

Influence of Supply Chain Integration on the Sustainable Performance of Dairy Farms in Pak Chong District, Nakhon Ratchasima

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ABSTRACT

Background and Objectives: Dairy farms in Thailand are facing a downward trend in their number of dairy cows and in raw milk production each year, which affects the sustainability of the dairy business. Therefore, sustainability operations are crucial to help dairy farms align with sustainable development goals in terms of the economy, society, and the environment. Supply chain integration in dairy farms is an important factor that will help farms remain competitive and operate efficiently. The objectives of this study are to examine the levels of supply chain integration and sustainable performance and to assess the influence supply chain integration has on the sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima.

Methodology: This quantitative study examined the impact of supply chain integration on the sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima. Data were collected through a structured questionnaire. The target population comprised 152 dairy farm operators registered with the Pak Chong Dairy Cooperative, Nakhon Ratchasima.

Main Results: The level of supply chain integration revealed that customer integration had the highest mean score of 4.58, followed by internal integration with a mean score of 4.15 and supplier integration with a mean score of 4.10. The level of sustainable performance revealed that the environmental aspect had the highest mean score of 4.41, followed by the social aspect with a mean score of 3.93 and the economic aspect with a mean score of 3.90. These results indicate that supplier and internal integration have a positive impact on both sustainable economic and social performance. However, customer integration has no significant impact on any aspects of sustainable performance. None of the integration types influence sustainable environmental performance. These statistical findings provide an understanding of the effectiveness of supply chain integration in supporting sustainable performance and offer insights for improving the competitiveness and sustainability of dairy farms.

Discussions: Supply chain integration and the sustainable performance of entrepreneurs are scored at a high level, particularly in terms of integration with suppliers, internal organizational integration, and integration with customers. Similarly, the average level of sustainable performance is also high. Entrepreneurs prioritize information exchange with suppliers and effective communication within the organization and with customers, which facilitates market demand planning and forecasting. This integration positively impacts

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economic and social sustainability but does not significantly affect environmental sustainability.

Conclusions: Dairy farm operators should prioritize supply chain integration, particularly with internal suppliers and customers, to enhance operational efficiency and foster long-term sustainable relationships. Strengthening supply chain integration will contribute to continuous growth and sustainability across economic, social, and environmental dimensions. Furthermore, optimizing operational processes and promoting both internal and external collaboration can improve environmental performance and enhance overall efficiency through more effective coordination.

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Introduction

In Thailand, dairy farming is a widespread occupation. However, the hot and humid climate induces stress in dairy cows and increases milk production costs. In 2020, the average price of milk in Thailand was 14.70 baht per kilogram, with labor costs accounting for 13.47% of total production expenses and feed costs comprising 65.89%. Efficient dairy farm management plays a crucial role in reducing production costs and enhancing milk yield. Despite its significance, the dairy farming industry faces multiple challenges, including rising expenses, labor shortages, and high feed costs, all of which threaten business sustainability. Additionally, several risk factors hinder the achievement of dairy farming objectives. Projections were made between 2022 and 2024 that the total number of dairy cows in Thailand would begin declining by 3.30% annually. As of 2024, the total population of dairy cows in Thailand was 723,788. Similarly, raw milk production was expected to decrease by 3.15% annually, totaling 1,113,000 tons as of 2024. The five provinces with the highest number of dairy farm operators in Thailand are Saraburi, Nakhon Ratchasima, Ratchaburi, Lopburi, and Chiang Mai. In 2022, Nakhon Ratchasima had 5,024 dairy farmers managing a total of 158,609 dairy cows. Pak Chong District has the highest concentration of dairy farms in Nakhon Ratchasima because of its favorable land and weather conditions. In Pak Chong District, the Dairy Farming Promotion Organization of Thailand under Royal Patronage serves as a major purchaser of raw milk, ensuring that farmers can sell their milk in quantities that match their production capacity (Working Group on the Review of the Dairy and Dairy Product Development Strategy, 2021).

