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A Maturity Model Approach to Evaluating Sustainable Supply Chains of Organic Agricultural Cooperatives Amid the Transition to Industry 5.0 in Rural Vietnam

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Abstract: The transition toward Industry 5.0 has necessitated a deeper understanding of sustainable supply chain development, particularly within organic agricultural cooperatives operating in rural environments. In this context, a comprehensive assessment was conducted to examine the determinants influencing sustainable supply chains and to evaluate their maturity within organic agricultural cooperatives in Vietnam's rural regions. A sample of 250 cooperatives was selected for analysis. The data were processed through a two-stage methodology: initially employing an ordinal logistic regression (OLR) model to identify key influencing factors, followed by the application of a sustainable supply chain maturity model to assess the developmental stage of these cooperatives. The results revealed that the average maturity level of sustainable supply chains among the surveyed cooperatives approached Level 3, suggesting a moderate stage of development with partial integration of sustainability practices. Among the evaluated dimensions, quality issues (mean score: 3.53), customer and marketing management (3.22), and supplier management (3.05) were found to exert the most substantial influence on supply chain sustainability. Furthermore, policy implications were proposed to support cooperative development. The study contributes to the existing literature by offering an empirically grounded maturity model framework tailored to the unique dynamics of rural organic agriculture and by advancing the discourse on sustainable supply chain management in emerging economies undergoing industrial transformation.

Keywords: Sustainable supply chain; Organic agricultural cooperatives; Maturity model; Ordinal logistic regression model

1. Introduction

Industry 5.0 has special characteristics with an emphasis on a human-centric, sustainable, and resilient industrial framework (Directorate-General for Research & Innovation, 2022). While Industry 4.0 focused on leveraging technology, Industry 5.0 focuses on sustainable development, focusing on the control of technology and enhancing social and environmental accountability. Organic agricultural cooperatives are recognized as a tool to improve sustainable and human-centric development by promoting environmentally responsible practices, economic resilience, and social inclusivity. By such means, they empower small-scale farmers with collective actions, improving market access and ensuring fair income distribution. Furthermore, they align with a human-centric approach by centering food systems around the well-being of both producers and consumers, promoting transparency, community engagement, and health (Banaszak, 2006). Implementing organic production not only promotes soil health, biodiversity, and water conservation, enabling fair pricing and stable incomes for smallholder farmers, but also improves food security and community resilience to climate change and economic shocks.

A sustainable supply chain, or the dynamic capability of a supply chain, is crucial for organic agricultural cooperatives to sustain optimal performance while adapting to changes by reconfiguring assets, strategies, and operations (Chowdhury & Quaddus, 2016). The sustainability of the supply chain empowers organic cooperatives to efficiently recover or transition to an improved state in the context of the transition towards Industry 5.0. To

improve sustainability, organic cooperatives should develop effective abilities, including adaptability, revenue, distribution, connection with suppliers, market competitiveness, and financial resilience (Azadeh et al., 2014). In these cooperatives, measuring sustainable supply chain performance also focuses on the overall connection between implemented practices and achieved outcomes (Ghosh et al., 2021).

Despite this rising literature on supply chain integration among agricultural enterprises, the sustainability and maturity level of the supply chain for organic agricultural cooperatives in the context of transition towards Industry 5.0 remains unexplored. This study aims to evaluate this relationship by investigating the factors affecting the sustainable supply chain of organic agricultural cooperatives in rural regions in the context of the transition towards Industry 5.0 in Vietnam. To do so, this study adopts the following research objectives:

• It aims to examine the maturity level of sustainable supply chains for these organic agricultural cooperatives in rural Vietnam, since the sustainable agricultural production is still in its early stages, and organic agricultural cooperatives in this country are generally young with low maturity levels of sustainable supply chains in a new context.

• It aims to identify factors that affect sustainable supply chains of organic agricultural cooperatives in rural regions by using the OLR model. In particular, by using models for the two types of organic agricultural cooperatives, the study also analyzes and evaluates the different factors affecting each type of cooperative.

2. Literature Review

2.1 Maturity of Sustainable Supply Chains

Research on sustainable supply chains points out that the integration of social, environmental, and economic objectives in the management of business processes can create sustainability and achieve the goal of increasing the long-term performance of the organizations (Carter & Rogers, 2008). The sustainable supply chains often involve the use of environmentally friendly resources by choosing sustainable suppliers and production processes (Hendiani et al., 2020). In the sustainable supply chain, responsible practices are required for sustainable management concerning environmental, social, and economic impacts across the entire production process. Organizational goals can be gained through the application of innovative technologies. Sustainability in the supply chain is derived from an integrated business model, which consists of stakeholder engagement, collaboration, and a network-based perspective, representing a new paradigm in supply chain management. In the sustainable supply chain, the connection with stakeholders plays an important role in creating added value. Thus, the supply chain is operated as a dynamic network of relationships and management practices (Yawar & Seuring, 2017). However, successfully implementing sustainable supply chain management also requires addressing and overcoming various challenges (Yadav & Singh, 2020). High costs, limited organizational legitimacy, lack of senior management commitment, inadequate training, weak linkages, and technological and financial constraints are the main difficulties in building sustainable supply chains. To foster sustainable development, organic agricultural cooperatives need to have a plan for long-term investments and an efficient strategy to strengthen competitive advantages and business resilience in an ever-changing environment (Datta, 2017).

