

Factors Affecting The Performance of Cold Chain for Export of Thailand's Longan Fruit

Narathip Titlo

Graduate program in Logistics Engineering and Supply chain Management
Department of Industrial Engineering
Chiang Mai University
Chiang Mai, Thailand
narathip_t@cmu.ac.th

Apichat Sopadang

Department of Industrial Engineering
Excellence Center in Logistics and Supply Chain Management
Chiang Mai University
Chiang Mai, Thailand
apichat@eng.cmu.ac.th

Abstract

China has been become the important imported destination of longan fruit in Thailand. The trade has been proceeded through R3A route which started from Chiang-rai then across Lao to China. There is a problem because the logan fruit is perishable. Therefore, exporters must handle temperature that calls the cold chain. This paper aims to propose a factor that important for measures the cold chain performance for exported of Thailand's longan fruit on the R3A route. The first stage is the identification of the key performance attribute (KPA) by review literature base performance of the supply chain and cold chain. Then, the researcher have discussed the factor affecting the performance such as Quality and safety, Traceability, Cost, and Responsiveness. The result from this paper shows that are 4 main-factor and 11 sub-factors to introduce exporter longan fruit. The factor would be calculated the weight of each KPA by using the Analytic Hierarchy Process (AHP) methodology that presents the numerical example of weight like Quality and safety factor (0.518) is the most important of KPA follow by Cost (0.296), Responsiveness (0.136), and Traceability (0.049), respectively. This paper has proposed framework shows the weight that important to each KPA that can facilitate decision-makers in understanding the structure of cold chain performance of the longan fruit exporting industry.

Keywords

Cold chain, Performance measurement, AHP, Export and Longan fruit.

1. Introduction

In recent years, consumer acceptance of exports of Thailand's longan fruit has been increasing around the world. According to the Office of the Permanent Secretary Ministry of Commerce website, it is reported that Thailand exports of longan fruit to China seem to grow consistently. In 2017, Thailand generated the export values of fresh longan fruit totaling \$152.74 million or 24.67% of the whole fresh fruits export values which account for \$618.96 million. Also, the growth rate rose by 90.25% from 2016 (Office of the Permanent Secretary Ministry of Commerce, 2016-2017). One of the most popular trading routes to carry out any export to China is the R3A; 37.58% is of fresh longan fruit export (Chiangkhong Customs, 2017). R3A route starts from Chiang Khong District, Thailand, crossing Friendship Bridge to Lao to Boten Border Checkpoint, Bohan Border Checkpoint, Chiang Rung (Jinghong) Border Checkpoint, and ending at Kunming, China. The total distance from Chiang Rai to Kunming is about 1,140 km. It takes only a few days for shipping via R3A, which allows fast longan fruit delivery in season from Thailand to China market, promotes good price, as well as, solves the problem of being undersold by middlemen. Nevertheless, the longan fruit a very short shelf-life under normal ambient conditions by reason of skin colour loss (brown colour) and deterioration during storage and transportation (Jiang, 1999). In addition, the food industry still faces food quality issues occurred in fresh raw materials from distributors or farmers, both in freshness and contamination. Most of the products are susceptible to spoilage, short-lived, or damaged from the arrangement. The product problems also include delays in transportation and ineffective or inappropriate temperature control. In addition, global demand for consumer products has increased nowadays, especially for fresh food. In the transportation of such sensitive products, Cold Chain is a solution of maintaining the quality of fresh food until reaching the final consumers. It is not just a storage system, but it also allows manufacturers and markets to access to food which increases the source productivity of raw materials. It could be said that cold chain provides zero-sum solution, as well. Not only does it use coldness to maintain product's freshness or preserve product quality, but also it manages post-harvest crops in food supply chain, improves agricultural business, as well as, helps reduce damage caused by spoilage of raw materials which results in lower food costs (SCGLogistics, 2015)

To meet consumers' needs in quality and safety, cold chain adds value to agricultural products, maintain products' quality, and extends the shelf life of products. For this reason, exporters must be mindful of the importance of cold chain performance to create more competitive advantages in the market. This research aims to discuss the key performance attributes (KPA) that affect the efficiency of the cold chain for longan fruit exports in Thailand on the R3A route. To conduct this study, the researcher would like to propose three steps: 1) identify and define KPAs by reviewing literatures related to the researches on performance measurement of agriculture food supply chain and cold chain, 2) calculate each weight factor by using the Analytic Hierarchy Process methodology (AHP), and 3) Conclude the research findings.