Understanding risk management and its connection to sustainable development goals is essential for dairy farming in Pak Chong District. Effective supply chain integration can significantly enhance the sustainable performance of dairy farms across economic, social, and environmental dimensions. From an economic sustainability perspective, efficient supply chain management enhances production performance and reduces operational costs, thereby improving the financial stability of dairy farms. Additionally, it fosters better work practices and skill development among dairy farmers, leading to increased income and long-term economic security. In terms of social sustainability, supply chain integration strengthens relationships among dairy farms and key stakeholders, including employees and local communities. It promotes corporate social responsibility and community engagement, generating positive social impacts. Regarding environmental sustainability, supply chain integration facilitates efficient natural resource management and enhances transparency, mitigating environmental impacts such as resource depletion and waste generation. This, in turn, supports the long-term environmental sustainability of dairy farms, ensuring their operations align with sustainable and responsible practices (Working group, 2021).

Network integration is essential in the highly competitive business environment, where companies must continuously adapt and share information among supply chain participants to enhance operational efficiency. Understanding consumer behavior and leveraging this knowledge to strengthen market positioning is critical, particularly in response to evolving demand patterns. Effective demand forecasting and strategic planning based on customer data are fundamental to ensuring adaptability and maintaining a competitive edge (Sulistiyari & Masa, 2023).

In accordance with this framework, the research questions are as follows: 1) To what extent do dairy farm operators in Pak Chong District integrate the supply chain and achieve sustainable performance? and 2) How does supply chain integration affect the sustainable performance of dairy farms in Pak Chong District? These research questions have been selected in order to study the impact of supply chain integration on sustainable operations in dairy farms. This is an area that has been relatively underexplored in Thailand, as noted in previous studies of Klincharoen (2018). These questions aim to address this gap and contribute to developing long-term sustainable strategies for dairy farm businesses (Working group, 2021).

Objectives

1. To study the level of supply chain integration and sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima
2. To study the influence of supply chain integration on the sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima

Review of literature

Supply Chain Integration

Jiang et al. (2023) define supply chain integration as a business process that integrates various systems and activities, which are important resources that affect the ability of the business to respond effectively to changes in consumer demand and market conditions. Similarly, Zanella et al. (2023) describe supply chain integration as an essential tool for enhancing organizational efficiency. They emphasize its role as a vital link within the supply chain, ensuring systematic and strategically coordinated operations from inception to completion. Additionally, Sulistiyari and Masa (2023) characterize supply chain integration as the level of collaboration between strategic organizations and supply chain partners, facilitating the seamless flow of products, services, information, and finances, ultimately supporting effective decision-making. The key dimensions of supply chain integration commonly explored in research include supplier integration, internal integration, and customer integration:

The first of these dimensions is supplier integration, which refers to the collaborative process in which manufacturing companies and supply chain entities engage in joint planning, execution, and decision-making. This integration fosters the exchange of information and technology, leading to improved cost efficiency, enhanced scheduling, and streamlined production planning (Awwad et al., 2022; Vaibhav & Bharamanaikar, 2023).

The second dimension is internal integration, which involves collaboration and information sharing among personnel within an organization to effectively understand and respond to customer needs. This process encompasses monitoring internal operations, including the management of information, materials, and services delivered to customers. A strong emphasis is placed on cost-reduction strategies to achieve a competitive advantage (Amoako et al., 2022; Ruzo-Sanmartin et al., 2023).

Finally, customer integration entails working closely with customers and exchanging information to gain a deeper understanding of their needs and expectations. This process involves managing information, materials, and services delivered to customers, facilitating improved market insights. Additionally, customer integration plays a crucial role in new

product development, allowing businesses to create superior value propositions that outperform competitors (Awwad et al., 2022; Aslam et al., 2023).

