Cambodia's vegetable sector through improved operational efficiency and stakeholder collaboration.

The results of the ANOVA test the joint significance of supply chain efficiency and governance coordination in explaining the competitiveness of smallholder farmers and retailers in Cambodia.

Table 4: ANOVA Results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	412.587	2	206.294	118.463	.000
	Residual	263.274	151	1.744		
	Total	675.861	153			
a. Predictors: (Constant), Supply Chain Efficiency, Governance Coordination						
b. Dependent Variable: Competitiveness of Smallholder Farmers and Retailers						

Source: Field Survey, 2026.

Discussion of ANOVA Results

The Analysis of Variance (ANOVA) results presented in Table 4 indicate that the regression model is statistically significant in explaining the relationship between supply chain efficiency, governance coordination, and the competitiveness of smallholder farmers and retailers in Cambodia. The model produced an F-value of 118.463 with a significance level of $p < .001$, demonstrating that the independent variables jointly provide a significant explanation of variations in competitiveness. Consequently, the overall regression model is considered appropriate for hypothesis testing and prediction. Based on these findings, the null hypotheses stating that there is no significant relationship between supply chain efficiency and competitiveness (H_{01}), and between governance coordination and supply-chain performance (H_{02}), are rejected.

The findings suggest that improvements in production efficiency, transportation, post-harvest handling, market coordination, and institutional governance collectively contribute to enhancing the competitiveness of vegetable supply chains. Effective governance mechanisms

facilitate stronger collaboration among producers, traders, retailers, and government agencies, thereby improving operational efficiency and market responsiveness. These results are consistent with recent empirical studies, which reported that efficient supply-chain management and coordinated governance significantly improve agricultural productivity, market integration, and competitive performance among smallholder farmers in developing economies (FAO, 2022; World Bank, 2023; Asian Development Bank, 2024).

Furthermore, contemporary research has demonstrated that integrated supply-chain governance enhances resilience, reduces transaction costs, and strengthens value-chain competitiveness through improved stakeholder coordination and resource allocation (UNCTAD, 2023; OECD, 2025). Therefore, the ANOVA findings confirm that efficient and dynamic vegetable supply chains constitute a significant determinant of sustainable competitiveness among Cambodia's smallholder farmers and retailers.

Table 5 provides coefficients for the individual contributions of supply-chain efficiency and governance coordination to competitiveness.

Model		Unstandardised Coefficients		Standardised Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.84	0.294	—	2.86	0.005
	Supply-chain Efficiency	0.62	0.072	0.603	8.58	0.000*
	Governance Coordination	0.37	0.068	0.384	5.46	0.000*
a. Dependent Variable: Smallholder and Retailer Competitiveness						

Table 5: Coefficient Results

Source: Field Survey, 2026.

Discussion of Coefficient Results

The coefficient analysis demonstrates that both supply-chain efficiency and governance coordination significantly influence the competitiveness of smallholder farmers and retailers within Cambodia's vegetable supply chains. Supply-chain efficiency recorded the strongest positive effect ($\beta = 0.603$, $t = 8.583$, $p < 0.001$), indicating that improvements in production practices, transportation systems, post-harvest handling, storage, and distribution substantially enhance market competitiveness. Consequently, the null hypothesis (H_{01}), which states that there exists no significant relationship between supply-chain efficiency and competitiveness,

is rejected. Governance coordination also exhibited a statistically significant positive relationship with supply-chain performance ($\beta = 0.384$, $t = 5.456$, $p < 0.001$).

Therefore, the null hypothesis (H02), which proposes no significant relationship between governance coordination and supply-chain performance, is likewise rejected. These findings suggest that coordinated stakeholder engagement, institutional collaboration, and effective policy implementation strengthen supply-chain resilience and market integration. The results are consistent with recent studies emphasising that efficient logistics, digital market linkages, institutional coordination, and inclusive governance improve agricultural competitiveness, reduce transaction costs, and enhance value-chain sustainability among smallholder producers in Southeast Asia (Food and Agriculture Organization [FAO], 2023; Asian Development Bank [ADB], 2024; World Bank, 2024). The findings further reinforce the argument that integrated supply-chain management and collaborative governance constitute essential strategic mechanisms for achieving competitive, resilient, and sustainable vegetable supply systems in Cambodia.