To ensure sustainable development, organic agricultural cooperatives must possess dynamic capability and adapt to dynamic environmental changes by implementing key strategies for long-term benefits. Market performance indicators involve exploring variables affecting competitive advantages and sustainable development during shocks, encompassing revenue growth, customer retention, profitability, capitalization ratio, and defining sustainable development through market and financial performance (Nguyen & Sarker, 2018). In addition, the "maturity" concept of a sustainable supply chain relates to the degree to which an enterprise or supply chain network has evolved in integrating sustainability into its operations, processes, and decision-making. Recent research shows some different definitions of maturity levels. The development and validation of these models generally follow a two-stage process. The first stage focuses on refining design elements by validating important areas and practices with evolution and maturity levels and enhancing the assessment framework used to determine organizational maturity. The second stage involves testing the maturity model itself, confirming the relevance and coherence of its structure, including the defined areas, practices, sub-practices, and maturity levels (Correia et al., 2023).

Maturity reflects an organization's capacity to apply sophisticated and efficient practices and procedures, thereby increasing its ability to achieve specific process or knowledge objectives. According to Yimam (2011), an enterprise can advance its maturity by a) enhancing its ability to adopt more advanced and effective practices, tools, techniques, and methods, and b) systematizing and refining its processes through clear strategies, management, standardization, measurement, control, and ongoing improvement. In this context, maturity signifies forward movement. It means that maturity relates to transitioning from a basic to a more advanced state. Similarly, Rudnicka (2016) confirmed that maturity is understood as the organization's capacity to plan, implement, and control various sustainability practices to enhance overall sustainability performance across the entire network. Göçer et al. (2018) also defined maturity as the extent to which an organization can discover, explain, spread

widely, and control sustainability throughout its supply chain.

Furthermore, some researchers have defined the levels of maturity models. According to Edgeman & Eskildsen (2013), lower maturity levels are characterized by the absence or incomplete implementation of basic sustainability practices, while higher levels denote the application of more sophisticated practices, often involving deeper collaboration with supply chain partners. Several studies have shown different maturity levels of supply chains. According to the proposed maturity model, a company with a very low maturity level (Level 1) is characterized by a focus mainly on internal and economic aspects of sustainability and a reactive attitude. At this level, fewer than 90% of the company's sub-practices are associated with the first evolution level, and different critical areas, such as sustainability governance, product and process level, customer and supplier management, and stakeholder focus, are below the third implementation level. To reach higher levels of maturity, the company must implement more demanding and sophisticated practices that imply greater involvement with its partners in the supply chain. When a company reaches Level 3, it means that it has a more proactive attitude towards sustainability, a broader implementation of internal sustainability practices, and engagement of traditional partners and other stakeholders in new collaboration on environmental and social issues (Ho et al., 2020).

In general, the maturity of a sustainable supply chain is often conceptualized as a continuum that reflects the degree to which sustainability practices are integrated into supply chain activities. Companies move through from initial awareness of sustainability to advanced integration and optimization. The framework provided by Correia et al. (2023) is frequently cited, identifying five levels of maturity in five stages. In the first stage, companies react to sustainability challenges only when they are forced by external pressures, such as regulations or customer demands. Sustainability initiatives are not systematically implemented but rather ad hoc. In the second stage, organizations start complying with sustainability regulations without considering sustainability a strategic priority. Basic environmental and social measures are implemented mostly to meet regulatory requirements. In the third stage, sustainability becomes integrated into strategic planning. Organizations start defining clear sustainability goals, engage suppliers in sustainability practices, and develop initial monitoring systems for sustainability performance. In the fourth stage, sustainability is embedded in the company's core strategy, and sustainable supply chain management is formalized. The organization actively manages sustainability metrics, optimizes resource usage, and engages in continuous improvement in collaboration with supply chain partners. In the fifth stage, sustainability is achieved across the entire supply chain. Sustainability is deeply embedded in both the organization's values and its supply chain relationships (Correia et al., 2023; De Almeida Santos et al., 2020).

2.2 Organic Cooperatives

Organic farming relates to the cultivation of safe and nutritious food without the use of chemical fertilizers. The agricultural production method relies on reduced tillage and biofertilizers and applies environmentally friendly pest control methods. Thus, organic farming plays an important role in promoting ecological balance, developing the economy in rural areas, and addressing pressing global issues related to food security and safety, and the broader social and environmental responsibilities of agriculture (Cristache et al., 2018). However, organic farming requires high capital, high-tech farming, and a suitable market for organic products. Therefore, many farms often take part in cooperatives to mitigate these challenges. Participation in cooperatives enables small farms to scale production, generate profits, and sustain their operations, thereby enhancing their competitiveness against larger agricultural enterprises. In this way, cooperatives support agricultural management by reducing uncertainties and mitigating operational risks.