Sustainable Performance

Yu et al. (2024) define performance goals as the objective of increasing profits for the company's stakeholders, emphasizing the company's overall performance, which includes sustainable development and social responsibility. These factors have a significant impact on the company's financial performance, incorporating aspects such as risk management and other critical elements. Similarly, Huma et al. (2023) classify sustainable performance into three key dimensions: economic, social, and environmental. These three dimensions collectively contribute to the profitability necessary for the company to achieve its goals, with an emphasis on environmentally friendly practices, which are essential for the company's image and the perception of its products by stakeholders. Pavanello et al. (2024) found that sustainable dairy farms positively impact economic, social, and environmental aspects. Economically, they reduce costs, increase profits, and enhance self-sufficiency in energy and feed. Socially, they improve farmers' quality of life, reduce workload, and strengthen community relations. Environmentally, they lower greenhouse gas emissions, conserve biodiversity, and promote cleaner energy use. Developing dairy farms should consider all three dimensions to ensure long-term sustainability.

Sustainable performance consists of economic, social and environmental dimensions. First, economic sustainable performance refers to a company's ability to generate stable and sustainable earnings, which is used to assess the organization's performance in a highly competitive environment. This includes expanding sales, increasing market share, and reaching out to consumers (Pinheiro et al., 2023; Sarwar & Franzoni, 2024; Lee & Kim, 2024).

Next, social sustainable performance refers to the objectives of a company's business operations that must be socially responsible, aiming to promote social development and improve the quality of life. This includes the development of labor efficiency, which influences working hours, labor costs, and work organization. A better understanding of the work process results in fewer work errors and plays an important role in achieving the goals set for sustainable operations (Huma et al., 2023; Sarwar & Franzoni, 2024).

Finally, environmentally sustainable performance focuses on the awareness of the impact of business operations on the environment, emphasizing the development and improvement of environmental management systems, such as water and energy use, wastewater treatment, and waste reduction, in order to conserve the environment with maximum efficiency. Additionally, the development of sustainable energy, water, and environmental systems is critical for meeting basic human needs (Rachman et al., 2022; Cheng et al., 2024).

Development of Research Hypotheses

Supplier integration influences sustainable performance

Hou et al. (2023) found that integrated suppliers directly affect product performance and positively influence sustainable performance. Akbar and Aslam (2023) studied supplier integration and demonstrated that it significantly enhances technological capabilities, as suppliers act as both upstream and downstream partners. This facilitates the sharing of production technology, experience, and resources, which positively affects sustainable performance. Huma et al. (2023) conducted a study on reducing environmental, social, and human impacts and proposed an integrative framework that identifies areas for improvement in economic, social, and environmental dimensions, from suppliers to customers. This integration positively impacts social sustainability performance. Furthermore, Awwad et al. (2022) examined the relationship between customer and supplier green integration, new

product development, sustainable green product innovation, and competitive advantage in terms of cost leadership and differentiation strategies. Their study revealed a positive effect on environmental sustainability performance. Kang et al. (2018) investigated supply chain integration and its impact on sustainability, highlighting that supply chain integration has a positive effect on both economic and environmental sustainability. Based on the findings of these studies, the following hypotheses are proposed in this research:

H1: Supplier integration has a positive influence on economic sustainability performance

H2: Supplier integration has a positive influence on social sustainability performance

H3: Supplier integration has a positive influence on environmental sustainability performance

Internal integration influences sustainable performance

Amoako et al. (2022) studied the mediating role of internal integration, focusing on its relationship with Small and Medium-sized Enterprises (SME) performance. They found that internal integration positively impacts both performance and sustainability performance. Additionally, Ruzo-Sanmartin et al. (2023) examined the impact of internal integration on business performance, revealing a positive effect on social sustainability performance. Arshad Ali and Mahmood (2023) analyzed the influence of both internal and external supply chain integration on product innovation capability, including the development of environmentally friendly products, which positively affects environmental sustainability. Based on the findings of these studies, the following hypotheses are proposed in this research:

H4: Internal integration has a positive influence on economic sustainability performance

H5: Internal integration has a positive influence on social sustainability performance

H6: Internal integration has a positive influence on environmental sustainability performance

Customer integration influences sustainable performance

Mohamed et al. (2023) conducted a study on the application of blockchain technology to improve the efficiency of the environmental supply chain, aiming to create sustainability and resilience, particularly in an uncertain environment. This improvement can lead to increased customer satisfaction and loyalty, demonstrating commitment to responsibility and differentiation from competitors, which positively impacts sustainable economic performance. Additionally, Aslam et al. (2023) focused on marketing approaches, supply chain strategies, and management between marketing functions to enhance efficiency in responding to market changes, which results in improved customer satisfaction. Furthermore, organizing work processes to better understand the workflow and reduce errors contributes to sustainable social performance. Lastly, Awwad et al. (2022) investigated the direct impact of green customer integration and new product flexibility on the development of sustainable green product innovations. Their study found that customer integration positively impacts sustainable environmental performance. Based on the results of these studies, the following hypotheses are proposed in this research:

H7: Customer integration has a positive influence on economic sustainability performance

H8: Customer integration has a positive influence on social sustainability performance

H9: Customer integration has a positive influence on environmental sustainability performance

This research fills the gap in the literature by studying the impact of supply chain integration in the Thai dairy farming sector, which differs from previous research that focuses on large-scale industries. It also analyzes the relationship between integration and sustainability in all dimensions, providing a deeper understanding that can be applied to the sustainable development of dairy farming businesses.

In accordance with the review of pertinent literature, the research framework is shown in Figure 1.

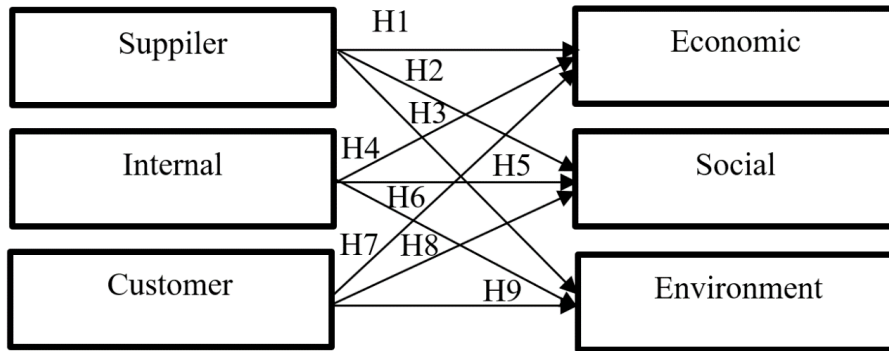


Figure 1 Conceptual Framework

Method

Participants

The population consisted of 337 dairy farm operators registered with the dairy cooperative in Pak Chong District, Nakhon Ratchasima. A non-probability sampling technique was used to select purposive samples based on the following criteria: owning at least five dairy cows, having at least one year of dairy farming experience, currently raising dairy cows at the time of data collection or delivering raw milk to the dairy cooperative, and being willing to complete the relevant questionnaires. The sample size was 152 dairy farm operators, calculated using the formula for a known population developed by Yamane (1973). In social science research, a tolerance of 5-10% is often applied, depending on the variables considered in calculating the sample size. However, to ensure more accurate results, a sampling error of 6% (or 0.06) was used (Vaghela, 2024).

Questionnaire

A questionnaire was used to collect general information and research variables from dairy farm operators. The questions regarding the research variables were closed-ended, using a 5-level rating scale, where 5 indicated "strongly agree" and 1 indicated "strongly disagree." The content validity of the questionnaire was assessed by three experts. The Item-Objective Congruence (IOC) of each item was 0.67 or higher, which is considered acceptable for content validity (Rovinelli & Hambleton, 1977). The questionnaire was then tested with 30 animal breeders who were not part of the sample group. Cronbach's alpha coefficients greater than 0.7 indicated that the questionnaire was reliable (Tavakol & Dennick, 2011). Data were collected from 152 dairy farm operators between August 20 and September 1, 2024.