2. Literature Review

2.1 A Cold Chain

A cold chain is a branch of the supply chain which handles temperature sensitive products and perishable products logistics (Kuo, J. C., & Chen, M. C., 2010). Then cold chain is supply chain that controlled-temperature conditions or relative humidity, atmospheric environment. Method of packaging or packaging suitable for produce or each product throughout the supply chain from harvesting. The preservation of the processing or packing, transport, and distribution including time management, supply chain operations in the shortest. Will be able to extend, maintain, and preserve the quality of the product (logistics forum, 2014). There are facilities such as refrigerated containers, warehouses or cold stores and cold display cabinets are needed to store and preserve perishable goods in the proper state (de Freitas Borghi et al., 2009). Furthermore, the integrity of the cold chain must be preserved from the point of production and processing to customer. The transport phases like loading, unloading, handling, and storage indicate the rule to achieve a goal (Montanari, 2008).

2.2 The Factor Impact the Performance of Cold Chain

The evaluation of cold chain performance is key for developing a more food supply chain (Defraeye et al., 2016). However, Measuring the performance of cold chain is difficult because there are many different aspects of the supply chain such as shelf life restrictions, seasonality in production, production facilities and equipment such as appearance, long production throughput time, refrigerated transportation and storage requirement, traceability, product quality and safety of product, etc. (Aramyan, Oude Lansink, Van Der Vorst, & Van Kooten, 2007; Mangina & Vlachos, 2005; Joshi et al., 2011).

The critical parameters affecting food quality and safety and quantification through a systematic modelling approach will allow monitoring the quality and safety status of food products throughout the cold chain (Montanari, 2008). Moreover, the temperature and another storage control in each stage of the supply chain is critical to maintaining the quality of the product until it reaches the final consumer. The perturbed time delays in actions and temperature disturbances that reduce the quality and the hygiene of perishables. Because temperature abuse in the cold chain can cause microbial hazard and losses of product quality, temperature control is essential to keep the final consumer safe cause the country has organized food safety regulations as product temperature control along the supply chain, tracking of air and product temperature in refrigerated vehicles, production cells and loading-reloading points, and checked standardized equipment (Bogataj et al., 2005). Accordingly, A good quality in the supply chain makes for higher performance cost of product variety lead companies to offer product variety that is greater than optimal (Aramyan et al. 2006). In addition, the traceability issues obtained by many researchers about that is a preventative strategy in food quality and safety management. However, when hazards or food scares occur, a good traceability system will facilitate timely product recall and determination of liability (Opara, 2003). Cold traceability was used tools and equipment like thermometers, temperature recorders, temperature indicators, and time-temperature integrators almost for the static mainly to the quality control of perishable goods Bogataj et al. (2005). Traceability was link not only to food safety, but also to food quality in the mind of the consumer (Van Rijswijk and Frewer., 2008). The temperature of the products may vary in different stages, particularly when loading and unloading achieved under controlled temperature. So that, traceability is an important concept must understand that get information about the history of time-temperature products from one step to another step in the cold chain. Furthermore, the microbial spoilage in the food industry represents a huge cost and waste of a valuable resource. Spoilage of fresh fruit and vegetables may occur at any stage between harvesting and consumption, such as operation cost, inventory cost, distribution cost, cost of expired/wasted product. (Joshi et al., 2011). The performance signification of an integrated supply chain strategy with customer service performance followed by the financial performance that have referred supply chain integration with respect to basic service like on-time delivery should affect customer service performance (e.g., delivery lead time, quality, cost). (Vickery et al., 2003). The researcher have presented supply chain developments in the UK fresh produce industry that was identified key success factors such as improvement in food safety, cost control, etc. (Fearne and Hughes 2000). Then, the researcher have studied a framework for supply chain performance measurement that discussed evaluation of suppliers like responsiveness implicate measure important have three issue include Strategic level like lead time, quality level, cost saving initiative, etc. Tactical level like cash flow, quality assurance methodology, etc. Operation level like ability to avoid complaints, etc. (Gunasekaran et al., 2004). Moreover, the performance supply chain have five indicator such as quality, responsiveness, total supply-chain cost, etc. (Van Der Vorst 2006) while discussing the conceptual framework of agri-food supply chain performance indicator have related responsiveness like lead time, customer complaints, customer response time, etc. and (Aramyan et al., 2006)