Furthermore, organic cooperatives not only assist small farmers in accessing high-tech, diversified products, market opportunities, and information on production and marketing but also act as an intermediary organization for promoting collaboration and connection between farmers, suppliers, and organizations (Chaddad & Cook, 2004). Moreover, Bezus & Bilotkach (2018) emphasized that organic cooperatives operate based on a strong commitment to natural, chemical-free farming practices that rely on simple methods and ingredients. This commitment enhances their success in the agricultural sector.

2.3 Factors Affecting Maturity of the Sustainable Supply Chain

Some studies have investigated the factors affecting the maturity of sustainable supply chains, including management, products and services, quality issues, and so on (Correia et al., 2017; Tasnim et al., 2023). For organic agricultural cooperatives, an efficient strategy facilitates the development of new products and services, clarifies network systems, and ensures effective communication among employees, suppliers, and customers. Ho et al. (2023) further emphasized that a cooperative strategy enables agricultural cooperatives to communicate their future vision with suppliers regarding market development for organic products.

A sustainable supply chain, such as organic agricultural cooperatives, often involves the coordination of suppliers and customers in delivering products or services according to organic standards of quality, timing, and efficiency. In general, stakeholders typically influence sustainable supply chains through environmental initiatives,

such as eco-design, responsible sourcing, green manufacturing, and green logistics (Graham, 2017). A sustainable supply chain depends on effective supplier management and collaboration among organizations while integrating the three pillars of sustainable development, including economic, environmental, and social performance. Incorporating environmental, social, and economic criteria into supply chain management enables organizations to achieve sustained economic profitability. Effective supply chain management involves prioritizing social considerations in procurement decisions, addressing the implications of modern slavery, and ensuring that ethical standards are upheld throughout the supply chain (Liu & Lee, 2018).

In addition, Liu & Lee (2018) affirmed a positive correlation between membership in supplier associations and supplier productivity, emphasizing strategic linkages in the supply chain. Supplier linkage involves establishing and evaluating successful relationships between providers and recipients, addressing communication and the timely delivery of products and services locally and globally. Simultaneously, collaboration encompasses cooperation, integration, or coordination interchangeably used based on the primary goal of ensuring effective flows of products and services, providing optimal benefit for the customer (Flynn et al., 2010). Stakeholder inclusion in organic cooperative development serves as the foundational block for sustainable development in agriculture. Improving collaboration among stakeholders in organic agricultural cooperatives' supply chains enhances information sharing with customers and distributors related to storage, processing, packing, logistics, and marketing. Collaborative efforts in the supply chain enable organic agricultural cooperatives to enhance demand forecasting with key partners and establish order systems with suppliers quickly, involving input (seeds, labor, and machinery) purchase, production, and storage. Efficient collaboration with suppliers enhances the benefits of cooperation. A sustainable supply chain is built upon three core principles, including social, environmental, and economic sustainability. In addition, it is dependent on resilience management, transparency, strategic alignment, and sustainable governance. In terms of organic agricultural cooperatives, sustainability refers to the improvement of organic processing and the provision of organic products to forward the ability to grow indefinitely while maximizing human benefits, optimizing resource efficiency, minimizing reliance on non-renewable inputs, and maintaining a harmonious balance with the natural environment (Carter & Rogers, 2008). Basically, implementing sustainable practices within the supply chain is an effective approach to engaging stakeholders and promoting collective actions toward shared objectives (Arruda et al., 2009).

In addition, for environmental and social sustainability, the supply chain concentrates on quality issues. These quality issues need to be integrated at various stages of the supply chain, from production to processing, packaging, and distribution, to raise the trust of consumers, partners, and certification bodies. This requires a collaborative network of participants who collectively adapt, implement, and coordinate shared values, strategies, and practices to integrate all dimensions of social responsibility into the supply chain's operations (Chen et al., 2023).

Overall, some of those studies have examined the factors affecting sustainable supply chains, such as products and services, strategies, sustainability governance, customer and supplier management, and quality issues. However, no studies have emphasized the factors affecting sustainable supply chains for organic agricultural cooperatives in rural Vietnam or evaluated the maturity of the sustainable supply chains. This study aims to address a significant gap in the literature and offers actionable strategies to enhance supply chain sustainability for organic agricultural cooperatives. The post-pandemic landscape presents an exciting opportunity for organic agricultural cooperatives to harness the groundbreaking advancements of Industry 5.0. By optimizing their supply chain operations through sustainable strategies, these organic agricultural cooperatives not only enhance efficiency but also champion sustainability initiatives that resonate with today's eco-conscious customers. This forward-thinking approach cultivates resilience and sets the stage for these companies to emerge as trailblazers in the quest for a sustainable future. Furthermore, it situates its findings within a comparative framework, yielding insights that are not only relevant to Vietnam but also applicable to other emerging economies.