Data Analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to describe the general data of the sample group and to address Objective 1, which involved measuring the level of supplier integration, internal integration, customer integration, and sustainable performance in terms of economics, society, and the environment. Inferential statistics were employed to test the research hypothesis and address Objective 2, which examined the impact of supply chain integration on sustainable performance using multiple regression analysis.

Procedures

The researcher personally collected the data by obtaining permission from dairy farmers in Pak Chong District, Nakhon Ratchasima Province. The data collection comprised both quantitative and qualitative data from secondary and primary sources. The procedures involved gathering secondary data, which included information on supply chain integration and sustainable performance, which was sourced from books, academic articles, research reports, questionnaires, and relevant online articles. Primary data were collected through questionnaires administered to 152 dairy farm operators in Pak Chong District, Nakhon Ratchasima Province, using purposive sampling. The data collection methods were as follows:

1) Contacting and coordinating with dairy farm cooperatives in Pak Chong District to gather data from operators listed in the cooperatives.

2) The researcher visited the field to personally administer the questionnaires. The objectives and questions were explained to the operators, and questionnaires were collected from one dairy farm operator or representative per establishment. The data collection period spanned from August 20 to September 1, 2024, for a total of 12 days.

Findings and Discussion

Of the 152 dairy farm operators sampled in the research, the majority (87.5 percent) had more than 5 years of experience in the farm operations. In addition, most respondents (42.8 percent) had between 10 and 30 dairy cows, followed by those with more than 50 dairy cows (26.3 percent), and those with 30 to 50 dairy cows (24.3 percent), while a smaller group had fewer than 10 dairy cows (6.6 percent).

Study of the level of supply chain integration and sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima Province

The integration with suppliers of dairy farms in Pak Chong District, Nakhon Ratchasima has a high mean value of 4.10. This is consistent with the research of Hou et al. (2023) who found that supplier integration directly affects product performance and is also consistent with the research of Akbar and Aslam (2023) who stated that supplier integration significantly enhances technological capabilities as suppliers act as upstream and downstream partners. A dairy farm in Pak Chong works with cooperatives or private stores to plan the purchase of feed and medicines, collaborating to predict future needs and addressing material shortages, thus effectively controlling production costs.

The integration within the organization of dairy farms in Pak Chong District, has a high mean score of 4.15. This is consistent with the research of Ruza-Sanmartin et al. (2023) who found that factors supporting internal integration affect business performance in the supply chain. It is also consistent with the research of Amoako et al. (2022) who found that the relationship between internal integration and the performance of SMEs has relationship with internal and external integration, affecting operational efficiency. In a family-owned dairy farm, tasks such as feeding cows, milking twice a day, and cleaning are efficiently managed through quick communication between family members. This allows them to resolve issues promptly and ensure smooth daily operations.

The integration between dairy farms in Pak Chong District, and their customers has a mean of 4.58. This is consistent with the research of Awad et al. (2022) who also found that customer integration affects market expectations and the opportunity to respond to customer needs. This includes the exchange of information with customers, which can be used as a strategy to increase competitive advantage. Moreover, Aslam et al. (2023) found that customer integration not only helps attract new customers but allows them to participate in decision-making to improve supply chain efficiency. A dairy farm in Pak Chong sells raw milk to cooperatives, who then provide market data, such as raw milk demand and price changes, which helps the farm adjust its production plans to align with market needs.

