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Modelling the Success of Supply Chain Collaboration in the Thai Dairy Industry

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Abstract

Thailand's dairy industry provides a source of protein for citizens; however, 90% of milk producers are smallholders, on average handling approximately 21–50 cows per farm. In addition to disease control and health regulations, supporting milk producers in supply chain activation by implementing a collaborative concept can significantly improve the success of the dairy industry. Understanding the contributory factors and collaboration model will lead to success in supply chain collaboration. This study gathered potential 95 variables from a literature review. Through the process of expert review, these were refined into 49 critical variables. Moreover, this pilot study, with participation from co-operatives and individual farmers, aims to develop conceptual frameworks in six areas: performance and commitment, internal and external collaboration, measurement and evaluation, joint operation, sharing and innovation, and negotiation. Furthermore, 26 factors were identified clearly by exploratory factory analysis. In addition, the main study was conducted via a paper-based questionnaire with 1,053 participants nationwide. A result of the study confirmed the proposed framework from EFA analysis, and a verified model, by confirmatory factor analysis and Structure Equation Modelling, gives a clearer understanding of the factors and constructs leading to the success of supply chain collaboration in Thailand's dairy industry.

Keywords: Supply Chain Collaboration, Thailand, Dairy Industry, Structure Equation Modelling

JEL Classification Code: C38, L79, Q13, Q19

1. Introduction

Milk and dairy products are cheaper than other sources of protein. They have high nutrient content, supplying energy, proteins, amino acids, minerals, and other micronutrients. The Thai dairy industry was founded in 1960, after dairy cows were given to Thailand by the King of Denmark. Dairy in Thailand comes from two main sources of raw milk: co-operatives and milk-collecting centers. The co-operatives, set up by small dairy farmers with an average of 15–20 lactating cows per farm, supply dairy milk to the co-operatives. The dairy co-operatives are managed by the Dairy Farming Promotion Organization (DPO), a state enterprise tasked with promoting, supporting, and developing the growth of the industry. Moreover, one of the examples of industry development is the school milk project, established by Thai Cabinet in 1985 following farmers' protests in 1984 over unsold milk. The project was later expanded and today all children in public schools are provided with 200ml of free milk each day. This project was intended to support the Thai dairy industry and increase Thai milk consumption per capita. However, despite such government initiatives, the dairy industry lacks information and understanding about supply chain collaboration. Understanding important factors or variables that lead to the success of supply chain collaboration can help Thailand's dairy farmers and industry achieve sustainability in the world trade environment.

Supply chain collaboration and supply chain management have been successfully implemented by many industries to varying degrees. Aristides et al. (2007) showed that supply

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chain collaboration is critical for the agri-food industry; however, there were some constraints to the implementation of supply chain collaboration, due to the nature of products in the industry, and the specific structure of the segment. Supply chain collaboration also has a critical impact on business success, as identified by Ramanathan and Gunasekaran (2013). They studied the impact of supply chain collaboration on long-term partnerships in the textile industry, demonstrating its effect on the success of supply chain activities. Moreover, collaboration in the execution of supply chain planning also leads to wider collaboration in the future. Barratt (2004) reported that, although supply chain collaboration is known to be very difficult to implement, it still has a high potential to deliver significant improvement to business, organization, or industry performances. Barratt (2004) also showed the scope of both vertical and horizontal supply chain collaboration. Furthermore, the literature review and future research agenda by Chen et al. (2017) regarding supply chain collaboration for sustainability identified numerous areas of implementation. These can be classified into 5 groups to measure supply chain sustainability as follows: collaboration with suppliers, customers, competitors, other organizations, and internal collaboration. They also demonstrated a model of supply chain collaboration for sustainability, confirming that collaboration in the supply chain leads to business success.

Currently, the dairy industry has a clear lack of information and understanding about supply chain collaboration. Recognizing the factors or variables that lead to the success of such collaboration can help Thailand's dairy farmers and the industry as a whole to become sustainable in the world trade environment.

2. Literature Review

2.1. Definitions

There are many authoritative definitions of supply chain collaboration. Horvath (2001), for example, argues that supply chain collaboration is the driving force of effective supply chain management, among all parties in the value chain, "whatever their size, function, or relative position." For Simatupang and Sridharan (2002), supply chain collaboration is "two or more autonomous firms working together to plan and execute supply chain activities". Wood and Gray (1991) note that "collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms and structures, to act or decide on issues related to that domain." Thus, we can summarize that supply chain collaboration involves two or more organizations, firms, or departments working together to process supply chain activities from one end to another thereby maximizing profit along the value chain.