3. Methodology

To optimize data collection from organic cooperatives and encourage their participation in sustainable supply chains, a multistage approach was employed. Initially, this study focused on key rural regions: Bac Giang, Hoa Binh, Bac Ninh, and Hung Yen. These regions were chosen due to their prominence in sustainable supply chain activities among organic cooperatives in Vietnam. Then, 250 registered organic agricultural cooperatives were randomly sampled from the comprehensive list provided by local authorities in these areas. The selected cooperatives, located in rural regions of the Red River Delta in Vietnam, were at least five years old and had a minimum of 30 members. Local authorities facilitated interviews at district committee offices, where the organic agricultural cooperatives were categorized into production and service groups. A total of 250 organic cooperatives were invited to participate in the study, all of which agreed to engage in an interview examining the maturity of sustainable supply chains for organic agricultural cooperatives.

In the first stage, to examine the maturity level of the sustainable supply chain for these organic agricultural cooperatives in rural Vietnam, the maturity model was used. Some studies have applied the maturity model to gauge the maturity level of sustainable supply chains (De Almeida Santos et al., 2020; Ho et al., 2020; Nawaz et

al., 2023). Therefore, this study also employed the maturity model, utilizing a set of variables, to assess the maturity level of sustainable supply chains for 250 organic agricultural cooperatives in rural Vietnam. The maturity model is designed to facilitate organic agricultural cooperatives in evaluating the maturity of their operations when those cooperatives progress through several maturity levels before reaching advanced stages.

The maturity level of each dimension is calculated as the weighted average of all maturity items (*MDLi*) within that dimension. The weighting factor (*gDLi*) corresponds to the average importance rating assigned to each item by a panel of 250 organic cooperatives joining in the survey. The suggested formula is as follows:

$$MD = \frac{\sum_{i=1}^{n} MDLi * gDLi}{\sum_{i=1}^{n} gDLi} \tag{1}$$

where, *MD* is the maturity, *DLi* is the dimension, *gDLi* is the weighting factor, and *n* is the number of maturity items.

In the second stage, to identify factors that affect sustainable supply chains of organic agricultural cooperatives in rural regions, the OLR model was used in this study. Some studies have investigated the factors that influence the sustainable supply chains (Meza-Ruiz et al., 2017; Robinson et al., 2006). Building on the foundation of previous research, this study also employed the OLR model to examine factors affecting the sustainability in the supply chains of organic agricultural cooperatives in rural Vietnam. The response variable (the sustainability level) is a polychotomous variable with five categories, which includes many of the factors affecting the level of sustainability in the supply chains of organic agricultural cooperatives in rural Vietnam with five levels (very low, low, moderate, high, and sustainability). Therefore, OLR was used to identify factors affecting the sustainable supply chains in Vietnam with group factors (product and services, sustainable governance, customer and supplier management, and quality issues). Let *Pij* (j = 1,2,3,4,5) represent the sustainability level of the supply chains of organic agricultural cooperatives in Vietnam, with j = 1,2,3,4,5 representing the very low, low, moderate, high, and sustainability levels, respectively. Then, the OLR model is given by:

$$Pij(j = kXi) = \frac{\exp(\beta kXi)}{\sum_{j=1}^{4} \exp(\beta jXi)} (j = 1,2,3,4,5) \tag{2}$$

To achieve model identification, the coefficient βj was set to zero for one of the categories, which is designated as the reference or base category (Cameron & Trivedi, 2005). By assigning βj a value of zero for one of the four groups, the OLR model can then be reformulated for each of the remaining groups as follows:

$$\begin{aligned} Pij(j = kXi) &= \frac{\exp(\beta kXi)}{\sum_{j=1}^{2} \exp(\beta jXi)} (j = 1,2,4) \\ Pij(j = 3Xi) &= \frac{1}{\sum_{j=1}^{4} \exp(\beta jXi)} (j = 1,2,3,4) \end{aligned} \tag{3}$$

The model can be estimated using the method of maximum likelihood.

The demographic factors were included as independent variables, including age, education level, gender, type, size, job level, and years of work experience. The dependent variables were grouped into eight dimensions, including strategies, processing, products and services, sustainable governance, supplier management, customer and marketing management, and quality issues. Table 1 shows the operationalization of variables.

Furthermore, factors influencing the level of supply chain sustainability in organic agricultural cooperatives were evaluated using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The average age of respondents was found to be approximately 35.24 years. A significant gender imbalance was observed, with 79.22% of the workforce identified as male. In terms of educational attainment, the majority of respondents reported more than 15 years of formal education. On average, the number of years since the establishment of the cooperatives exceeded seven years. The average size of the cooperatives, measured by the number of full-time members, was calculated at 2.31. However, most of the cooperatives surveyed were classified as small-scale entities, with membership exceeding 50 individuals in over half of the cases.