Table 1. Descriptive statistics of research variables

Variables	\bar{x}	Standard deviation
Supplier Integration	4.10	0.489
Internal Integration	4.15	0.470
Customer Integration	4.58	0.363
Economic Sustainable performance	3.90	0.609
Social Sustainable performance	3.93	0.412
Environment Sustainable performance	4.41	0.390

The sustainable economic performance average of dairy farms in Pak Chong District was 3.90. This is consistent with the research of Hou et al. (2023) who found that sustainable economic performance shows that the enterprise can improve its products according to market demand, increasing the enterprise's competitiveness. A dairy farm with fewer than 50 cows will face higher production costs due to a lack of milk-producing cows. However, farms with more than 50 cows can better manage costs and improve operational performance, leading to higher profitability.

The sustainable social performance average of dairy farms in Pak Chong district was 3.93. This is consistent with the research of Huma et al. (2023) who found that social sustainability performance helps in gaining competitive advantage and can improve and strengthen sustainable practices for a better society. In larger farms with more than 50 cows, employee welfare is a priority. Farms ensure that working conditions are safe and hygienic, offering fair compensation and opportunities for skill development, improving both productivity and employee satisfaction.

The sustainable environment performance average of dairy farms in Pak Chong District was 4.41. This is consistent with the research of Arshad Ali and Mahmood (2023) who found that environmental performance affects operational capabilities and efficiency, enabling the development of environmentally friendly products. A dairy farm in Pak Chong manages its waste effectively by plowing under animal manure and recycling waste materials, minimizing environmental impact. The farm also controls wastewater discharge and uses resources efficiently, ensuring environmentally friendly operations.

Study of the influence of supply chain integration on the sustainable performance of dairy farms in Pak Chong District, Nakhon Ratchasima Province

Table 2. The influence of supply chain integration on sustainable performance

Variable	Unstandardized Coefficients	Standardize Coefficients	p value
Dependent variable:	Economic sustainable performance		
Constant	1.997*		0.004
Supplier integration	0.290*	0.233*	0.013
Internal integration	0.337*	0.260*	0.005
Customer integration	-0.149	-0.089	0.237
Remark	F = 11.679, p = 0.000, R ² = 0.191, Adjust R ² = 0.175		
Dependent variable:	Social sustainable performance		
Constant	1.949*		0.000
Supplier integration	0.257*	0.305*	0.000
Internal integration	0.361*	0.412*	0.000
Customer integration	-0.126	-0.111	0.086
Remark	F = 33.622, p = 0.000, R ² = 0.405, Adjust R ² = 0.393		

Table 2. (Cont.)

Variable	Unstandardized Coefficients	Standardize Coefficients	<i>p</i> value
Dependent variable:	Environment sustainable performance		
Constant	3.275*		0.000
Supplier integration	0.026	0.032	0.748
Internal integration	0.101	0.122	0.228
Customer integration	0.134	0.124	0.128
Remark	F = 2.366, p = 0.073, R ² = 0.041, Adjust R ² = 0.021		

Supplier integration has a direct and statistically significant positive impact on sustainable economic performance (accept H1). This conclusion is consistent with most of research findings of Hou et al. (2023). They found that supplier integration has a direct effect on product performance, which has a positive effect on economic performance. Akbar and Aslam (2023) also stated that supplier integration significantly enhances technological capabilities as suppliers act as both upstream and downstream partners, which has a positive impact on economic performance. The integration with suppliers in dairy farms helps control costs and maintain raw material quality. For instance, a dairy farm regularly exchanges information about raw material requirements with its suppliers. This allows them to plan their orders in advance, reducing raw material waste and effectively manage production costs.

Supplier integration has a direct and statistically significant positive impact on sustainable social performance (accept H2). This conclusion is consistent with the majority of research findings. This is consistent with the research of Huma et al. (2023) who found that the integration framework can improve economic, social and environmental performance from suppliers to customers and can reduce harmful impacts on the environment and society. A dairy farm that integrates its operations with suppliers in terms of ordering materials and controlling costs sees improved teamwork between employees and suppliers. By collaborating in planning material orders, the farm reduces errors in purchasing and quality control, which also strengthens relationships between the staff and suppliers.