2.2. Review of Factors

To identify the key factors that lead to successful supply chain collaboration, data was collected from 43 supply chain collaboration studies. This identified 95 variables leading to supply chain collaboration success in many industries. However, in milk and related products, studies of supply chain collaboration are more limited. From 95 variables, qualitative research (the interviewing of experts in the field) narrowed down the spread of variables from 95 to 49, as shown in Table 1.

Table 1: Variables List as a Result from Literature Review and IOC

Item	Variable	IOC	Author
V01	Adaptation	1.00	Dania, Xing and Amer (2018)
V02	Alliance and conflict resolution	0.64	Kumar and Banerjee (2012); Lemma (2015)
V03	Business objective (financial/operational)	1.00	Ramanathan (2014); Ramanathan, Gunasekaran and Subramanian (2011)
V06	Collaborative performance system	1.00	Simatupang and Sridharan (2007)
V07	Commitment	1.00	Banomyong (2018)
V08	Communication and understanding	1.00	Barratt (2004); Cao and Zhang (2011);
V09	Continuous improvement	1.00	Dania et al. (2018)
V10	Cost reduction	1.00	Ramanathan and Gunasekaran (2013); Banchuen et al. (2017)
V13	Decision synchronization	1.00	Ramanathan and Gunasekaran (2013); Lemma (2015); Banomyong (2018)
V14	Delivery schedules	1.00	Kumar and Banerjee (2012)
V16	Demand forecast accuracy	0.73	Ramanathan (2013)
V18	Environmental collaboration	0.73	Vachona and Klassen (2008)

Table 1: (Continued)

Item	Variable	IOC	Author
V25	Information quality	1.00	Ramanathan et al. (2011)
V26	Information sharing	0.73	Prajogo and Jan (2012); Lemma (2015); Banomyong (2018)
V28	Initiating and maintaining operations	1.00	Ramanathan et al. (2011); Soosay et al. (2008)
V29	Innovative supply chain processes	0.64	Cao and Zhang (2010)
V30	Integrated information technology	0.64	Prajogo and Jan (2012)
V32	Intelligence gathering and analysis	1.00	Horvath (2001)
V36	Joint business planning	1.00	Ramanathan and Gunasekaran (2013); Cao and Zhang (2010)
V37	Joint efforts	1.00	Dania et al. (2018)
V38	Joint organizational learning	1.00	Kumar and Banerjee (2012)
V40	Joint problem solving	1.00	Min et al. (2005)
V41	Joint production	0.82	Chen et al. (2017)
V42	Joint teamwork	0.82	Ramanathan and Gunasekaran (2013)
V43	Knowledge transfer and integration	1.00	Kumar and Banerjee (2012); Herczeg et al. (2017); Soosay et al. (2008)
V46	Loyalty	1.00	Kumar and Banerjee (2012)
V49	Monitoring by customer	1.00	Chen et al. (2017)
V50	Mutual interest, benefits, risks and rewards	1.00	Kumar and Banerjee (2012); Chen et al. (2017); Lemma (2015)
V54	On time production	1.00	Ramanathan et al. (2011)
V56	People management and development	1.00	Fawcett, Magnan and McCarter (2008)
V62	Power	1.00	Dania et al. (2018); Suong (2017)
V63	Price	1.00	Ramanathan and Gunasekaran (2013); Lemma (2015)
V64	Prioritizing goals and objectives	1.00	Kumar and Banerjee (2012)
V69	Production and delivery systems	1.00	Herczeg et al. (2017)
V70	Purchasing	1.00	Kumar and Banerjee (2012)
V71	Quality	1.00	Cao and Zhang (2010); Banchuen et al. (2017)
V73	Relationship management & trust building	1.00	Fawcett et al. (2008); Chen et al. (2017); Prajogo and Jan (2012)
V74	Reliability of supply	1.00	Akintoye, McIntosh and Fitzgerald (2000)
V79	Shared supply chain processes	0.82	Simatupang and Sridharan (2004)
V80	Sharing responsibility for product recovery	0.64	Chen et al. (2017)
V81	Stability	1.00	Dania et al. (2018)
V82	Strategic project definition	1.00	Herczeg et al. (2017)
V88	Supplier monitoring	1.00	Chen et al. (2017)
V90	Supply chain collaboration exchanges	0.82	Horvath (2001)
V91	Supply chain metrics	0.64	Barratt (2004)
V92	Supply-demand agreements	1.00	Herczeg et al. (2017)
V93	Technology	1.00	Kumar and Banerjee (2012)
V94	Top management support	1.00	Akintoye et al. (2000)
V95	Trust	1.00	Lemma (2015); Banomyong (2018); Suong (2017)