Table 1. Operationalization of variables

Variables	Definition
Age	Respondent's actual age (years)
Education	1 = Primary education 2 = Lower secondary education 3 = Upper secondary education 4 = College 5 = University and higher
Gender	1 = Male 2 = Female
Size of cooperatives	1 = Super small (below 50 members) 2 = Small (50 members) 3 = Medium (200 members) 4 = Large (300 members)
Position	1 = APS level 2 = Executive level
Working years	The time since the business was established
Maturity of sustainable supply chains	Sustainable supply chains with five levels involve incorporating environmental, social, and economic considerations into their management practices to achieve long-term sustainability, including very low, low, moderate, high, and sustainability
Processing	Using weed and plant disease, and pest management according to the stipulated standards
Products and services	The sustainability of environmental considerations, working conditions, safety, waste handling, and resource use efficiency
Strategies	Efficient strategies facilitate the development of network systems, new products and services, communication and direction of the corporation, and vision strategy sharing
Sustainable governance	Corporate environment, corporate social governance, reporting, and performance management
Customer and marketing management	Management of distribution channels, market information, and digital marketplaces
Supplier management	Coordinating and overseeing relationships with input suppliers and farm members to ensure the consistent delivery of high-quality, certified organic products
Quality issues	Improving certification standards, including common standards, processing, packaging, and distribution of crops, livestock products, aquatic plants, and aquatic animals
Resilience	The capability to be alert, respond quickly, and adapt to changes

4. Results

4.1 Results of the Maturity Level

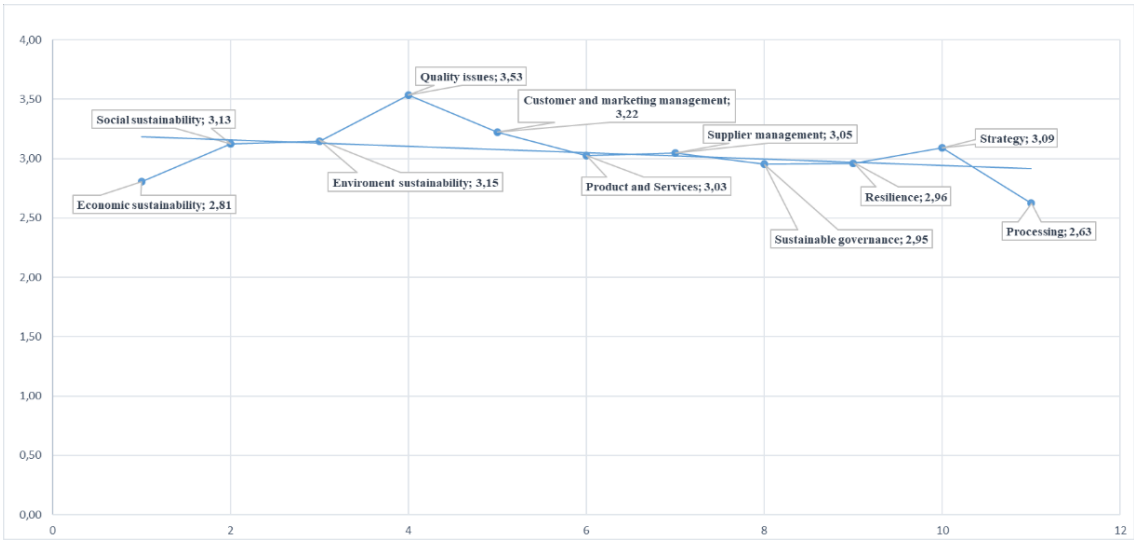

Figure 1. The maturity level of the sustainable supply chain of organic cooperatives

A survey was conducted involving 250 organic cooperatives. The evaluation was based on the integration of sustainability across economic, environmental, and social dimensions. The average maturity scores reported were 2.81 for economic sustainability, 3.15 for environmental sustainability, and 3.13 for social sustainability. Figure 1 shows the visualized maturity level in eight dimensions. The survey results show that the maturity level of the sustainable supply chain is around Level 3 for all factors.

The various facets and significance of the subject highlight the necessity of targeted analysis across its constituent dimensions. In addition, the outcomes of implementing this model in the supply chains of organic cooperatives reveal that cooperatives achieved the highest scores in quality issues (3.53), customer and marketing management (3.22), and strategies (3.09). The findings indicate that supply chain maturity scored lowest in processes (2.63) and sustainable governance (2.95). In the supply chain of cooperatives, the resilience was rated at 2.96, indicating a lower level of maturity.

4.2 Results of Influencing Factors

Table 2 presents the results of the OLR model on factors affecting the sustainable supply chains of organic cooperatives in rural Vietnam. The variables, which are products and services, strategies, governance, customer and supplier management, and quality issues, have an impact. A statistically significant F-test result ($p < 0.05$) confirmed the overall validity of the model, suggesting that the model specification was appropriate and that no systematic specification error had occurred.