Supplier integration has a direct but not statistically significant positive impact on sustainable environment performance (reject H3). This conclusion is consistent with the majority of research findings. This is consistent with the research of Klincharoen (2018) which studied the sustainable performance of industrial businesses to analyze the confirmatory components of environmental management factors and sustainable performance factors. An example of this is a dairy farm that integrates with suppliers in using eco-friendly materials, such as selecting construction materials with minimal environmental impact and choosing suppliers who employ sustainable production practices. However, despite this integration, some farms might not see a significant change in environmental impact.

Internal integration has a direct and statistically significant positive impact on sustainable economic performance (accept H4). This conclusion is consistent with the majority of research findings. This is consistent with the research of Ruzo-Sanmartin et al. (2023) who found that factors supporting internal integration affect business performance in the supply chain. This is also consistent with Amoako et al. (2022) who found that the relationship between internal integration and the performance of SMEs has a relationship between internal and external. There is a mutually beneficial relationship. Effective internal management facilitates smooth collaboration with partners, while external integration enhances organizational efficiency. Within a dairy farm, integrating information between departments, such as inventory management and production, reduces raw material shortages and improves teamwork. This collaboration helps reduce production costs and enhances operational efficiency.

Internal integration has a direct and statistically significant positive impact on sustainable social performance (accept H5). This conclusion is consistent with the majority of research findings. This is consistent with the research of Ruzo-Sanmartin et al. (2023) who found that internal integration has an effect on social performance, helping the work process by exchanging knowledge and skills. A dairy farm that promotes collaboration between departments through data sharing and joint planning improves operational efficiency, streamlines processes, and enhances decision-making for better productivity. For example, organizing staff trainings on dairy farming processes enhances employee performance, the meeting of standards, and fosters a collaborative work culture.

Internal integration has a direct but not statistically significant positive impact on sustainable environment performance (reject H6). This conclusion is consistent with the majority of research findings. This is consistent with the research of Khalaf and Mokadem (2019) who found that the relationship between internal integration, internal flexibility and external flexibility can improve internal processes but has no effect on environmental performance. This is also consistent with the research of Kang et al. (2018) who found that internal integration and sustainability impact for competitive advantage have no effect on environmental performance. In the case of a dairy farm, strong internal integration may improve processes to reduce costs, but it does not necessarily lead to the adoption of eco-friendly materials or sustainable resource consumption.

Customer integration has a direct but not statistically significant negative impact on sustainable economic performance (reject H7). This conclusion is consistent with the majority of research findings. This is consistent with the research of Abidin et al. (2016) found that customer integration on sustainability performance directly affects the company's investment value, but has no effect on economic performance. This is also consistent with the research of Yeh et al. (2020) who found that small business customer integration under uncertainty has no effect on economic performance. In most dairy farms in Thailand, milk is sold to cooperatives or companies that purchase raw milk. Integration with customers in this manner does not directly impact economic performance, as these businesses do not rely on close customer relationships for product management.

Customer integration has a direct but not statistically significant negative impact on sustainable social performance (reject H8). This conclusion is consistent with the majority of research findings. This is consistent with the research of Abidin et al. (2016) who found that customer integration can impact a company's investment value but not its social performance. There is also research by Mohamed et al. (2023) which found that customer integration had no effect on social performance. Dairy farms selling raw milk to cooperatives and companies are not required to integrate with customers on a social level, thus not having a significant effect on social performance. There is no need to manage customer expectations at a high level in these transactions.