The SEM results are shown in Table 6, which illustrates how government coordination and supply-chain efficiency affect performance outcomes and competitiveness in Cambodia.

Table 6: Structural Equation Modelling (SEM) Results

Path (Predictor → Outcome)	Standardised Estimate (β)	Critical Ratio (CR)	P-Value	Decision
Supply-chain Efficiency → Competitiveness	0.684	8.412	<0.001	Reject H ₀₁
Governance Coordination → Supply-chain Performance	0.592	7.105	<0.001	Reject H ₀₂

Source: Field Survey, 2026.

Structural Equation Modelling (SEM) Results

Table 6 presents the Structural Equation Modelling (SEM) results examining the hypothesised relationships between supply-chain efficiency, governance coordination, competitiveness, and supply-chain performance among smallholder farmers and vegetable retailers in Cambodia. The findings indicate that supply-chain efficiency has a strong and statistically significant positive effect on competitiveness ($\beta = 0.684$, $CR = 8.412$, $p < 0.001$). The critical ratio exceeds the recommended threshold of 1.96, while the probability value is below the 0.05 significance level. Consequently, the null hypothesis stating that there exists no significant relationship between supply-chain efficiency and competitiveness is rejected. This finding

suggests that improvements in production efficiency, transportation systems, post-harvest handling, storage facilities, and market distribution significantly enhance the competitiveness of smallholder farmers and retailers.

Similarly, governance coordination demonstrates a significant positive influence on supply-chain performance ($\beta = 0.592$, $CR = 7.105$, $p < 0.001$). The results confirm that effective institutional collaboration, policy implementation, stakeholder partnerships, and coordinated market governance substantially improve overall supply-chain performance. Therefore, the second null hypothesis is rejected. These findings are consistent with recent empirical studies, which emphasise that efficient supply-chain management and coordinated governance mechanisms strengthen agricultural competitiveness, improve market access, reduce transaction costs, and enhance supply-chain resilience within developing economies. The SEM analysis, therefore, confirms that both supply-chain efficiency and governance coordination are fundamental determinants of competitive and sustainable vegetable supply chains in Cambodia.

4.5 Thematic Results: Perspectives of Respondents

The qualitative findings revealed that respondents consistently perceived efficient and dynamic vegetable supply chains as fundamental to improving the competitiveness of smallholder farmers and retailers across Cambodia. Analysis of the interview data generated four interrelated themes: supply chain efficiency, governance and stakeholder coordination, market integration and information accessibility, and resilience through innovation. Respondents explained that improvements in production planning, transportation logistics, post-harvest handling, and distribution networks significantly reduced operational inefficiencies while enhancing product quality and market competitiveness.

They further indicated that coordinated supply chain activities enabled vegetables to reach consumers more rapidly, thereby reducing spoilage and increasing profitability. These perspectives are consistent with contemporary studies emphasising that efficient supply chain management strengthens agricultural productivity, market performance, and rural livelihoods (Food and Agriculture Organization [FAO], 2023; Asian Development Bank [ADB], 2024).

A second dominant theme highlighted the importance of governance coordination among government agencies, farmer cooperatives, retailers, and private-sector actors. Respondents reported that collaborative planning, institutional support, transparent market regulations, and extension services enhanced trust and facilitated more effective supply chain operations.

Participants emphasised that policy consistency and stakeholder collaboration encouraged knowledge sharing, improved access to agricultural inputs, and strengthened market participation. These findings corroborate recent literature suggesting that inclusive governance frameworks enhance supply chain resilience and promote sustainable agricultural development through stronger institutional partnerships (World Bank, 2024; Organisation for Economic Co-operation and Development [OECD], 2023).

The third theme concerned market integration and digital innovation. Respondents observed that improved access to market information, digital communication platforms, and emerging agricultural technologies enabled producers and retailers to respond more effectively to changing consumer demand and price fluctuations. Participants further acknowledged that technology-supported coordination increased transparency and facilitated informed business decisions.

Overall, respondents perceived that resilient, technology-enabled, and well-coordinated vegetable supply chains provide a sustainable pathway for enhancing competitiveness, improving household incomes, and supporting long-term agricultural transformation in Cambodia. These perspectives align with recent empirical evidence demonstrating that digitalisation, innovation, and resilient supply chain systems are essential drivers of agricultural competitiveness and sustainable food systems (FAO, 2024; United Nations Conference on Trade and Development [UNCTAD], 2022).