2.4 Analytic Hierarchy Process

The analytic hierarchy process (AHP) was developed by Saaty in 1971 to solve the scarce resources allocation and planning needs for the military (Saaty, 1980). The AHP is a widely used multiple-criteria decision-making (MCDM) methods and has been used to solve unstructured problems in different areas of human needs and interests, such as political, economic, social and management sciences (George, M., 2000). Moreover, AHP is an approach to decision making that involves structuring multiple-choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternative (Kaya et al., 2007). There are many advantages such as the AHP leads to accurate decisions because a subjective decision process can be broken down to the hierarchy structure, the consistency of the decision judgment can be ensures, to divide the factor into sub-factor that easier to understand, the comparison may be made by experts or an iterative process until an agreement is reached by the team members and for the final judgment is rendered should perform sensitivity analysis before (Chaowarat, W., 2011).

3. Methodology

We have considered factor affecting the performance of cold chain for exported of Thailand's longan fruit. There are two steps, the first step discussed a conceptual the factor of cold chain performance and the most refer factor in paper and groped to the relation each factor. The second step determine weighting of key performance attribute by using AHP method. The research methods are introduced as shown figure 1.

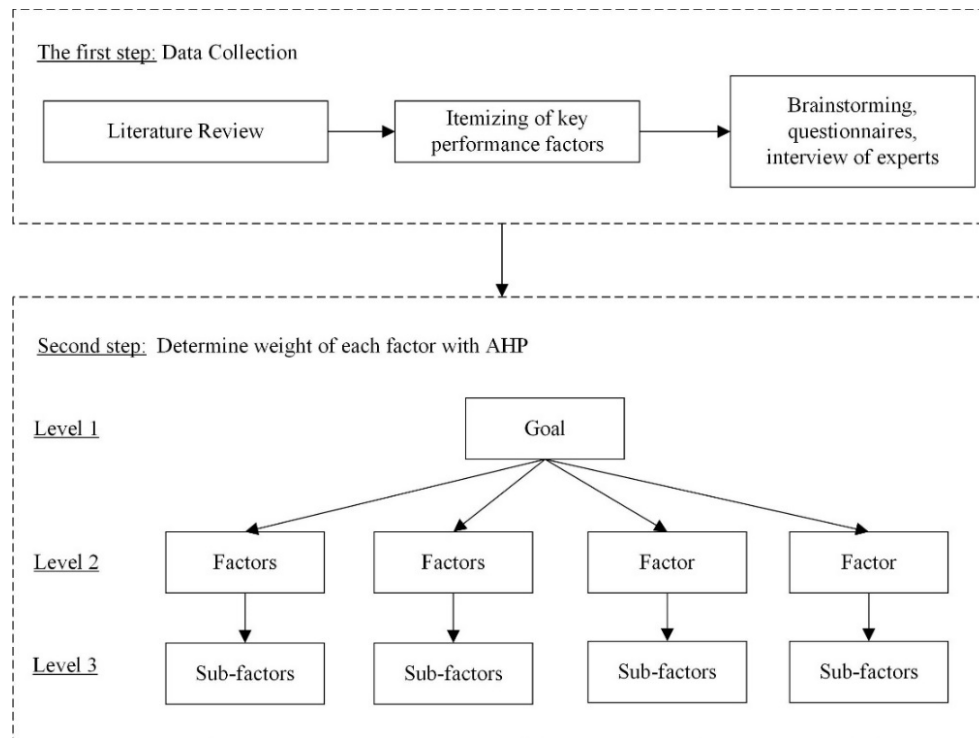


Figure 1. Framework research methodology

3.1 Data collection

This step starts to discuss the factor impact the performance cold chain for exported based on literature review of agriculture performance measurement supply chain. The factors were managed from frequently being used in the literature for mention the most useful factor. After that, we have interviewed export of longan fruit experts on the R3A route to consider the appropriate factor. Then, we group of the factor by regarding the implication of each aspect which refer to a priority of the factor based on the AHP method.

3.2 Analytic Hierarchy Process

AHP is used to evaluate the factors affecting the performance of cold chain level for exported of Thailand's longan fruit that can give a clear view about cold chain performance of the company with respect to each individual factor of the cold chain. To make a decision by using AHP determine the problem and the structure hierarchy from the top level, then the objectives through the intermediate levels to the lowest level which always is a set of alternatives. The AHP method using pairwise comparisons of each pair of factors by using a nine-point scale as shown table 1.