Customer integration has a direct but not statistically significant positive impact on sustainable environmental performance (reject H9). This conclusion is consistent with the majority of research findings. This is consistent with the research of Ruzo-Sanmartin et al. (2023) who found that customer integration, which affects supply chain performance through the relationship between the company and the customer, has no effect on environmental performance. It is also consistent with the research of Aslam et al. (2023) who found that customer integration is a process of building and enhancing capabilities but has no effect on environmental performance. In dairy farms that sell raw milk to cooperatives or companies, customer integration does not affect environmental performance. There is no exchange of information regarding environmental impacts, and the farms do not focus on making their operations eco-friendlier due to the nature of the relationship with customers.

Customer integration does not influence sustainable performance because dairy farms sell through cooperatives, follow strict production standards, and have limited direct interaction

with consumers. Unlike manufacturing and retail industries, where customer integration drives business success, dairy farming relies more on supplier and internal integration due to market constraints and cooperative structures.

Conclusions and Applications

The analysis of supply chain integration found that customer integration had the highest mean, followed by internal integration, while supplier integration had the lowest mean. This research also found that the environment sustainable performance had the highest mean, followed by the social aspect, with the economic aspect having the lowest mean. Concerning the results of the multiple regression analysis, integration with suppliers and internal integration had a positive effect on sustainable economic performance, and integration with customers had no influence on sustainable economic performance. Therefore, Hypotheses 1 and 4 were accepted, but Hypothesis 7 was rejected.

The analysis results found that integration with suppliers and internal integration had a positive effect on sustainable social performance, and integration with customers had no influence on sustainable social performance. Therefore, Hypotheses 2 and 5 were accepted, but Hypothesis 8 was rejected.

The analysis results found that integration with suppliers, internal integration, and customer integration had no influence on sustainable environmental performance. Therefore, Hypotheses 3, 6, and 9 were rejected.

Dairy farm operators can apply these research findings as follows:

Supplier Integration: Dairy farm owners should select high-quality and reliable suppliers to obtain quality raw materials at reasonable prices that are safe for dairy cows. Additionally, regular inspections and evaluations of suppliers should be conducted to ensure that the products meet the specified standards. Building strong and sustainable relationships with suppliers will help promote effective cooperation and ensure long-term success.

Internal integration: Dairy farm owners should improve internal processes by providing training and skill development for farm personnel to enhance their understanding of supply chain integration and sustainable operations. Creating an organizational culture that emphasizes continuous learning, and development is key to increasing operational efficiency.

Customer integration: Dairy farm entrepreneurs should establish strong and sustainable relationships with customers through transparent communication and quick, effective responses to customer needs and feedback. Building good relationships with customers ensures that the farm can adapt and grow sustainably over the long term.

Dairy farm owners need to take action to enhance environmental performance by implementing sustainable practices, such as using renewable energy, managing waste properly, and optimizing water and feed management systems to minimize the farm's ecological footprint.

Collaboration with suppliers and improving internal processes are crucial for enhancing the economic performance of dairy farms. Therefore, farm owners should foster strong partnerships with suppliers and focus on improving internal collaboration processes for greater operational efficiency.

Developing partnerships both internally and externally is crucial for enhancing social performance. Therefore, dairy farm owners should focus on creating positive relationships with the community, ensuring employee welfare, and implementing socially responsible practices to improve social outcomes in the long run.

In future studies, a qualitative research approach should be employed, utilizing in-depth interviews or focus group discussions to gather comprehensive and detailed insights into the environmental factors that may influence environmental performance. These factors could include resource usage, waste management, and compliance with environmental regulations, as well as other aspects that may not have been covered in the previous questionnaire. By using

qualitative methods, the study would capture perspectives from key stakeholders, such as farm managers, suppliers, and environmental experts, providing a more complete understanding of the environmental impacts and offering richer, more thorough data for analysis.

Theoretical Contributions

This study contributes to supply chain integration theories by demonstrating that supplier and internal integration positively impact economic and social performance. However, customer integration shows no significant effect on these dimensions. The findings expand existing frameworks by highlighting the limited environmental impact of integration in the agricultural sector.

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