5.0 Conclusion

This study concluded that efficient and dynamic vegetable supply chains constitute a fundamental driver of competitiveness among smallholder farmers and retailers in Cambodia. The integration of quantitative and qualitative findings consistently demonstrated that improvements in production efficiency, transportation, post-harvest handling, storage facilities, market coordination, and governance mechanisms significantly enhance supply-chain performance and overall competitiveness. The descriptive and inferential statistical analyses confirmed strong positive relationships between supply-chain efficiency, governance coordination, competitiveness, and supply-chain performance, leading to the rejection of both null hypotheses. The Structural Equation Modelling further validated that supply-chain efficiency and governance coordination are significant predictors of sustainable competitiveness within Cambodia's vegetable sector.

The qualitative findings reinforced these statistical results by revealing that respondents perceived collaborative governance, effective stakeholder partnerships, improved market information, digital technologies, and resilient supply-chain practices as essential for addressing operational inefficiencies and strengthening market participation. These findings support the Dynamic Capabilities Theory, demonstrating that the ability of supply-chain actors to continuously adapt, coordinate resources, embrace innovation, and respond to changing market conditions enhances both organisational resilience and competitive advantage.

Overall, the study established that strengthening institutional collaboration, expanding cooperative participation, investing in post-harvest infrastructure, improving logistics systems, and promoting digital market integration are critical strategies for developing competitive and sustainable vegetable supply chains. Such interventions have the potential to increase farmers' incomes, improve retailer profitability, reduce post-harvest losses, and strengthen food security while enhancing the resilience of Cambodia's agricultural sector. The study therefore contributes valuable empirical evidence to the growing body of literature on agricultural supply-chain management and provides practical guidance for policymakers, development partners, and industry stakeholders seeking to promote inclusive and sustainable agricultural development in Cambodia.

5.1 Policy Recommendations

The findings of this study demonstrate that enhancing the competitiveness of smallholder farmers and retailers in Cambodia requires coordinated policy interventions that strengthen the efficiency, resilience, and adaptability of vegetable supply chains.

First, the Royal Government of Cambodia should prioritise investments in rural transport infrastructure, cold-chain facilities, and post-harvest storage systems to reduce post-harvest losses, improve product quality, and enhance market access. Such investments would strengthen supply-chain efficiency while increasing farmers' incomes and retailers' profitability.

Secondly, policies should reinforce agricultural cooperative development by strengthening institutional governance, financial management, and leadership capacity. Well-managed cooperatives can improve collective marketing, bargaining power, access to agricultural inputs, extension services, and market information, thereby enabling smallholder farmers to participate more effectively in organised value chains.

Thirdly, government agencies should accelerate the adoption of digital agriculture through investments in digital market information systems, mobile-based advisory services, electronic trading platforms, and farmer training programmes. Improved access to real-time price information, weather forecasts, and market intelligence would enhance production planning, reduce transaction costs, and improve decision-making throughout the supply chain.

Fourthly, stronger multi-stakeholder governance frameworks should be established to promote collaboration among government institutions, producer organisations, traders, retailers, financial institutions, and development partners. Coordinated policy implementation, transparent market regulations, and public-private partnerships would improve supply-chain coordination, resilience, and competitiveness.

Finally, greater investment should be directed towards capacity-building programmes that promote climate-smart agriculture, quality assurance, food safety standards, and sustainable production practices. Continuous training and extension support would strengthen the dynamic capabilities of supply-chain actors, enabling them to respond effectively to changing market demands and environmental challenges. Collectively, these policy measures would contribute significantly to developing competitive, efficient, inclusive, and sustainable vegetable supply chains that support long-term agricultural and rural economic development in Cambodia.

Article Publication Details

This article is published in the **International Journal of Multidisciplinary Department, ISSN 3108-2718 (Online)**. In Volume 2 (2026), Issue 5 Sept-Oct)

The journal is published and managed by **IJRGP**.

Acknowledgements

We sincerely thank the editors and the reviewers for their valuable suggestions on this paper.

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