Table 1. Nine- point Scale

Numerical Rating	Verbal Judgment
1	Equal important
2	Equal to moderately more important
3	Moderately important
4	Moderate to strongly important
5	Strongly important
6	Strongly to very strongly importance
7	Very Strongly important
8	Very Strongly more important
9	Extremely important

The judgments may be inconsistent, the calculations to set the weight of each criteria is according to the theory AHP method and then calculating the agreement of data by calculate the max of Eigen Value (λ_{max}) consistency Index

(CR) and consistency Ratio (CI). Because data received by this interview always may be incorrect. So, it must be validated by consistency check. The results in measurement of CR must be less 0.1 (Chaowarat, W., 2011). The consistency rate can be obtained from this equation as follows:

- 1) The consistency ratio (CR)

$$CR = \frac{CI}{RI} \quad (1)$$

- 2) The consistency index (CI)

$$CI = \frac{\lambda - n}{n - 1} \quad (2)$$

By n = the size of the square matrix or the number of criteria

$$\lambda_{max} = \frac{\Sigma \left(\frac{AW^T}{W^T} \right)}{n} \quad (3)$$

Table 2. Average Random Index (RI) (Saaty, 2008)

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

If $CR \leq 0.1$, the pairwise comparison matrix is considered to have an acceptable consistency and more than 0.1 is considered to have unacceptable, therefore required to be revised.

4. Result

In this section, stepwise demonstration of result is given to find factors affecting performance of cold chain how data collection and AHP approach can be utilized for the evaluation of the cold chain performance of the export longan fruit industry. The first stage of data collection is done as discussed in previous section. The result of this stage is identified Key Performance Attribute (KPA), sub-factors and next stage it is given weighting by AHP methodology as follow:

4.1 Key Performance Attribute of cold chain

The result of collecting data and considering factor affecting the performance of cold chain for exported of Thailand's Longan fruit to 15 factors. They were the most appropriate for exported of Thailand's longan fruit on the route R3A. In this stage, we can identify that the quality and safety the important role for export of longan fruit industries than any other factor follow by a cold chain performance. It's means that the activities which concerned with the quality and safety are very critical in the industries as shown in table 3. Moreover, we have grouped the factor and rank the important by AHP. The KPA can be grouped into four main factors: Quality and safety, Cost, Traceability, Responsiveness. Each of factor is contains more detailed performance indicators shown in Figure 2. And the definition of each factor was shown in the table 4.

Table 3. Frequency of factor in 12 papers

KPA	Frequency	Aramyan et al. (2006)	Joshi et al. (2011)	Van de Vost (2002)	Chaowarat, W. (2011)	Vickery et al. (2003)	Gunasekaran et al. (2004)	(Van Rijswijk and Frewer (2008)	(Mahmoodzadeh et al. (2007)	Opata (2003)	Bogataj et al. (2005)	Fearne and Hughes (2000)	Montanari (2008)
Quality and safety	11	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Cost	9	✓	✓	✓	✓	✓	✓	✓	✓			✓	
Responsiveness	5	✓		✓	✓	✓		✓					
Traceability	5		✓					✓		✓	✓		✓
Inventory cost	4	✓	✓	✓	✓								
Distribution cost	4	✓	✓	✓	✓								
Operation cost	3	✓	✓	✓									
Cost of expired/wasted product	3	✓	✓	✓									
Lead-time	3	✓				✓		✓					
On time delivery	3	✓			✓	✓		✓					
Customer complaint	3	✓			✓		✓						
Rate of return product	2				✓				✓				
No. of certification	1		✓										
No. of point monitoring	1		✓										
No. of information secured	1		✓										
Degree of automation	1		✓										

Note: The factors literature is arranged in accordance to the frequency of cold chain performance