3. Methodology

In this section research population, data collection, study design, survey tool, and sampling method will be defined. Moreover, the tools of the pretest and main studies will be addressed.

3.1. Population and Sample

Thailand's dairy farmers represent 16,248 farms with 670 milk-collecting centers; however, only 187 of those centers are certified GMP by the Department of Livestock Development. The dairy farms serving these GMP certified milk collecting centers constituted the target sample. Moreover, in the pretest study, samples were collected from heads of dairy co-operatives, DPO managers, academic experts such as professors from veterinary schools, and officers of the Department of Livestock Development. On the other hand, the, main study focused on senior co-operative and milk-collecting center representatives (presidents, managers, and committees) and dairy farms.

3.2. Data Collection

3.2.1. Focus Group Variables Evaluation

Researchers were trying to determine which constructs would account for a successful supply chain collaboration in the Thai dairy industry. Researchers conducted focus group interviews in order to evaluate the selected variables from the literature review. Four groups of interviews were conducted in different areas of Thailand with dairy industry experts. In total, 11 participants were questioned about 95 variables. The index of item-objective congruence (IOC) was used at this stage to evaluate the variables and, as a result of IOC, 49 variables were selected with scores from 0.64 to 1.0. The items with scores higher than or equal to 0.5 were considered appropriate (Rovinelli & Hambleton, 1977). However, the variables were not grouped at this stage.

3.2.2. Pretest Data Collection

A paper-based survey was conducted of randomly-chosen participants, using the Likert scale from 1–9 (least to most important). The pretest survey used face-to-face visits and paper-based surveys conducted by mail. 64 face-to-face samples were obtained, and 94 mail samples, with 36 interviewees not responding. Thus, the total of 122 respondents reached the minimum sample size of pilot research recommended by Hoque and Awang (2016). The pretest survey was conducted using exploratory factor analysis (EFA).

Exploratory Factor Analysis (EFA)

Exploratory factor analysis was also used to test and explain the interrelationship of each variable and identify the appropriate constructs. Exploratory factor analysis is suitable for this purpose, as shown by Fabrigar and Wegener (2012). EFA was used to reduce the dimension of the variables and explain the interrelationship of the major components. Principal axis factoring (PAF) was performed with Oblimin rotation, as the relation between variables cannot be ignored. This analysis required both Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity assessment. The KMO value ranges from 0–1; however, more than 0.6 is recommended (Hoque and Awang, 2016). Bartlett's Test of Sphericity should be significant at $P < 0.05$ (Awang, 2015).

Survey Tool, and Questionnaire development

The 49 IOC tested variables led to dimension reduction with PAF, and a paper-based questionnaire was designed for the main study survey. The study used the Likert-scale from 1–5 (least to most important) as a tool to capture dairy farmers' opinions.

3.2.3. Main Study Data Collection

The paper-based survey was conducted by researchers who sent out 5,610 questionnaires to farmers in 187 co-operatives and milk-collecting centers nationwide. Each co-operative or milk-collecting center received 30 copies of the questionnaire. Four weeks later, a follow-up email was sent to all survey recipients. 1,137 questionnaires were returned, a 20.26% response rate; however, after discounting some incomplete replies, there were 1,053 valid responses, an 18.77% response rate.

4. Results

4.1. Descriptive Analysis

As showed in Figure 1, most participants (46.91%) have approximately 21–50 cows per farm, followed by 1–20 cows per farm (27.16%), and 210 cows per farm (19.94%). These three groups constituted 94.02%. Also as shown in Figure 1, questionnaires were received from many regions of Thailand.