Table 2. Factors affecting the sustainability level of the supply chains of organic agricultural cooperatives

Variables	Organic Agricultural Cooperatives		Agricultural Cooperatives	
	Coef.	Std. Err.	Coef.	Std. Err.
Processing	0.232	0.233**	0.327	0.421***
Products and services	-0.040	0.116**	-0112	0.359**
Strategies	0.396	0.176***	0.046	0.047***
Sustainable governance	0.187	0.187**	-0.438	0.364*
Customer and marketing management	0.305	0.105**	0.456	0.459**
Supplier management	0.233	0.233**	0.618	0.618**
Quality issues	0.515	0.051**	-0.438	0.640**
Resilience	0.088	0.109**	0.243	0.243***
Const	0.746	0.587	1.307	1.466
Obs	250		144	

Note: Robust standard errors are reported in parentheses. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

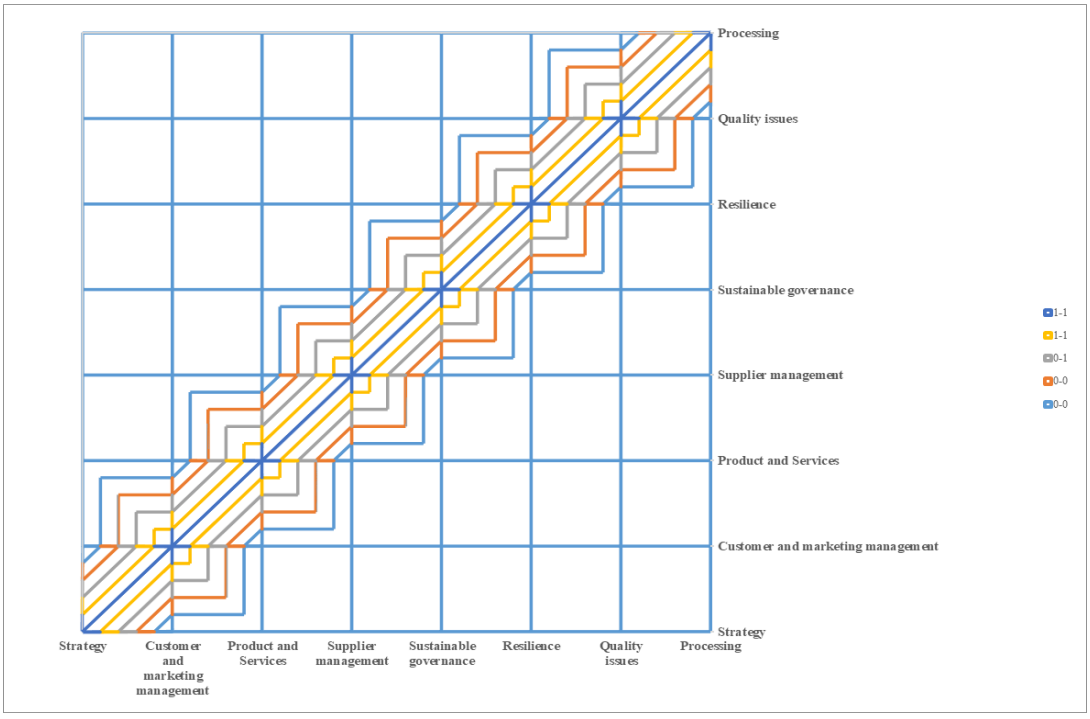

Figure 2. Correlation between factors affecting the sustainability level of the supply chains of organic agricultural cooperatives

The results show that the quality issues factor (0.515) exerts the most substantial influence on the sustainable supply chain maturity of organic cooperatives in rural regions. The other factors affecting the maturity of sustainability in the supply chains are strategies (0.396), customer and marketing management (0.305), and supplier management (0.233). In addition, processing (0.232) also plays a role in driving sustainable supply chains by providing the tools and metrics needed to monitor, measure, and optimize operations. However, Table 2 also shows that products and services do not have an impact on the maturity of sustainable supply chains for organic cooperatives.

In addition, the study also evaluated the relationships among the factors affecting the level of sustainability in the supply chains of organic agricultural cooperatives, as shown in Figure 2. The strongest positive correlations exist between supplier management and quality issues (0.462), between products and services with quality issues (0.421), as well as between sustainable governance and quality issues (0.374). The negative correlations exist between strategies and products and services (-0.119) as well as between products and services and supplier management (-0.118).

5. Discussion

The findings show that the maturity in the sustainable supply chain with five levels involves incorporating environmental consideration into its management practices to achieve long-term sustainability, which is the highest (3.15). According to Ho et al. (2016), the level of maturity in sustainable supply chains indicates how well a supply chain incorporates sustainability practices across environmental, social, and economic aspects with five stages: a) Initial stage: activities lack consistency and are not effectively managed; b) Managed stage: procedures are outlined but still not comprehensive, which leads to passive responses to issues; c) Defined stage: procedures are formalized and applied organization-wide, with a forward-looking approach; d) Quantitatively managed stage: business is tracked using data, ensuring processes in the supply chain are under control; and e) Optimizing stage: enhancement is continuous and processes are operated with innovation. Therefore, Figure 1 shows that organic agricultural cooperatives apply basic supply chain management processes, which are defined and documented. Sustainability is considered in the supply chain for suppliers and in reporting metrics. Process performance is more predictable. Performance targets are established but frequently not achieved. Customers' needs are one of the important criteria in process improvement initiatives, and customer satisfaction is not entirely met. Besides, collaboration among internal cooperatives, suppliers, and customers is facilitated through cross-functional teams that align around shared supply chain management metrics and objectives extending across the whole supply chain. However, the economic facet involves balancing cost efficiency and environmental and social responsibilities, ensuring that economic growth fostered by sustainable initiatives is lower (2.81). Organic agricultural cooperatives often exhibit higher environmental and social sustainability than economic sustainability because organic farming practices enhance soil fertility, conserve water, and protect ecosystems from the harmful effects of synthetic fertilizers and pesticides, protect ecosystems and contribute significantly to long-term environmental resilience (Zhou et al., 2018). In the short term, they may not always lead to immediate economic gains due to higher production costs, limited market access, and price competition with conventional agriculture.