4.2. Result of Pretest Study

The result of the pretest study is demonstrated in Table 2. The KMO measure of sampling adequacy score was 0.901, confirming that the data from the samples were appropriate to be used. In addition, Bartlett's Test significance value is 0.000, less than 0.05. Therefore, the data set of samples was suitable for the EFA process.

The EFA result expresses that all seven extracted contracts exceed the recommended quality of more than

1.0. Component 1's Eigenvalue is 27.390, component 2's is 3.326, component 3's is 2.241, component 4's is 1.857, component 5's is 1.712, component 6's is 1.411, and component 7's is 1.069.

The cumulative % variance of these seven components is 77.422 percent, which is above the recommended value of 60% (Hair, Black, Babin, & Anderson, 2019). However, these seven components could not be used, since their factor loadings were cut off at 0.5. Finally, six components were used to develop the questionnaire. The researchers also propose the framework as showed in Figure 2. Also, the researchers considered the following hypothesizes:

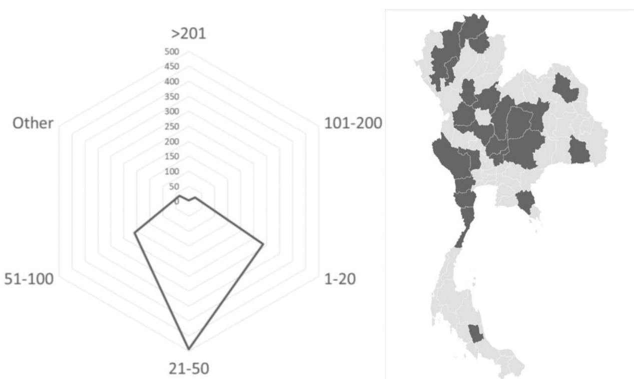

Figure 1: Characteristics of the Study Sample: Left Shows Number of Cows per Farm; Right Shows Distribution of Responding Farms

Table 2: KMO and Bartlett's Test Result for the Items of EFA

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.901
Bartlett's Test of Sphericity	Approx Chi-Square	7919.962
	df	1176
	Sig	0.000

H1: *Performance and commitment have a positive impact on supply chain collaboration.*

H2: *Internal and external collaboration have a positive impact on supply chain collaboration.*

H3: *Measurement and evaluation have a positive impact on supply chain collaboration.*

H4: *Joint operation has a positive impact on supply chain collaboration.*

H5: *Sharing and innovation have a positive impact on supply chain collaboration.*

H6: *Negotiation has a positive impact on supply chain collaboration.*

H7: *Supply chain collaboration has a positive impact on the success of Thai dairy supply chains.*

4.2.1. Reliability Analysis for Item Measurement

Reliability analysis of the items can be explained by Cronbach's Alpha value, which should be more than 0.5; however, Hoque and Awang (2016) suggest that a value above 0.6 can ensure consistency.

As presented in Table 3, components in this study were calculated according to Cronbach's Alpha component 1–6 at 0.939, 0.930, 0.917, 0.906, 0.808, and 0.911, respectively. All components exceeded 0.8, which is higher than the suggested minimum of 0.7, and the results can therefore be regarded as reliable measurements.

4.3. Results of Main Study

4.3.1. Confirmatory Factor Analysis (CFA)

According to Faul, Erdfelder, Lang, and Buchner (2007), a study of 26 items, with effect size 0.4 in G*Power 3, requires a minimum sample size of 611; thus, the main study's total sample of 1,053 exceeds the threshold for analysis. Moreover, the assessment of normality as a result of skewness was between 0.046 and −0.609, with Kurtosis not more than 7. However, Mahalonobis Distance test results suggest that 76 of the 1,053 participants should be removed (p-value < 0.001). The removal of these 76 samples

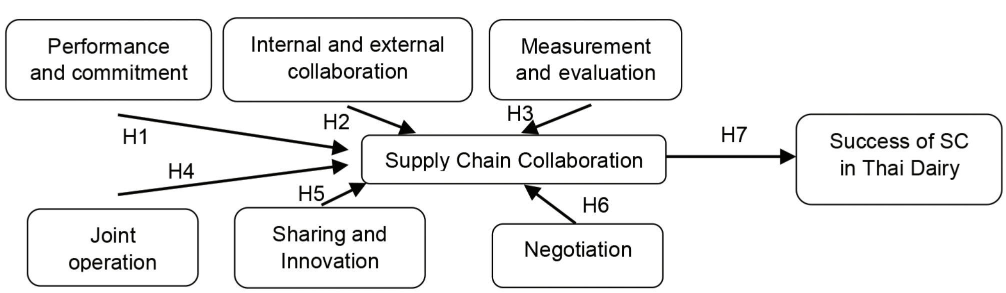

Figure 2: Proposed Framework

Table 3: Reliability Statistics for the 7 Construct Factors of EFA Output

Construct	Item	Variables	Loading							Cronbach's Alpha
			1	2	3	4	5	6	7	
Performance and commitment	PC1	Communicating and understanding	0.791							0.939
	PC2	Continuous Improvement	0.747							
	PC3	Information quality	0.738							
	PC4	Delivery	0.736							
	PC5	Collaborative performance system	0.678							
	PC6	People Management and Development	0.649							
	PC7	Commitment	0.601							
Internal and external collaboration	IEC1	Environmental collaboration		0.928						0.930
	IEC2	Information sharing		0.919						
	IEC3	Alliance or Conflict resolution		0.857						
	IEC4	Demand forecast accuracy Forecast accuracy		0.857						
Measurement and evaluation	ME1	On time production			0.679					0.917
	ME2	Prioritizing goals and objectives			0.641					
	ME3	Mutual sharing			0.567					
	ME4	Supply chain metrics			0.503					
Joint operation	JO1	Joint teamwork				0.792				0.906
	JO2	Cost reduction Cost				0.758				
	JO3	Joint production				0.669				
	JO4	Technology				0.663				
	JO5	Joint Efforts				0.636				
Sharing and Innovation	SI1	Shared supply chain processes					0.870			0.808
	SI2	Sharing responsibility for product recovery					0.599			
	SI3	Innovation Innovative supply chain processes					0.552			
Negotiation	NEO1	Purchasing						−0.696		0.911
	NEO2	Stability						−0.686		
	NEO3	Power						−0.680		

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

resulted in an altered skewness of between 0.007 and −0.43, which was better than previous results. Consequently, the model was within the normal range for model modification. In Table 4, the CFA analysis thus shows all items in each construct have a positive impact on the main constructs. The model is in line with reliability tests, mean extracted variance (AVE), and composite reliability (CR), as the benchmarks for Cronbach's Alpha should be >0.6, AVE > 0.5 and CR > 0.7.

The goodness-of-fit indicators are as follows: Root Mean Square Error of Approximation (RMSEA) = 0.053; Root mean square residual (RMR) = 0.033; Comparative Fit Index (CFI) = 0.965; Tucker-Lewis Index (TLI) = 0.950; Normed Fit Index (NFI) = 0.953; Goodness of Fit Index (GFI) = 0.936; Adjusted Goodness of Fit Index (AGFI) = 0.901; df = 226; Chi-square = 844.695; Minimum discrepancy (CMIN/df) = 3.738. These indicators met the required cut-off values, suggesting a good model fit. The result of analysis showed that all constructs and items from EFA, are appropriate to the large sample size. The researchers could thus further test the structural model.

4.3.2. Structural Modeling

Faul et al. (2007) recommend that research with 31 variables, with effect size 0.4 in G * Power, requires a minimum sample size of 714; thus, the total sample of 977 exceeds the threshold for analysis. Furthermore, the data

Table 4: Confirmatory Factor Analysis Result

Items	Loading	S.E.	*t*-value	*P*	Cronbach's Alpha	CR	AVE
PC7	1	–	–		0.890	0.902	0.570
PC6	1.148	0.05	22.883	***			
PC5	0.928	0.046	20.196	***			
PC4	0.926	0.047	19.888	***			
PC3	1.236	0.055	22.511	***			
PC2	1.115	0.043	25.826	***			
PC1	1.144	0.047	24.27	***			
IEC4	1	–	–		0.878	0.897	0.686
IEC3	0.824	0.029	28.764	***			
IEC2	0.942	0.027	34.8	***			
IEC1	0.962	0.029	33.091	***			
ME4	1	–	–		0.839	0.832	0.553
ME3	0.903	0.032	28.645	***			
ME2	0.975	0.04	24.633	***			
ME1	0.826	0.037	22.202	***			
JO5	0.797	0.044	18.208	***			
JO4	1	–	–		0.819	0.856	0.547
JO3	1.043	0.051	20.494	***			
JO2	0.831	0.047	17.647	***			
JO1	1.032	0.049	21.201	***			
SI3	1	–	–		0.771	0.798	0.569
SI2	1.049	0.05	20.78	***			
SI1	1.103	0.045	24.663	***			
NEO3	1	–	–		0.809	0.832	0.624
NEO2	0.806	0.036	22.702	***			
NEO1	1.059	0.038	27.784	***			

Note: AVE: Average Variance Extracted; CR: Composite Reliability; SE: Standard Error.