In Figure 1, the maturity level in eight dimensions is visualized. The results of the OLR model show that the various facets and significance of the subject highlight the necessity of giving specific attention to the supply chain of the cooperatives and offering solutions and tools for its enhancement. The outcomes of implementing this model in the supply chains of organic cooperatives reveal that they achieved the highest scores in quality issues (3.53), customer and marketing management (3.22), and strategies (3.09). The quality issues factor exerts the most substantial influence on Vietnamese organic agricultural cooperatives in the rural region. These cooperatives also know that new requirements for quality issues are elicited and realized by the cultivation of new utility values. Correia et al. (2023) proved that sustainable production plays a critical role in enhancing the sustainable supply chain of organic agricultural cooperatives by meeting quality requirements concerning environmental, social, and economic impacts throughout the life cycle of agricultural products. Sustainable products and services promote optimizing the entire supply chain from production to delivery.

The result of the customer and marketing management factor is 3.22. At this level, the cooperatives have established informal digital platforms through social networks for sharing knowledge about production and business. They have a plan for evaluating competitors and know how to attract customer attention for their organic products. Additionally, they use specific metrics to effectively conduct comparative analyses of competing products at relevant stages of the product life cycle. They also concentrate on developing organic products and markets for commercialization. The process commences with identifying the needs and challenges within the agricultural domain, such as enhancing crop yield, minimizing environmental impact, or optimizing supply chain efficiency. Establishing a robust brand and a marketing strategy is indispensable for customer attraction, which may entail emphasizing the product's sustainability, efficiency, and innovation. In general, integrating production across the value chain has yielded advantages for cooperatives and farmers, reducing intermediary stages, decreasing production costs, and amplifying product value (Ho et al., 2020). Notably, strategies enable organic

agricultural cooperatives to invest in sustainable infrastructure, technologies, and practices while managing risks and ensuring ethical sourcing. According to Tseng et al. (2019), the right strategies help create a sustainable supply chain that is not only economically viable but also socially and environmentally responsible. Strategy backing helps organic agricultural cooperatives scale their operations in a sustainable manner. Expanding and adhering to environmentally friendly practices requires significant investment, particularly in training, certification, and compliance with sustainability standards. For organic agricultural cooperatives that wish to reach global markets, financial resources help with meeting international sustainability standards, certifications, and building partnerships that adhere to ethical practices.

The findings indicate that supply chain maturity scored lowest in processing (2.63), resilience (2.96), and sustainable governance (2.95). Sustainable governance in organic agricultural cooperatives also plays a critical role in driving sustainable supply chains by providing the tools and metrics needed to monitor, measure, and optimize operations. Through the effective use of sustainable governance, organic agricultural cooperatives can improve resource efficiency, reduce environmental impact, enhance supply chain resilience, and achieve long-term sustainability goals while staying competitive in the agricultural market. By regularly monitoring supply chain performance, organic agricultural cooperatives can identify potential risks and disruptions, such as climate-related events, supply shortages, or changes in consumer demand. Effective performance management allows organic agricultural cooperatives to build more resilient supply chains that can adapt to these challenges while maintaining sustainability (Huo et al., 2022). However, many cooperatives face governance challenges that undermine long-term sustainability (2.95). Strengthening governance systems is vital to ensure transparency, equity, and resilience. Simultaneously, the findings indicate that the maturity level of supply chain maturity scored lowest in processing (2.63). Organic agricultural cooperatives often operate in rural or resource-constrained areas where market infrastructure and financial support are limited, making it challenging to apply organic farming practices.

In summary, Industry 5.0 is becoming increasingly critical. Industry 5.0 shifts the emphasis towards sustainability, human-centricity, and resilience. The core elements of sustainability with regard to Industry 5.0 emphasize that organizations should improve certification standards (including common standards), processing, packaging, and distribution (such as using renewable power sources, reducing air emissions and wastewater disposal, and recycling and reusing resources) (Seuring & Müller, 2008). Basically, organic cooperatives significantly contribute to sustainable development by gaining the highest score in applying quality issues and customer and marketing management. These cooperatives not only enhance efficiency but also champion sustainability initiatives that resonate with today's eco-conscious consumers. This forward-thinking approach cultivates resilience and sets the stage for these companies to emerge as trailblazers in the quest for a sustainable future and Industry 5.0 readiness.