Table 5: Results of Main Study

	Loading	*t*-value	*P*	Result
PC ← SCC	0.556	22.584	***	Support
IEC ← SCC	0.64	27.691	***	Support
ME ← SCC	0.632	24.910	***	Support
JO ← SCC	0.544	18.798	***	Support
SI ← SCC	0.621	23.587	***	Support
NEO ← SCC	0.632	22.191	***	Support
SofSC ← SCC	0.359	13.593	***	Support

***$p < 0.001$.

was found to be normal as result of Skew between 0.024 and −0.430, and Kurtosis not more than 7. The sample size and assessment of normality were therefore ready for further analysis.

4.3.3. Testing Model

The proposed framework model was tested and evaluated by IBM Amos software (version 22) The goodness-of-fit indicators are as follows: RMSEA = 0.054; RMR = 0.052; CFI = 0.954; TLI = 0.937; NFI = 0.940; GFI = 0.920; df = 334; Chi-square = 1,279.239; CMIN/df = 3.830. These indicators met the required cut-off values, suggesting a good model fit. The model as analysis results were as following (see Table 5):

This demonstrates that PC, IEC, ME, JO, SI, NEO results have a positive impact on supply chain collaboration with loading 0.556, 0.636, 0.632, 0.544, 0.621, and 0.632, respectively, and all constructs have *t*-value more than 1.96 with $p < 0.001$ in all cases. Furthermore, supply chain collaboration has a positive impact on the success of supply chains in the Thai dairy industry, with loading 0.359, *t*-value = 13.593, and *p*-value < 0.001. In summary, the proposed hypothesizes were accepted with $p < 0.001$ and all were supported with the results from structural equation modeling.

5. Discussion and Conclusion

As demonstrated by the literature review, there are few existing studies of supply chain collaboration in the dairy business, and such studies specifically related to Thailand or Asia are even more scarce. Some researchers examined the strategies and supply chain management of dairy products in Thailand environment, though they presented a general overview of industry, while the results of this study show the specific dimensions that are impacted.

In general, Thai dairy farmers have an average of 21–50 cows and the majority is in central and north regions. The co-operatives and milk-collecting centers are the main drivers of the Thai dairy industry; however, the study surveyed both farmers and co-operatives, as it is important to understand the mindset of Thai farmers as well as the co-operatives. A further study is planned, to survey in the same context with the co-operatives and milk-collecting centers here in Thailand, and to include other SEA countries in an expanded CFA analysis.

From a starting point of 95 variables, after the various testing and analytical methodologies were applied, it can ultimately be determined that the variables positively impacting Thai dairy industry supply chain collaboration can be classified into six dimensions as follows: performance and commitment, internal and external collaboration, measurement and evaluation, joint operation, sharing and innovation, and negotiation. While Al-Mansour and Al-Ajmi (2020) said that cross-functional team and stabilize supply chain are critical in serious situations. Moreover, from the result, supply chain collaboration has a positive impact on the success of supply chains in the Thai dairy industry. This aligns with Lee and Ha (2020) who showed that supply chain collaboration positively affects sustainable supply chain performance.

The researchers strongly believe that these results will lead Thai farmers and co-operatives to start implementing supply chain strategies to create competitive advantages over other exporter countries. Moreover, the findings can also be implemented in neighboring countries in South-East Asia to create a competitive advantage for SEA countries in the global market.

As this study was conducted during the COVID-19 pandemic in Thailand, this presents a challenge when it comes to passing on the findings to farmers themselves. Face-to-face meetings between the researchers and farmers would likely be a productive forum in which to present the results more effectively. In a further study, more variables linked to supply chain collaboration could be added to the questionnaire.

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