The results of the OLR model show that quality issues, strategies, and customer and supplier management are the factors with the highest impact on the sustainable supply chain of Vietnamese organic agricultural cooperatives. Correia et al. (2023) proved that sustainable production concerning customer and supplier management plays an essential role in enhancing the sustainable supply chain by addressing environmental, social, and economic impacts throughout the life cycle of agricultural products. Sustainable supplier management promotes optimizing the entire supply chain from production to delivery. Therefore, organic agricultural cooperatives can leverage local sourcing, shorter distribution channels, and farm-to-table logistics for greater efficiency.

In addition, organic agricultural cooperatives in rural regions can improve the sustainability in supply chains by enhancing quality issues because the factor is also a key component of sustainable supply chains in organic agricultural cooperatives as it ensures that the processes used to produce agricultural goods and related products are environmentally friendly, socially responsible, and economically viable. Quality issues emphasize the use of energy-efficient processes and machinery, reducing the overall energy footprint of production. This is particularly important for organic agricultural cooperatives seeking to minimize operational costs and environmental impact (Graham, 2017). In contrast, quality issues do not have an impact on agricultural cooperatives (-0.438) because these cooperatives still use the traditional production method.

Moreover, sustainable strategies enable organic agricultural cooperatives to invest in sustainable infrastructure, technologies, and practices while managing risks and ensuring ethical sourcing. According to Tseng et al. (2019), the right strategies help create a sustainable supply chain that is not only economically viable but also socially and environmentally responsible. Expanding and adhering to environmentally friendly practices requires significant investment, particularly in training, certification, and compliance with sustainability standards. For organic agricultural cooperatives that wish to reach global markets, financial resources help with meeting international sustainability standards, certifications, and building partnerships that adhere to ethical practices. However, products and services do not have an impact on the supply chain sustainability of organic agricultural cooperatives. Because the cooperatives' customers are special and unchangeable, they value health, sustainability, and community impact. Organic cooperatives offer products that are grown without synthetic chemicals, making them safer and more environmentally friendly. This sense of trust, quality assurance, and shared values encourages ongoing customer support for organic cooperatives. Besides, the results show relationships between advanced

technologies and supply chain components. For instance, the strong positive correlation (0.464) between supplier management and quality issues underscores the ability of organic cooperatives to meet production standards to enhance supply chain maturity. Conversely, weak correlations between strategies and products and services (-0.119) as well as between products and services and supplier management (-0.118) present opportunities for focused interventions to reinforce these factors.

6. Conclusions

The maturity model and the OLR model were utilized in this study to examine the maturity of the sustainable supply chain and factors affecting the sustainable supply chain of organic agricultural cooperatives in rural Vietnam. The analysis extends scholarly discussions on the interplay of supply chain influencing factors with the sustainable development of organic agricultural cooperatives in rural Vietnam. The findings emphasize the need for strategies, customer and supplier management, and quality issues in organic cooperatives. The key recommendations are as follows:

Firstly, strengthening sustainability governance involves fostering inclusive decision-making, adopting transparent certification standards, and building monitoring systems that integrate environmental and social indicators. Boosting resilience requires diversifying income streams, enhancing access to financial services and insurance, and building strategic alliances with non-governmental organizations, research institutions, and local governments. These measures collectively help organic cooperatives become more adaptive to market fluctuations, climate impacts, and social changes.

Secondly, the government should implement coordinated measures to enhance infrastructure and technical capabilities, emphasizing improvements in information systems for customers and suppliers in the sustainable supply chain for rural organic agricultural cooperatives.

Thirdly, establishing robust collaboration within the sustainable supply chain is essential for improving operational efficiency, minimizing wastage, and fostering sustainability. Leveraging digital platforms that facilitate seamless collaboration, such as supply chain management software, cloud-based data sharing, and real-time tracking systems, is imperative.

Fourthly, innovative strategies tailored for organic agricultural cooperatives should be developed in coordination between the state and organic agricultural cooperatives. Advocating for policies and governmental support that promote cooperative conduct and offer incentives for sustainable practices is crucial in creating an enabling landscape for collaboration, thereby facilitating concerted efforts towards shared sustainability objectives. Governments should incentivize collaboration through tax breaks and grants for joint projects.

In general, this research delves into the realm of business model innovation by examining the supply chain with a focus on organic cooperatives, integrating it with the sustainable principles of Industry 5.0, which has a mutually reinforcing effect. This forward-thinking approach cultivates resilience and sets the stage for these cooperatives to emerge as trailblazers to harness the groundbreaking advancements of Industry 5.0. It situates its findings within a comparative framework, yielding insights that are not only relevant to Vietnam but also applicable to other emerging economies. The reported findings should be viewed in the light of some limitations of the investigation, which suggest directions for future research. These organic cooperatives were evaluated only in the rural northern areas. Nevertheless, other areas will be incorporated into future research in order to reduce this bias.

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Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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