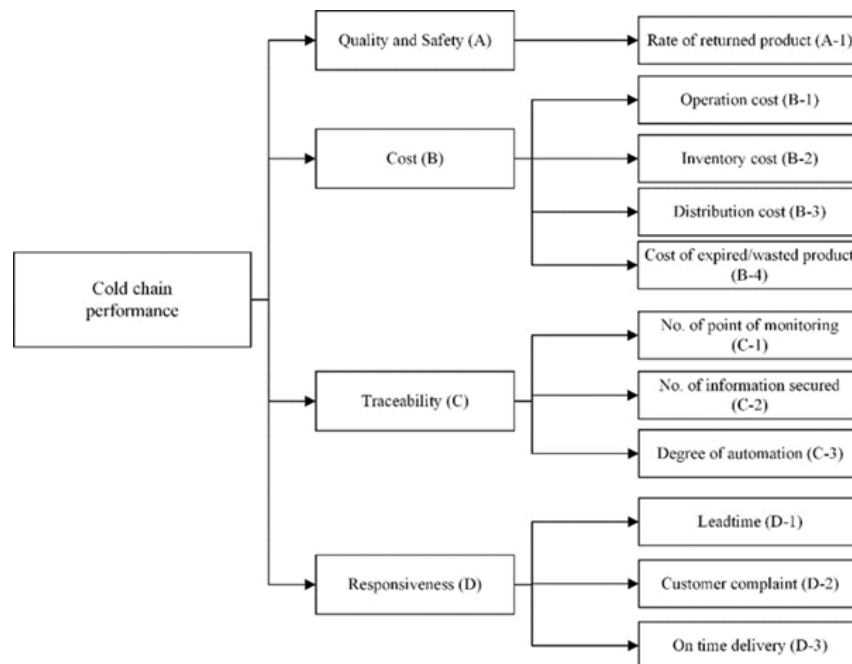


Figure 2. The priorities of cold chain performance factor

Table 4. Definition of factor and sub-factors for performance attributes.

Factors	Code	Definition of factors	Reference
Quality and safety	A	The characteristics (safety and hygiene) and features (freshness and juiciness) are the measure of quality	(Joshi et al., 2011) (Bogataj et al., 2005)
Rate of returned product	A-1	Percentage of number of returned products per all products	Chaowarat, W. (2011)
Cost	B	All Expense on the whole cold chain operation of organization	(Joshi et al., 2011) (Aramyan et al., 2007) Van Der Vorst, J. G. (2006).
Operation cost	B-1	Includes costs of refrigeration including internal or external service, maintenance costs, lost time costs, salary of dedicated employee and energy costs	(Joshi et al., 2011) (Aramyan et al., 2007) (Bogataj et al., 2005)
Inventory cost	B-2	Includes storage cost and carrying cost	(Joshi et al., 2011) (Aramyan et al., 2007)
Distribution cost	B-3	Cost associated with delivery activities such as refrigerated transportation and handling	(Joshi et al., 2011) (Aramyan et al., 2007) Gunasekaran et al. (2004)
Cost of expired/ wasted product	B-4	Includes cost of product losses, which perish due to overage or mishandling	(Joshi et al., 2011) (Aramyan et al., 2007)
Traceability	C	The ability to trace product information related location (warehouse, traffic, inventory), condition (temperature, humidity) and time (self life) through all stages of production, processing and distribution.	(Joshi et al., 2011) (Van Rijswijk and Frewer., 2008) Montanari (2008) (Opara, 2003).
No. of point monitoring	C-1	No. of points the products is traces with RFID/barcode/smart tags and Trucks with temperature indicators/GPS, etc.	(Joshi et al., 2011)
No. of information secured	C-2	No. of information (time, temperature, humidity, expected shelf life, price, weight, volume, sell by date, etc.) secured about the product while monitoring	(Joshi et al., 2011)
Degree of automation	C-3	The degree of automation (manual, semi-automatic, automatic) of item identification and data collection process	(Joshi et al., 2011)
Responsiveness	D	the ability to request products with a short lead-time	Lai et al. (2002) Aramyan et al. (2006) Van de Vost (2000)
Lead-time	D-1	Total amount of time required to produce a particular item or service	Aramyan et al. (2006) Gunasekaran et al. (2004)
Customer complaint	D-2	Registered complaints from customers about product or service	Aramyan et al. (2006)

On time delivery	D-3	The amount of time between the promised product delivery date and the actual product delivery date	Aramyan et al. (2006)
------------------	-----	--	-----------------------

4.2 Cold Chain Performance Weighting by AHP

In this stage of AHP, showed the weight of decision-making criteria for weighting cold chain performance evaluation is separated into kinds of main factors and sub-factors. The criterion important weight can be found by interviewing the expert in export longan fruit to pairwise comparison within the same level as shown in table 5.

Table 5. Main factor pairwise comparisons

	A	B	C	D
A	1	2	7	5
B		1	5	3
C			1	1/5
D				1

Note: Consistency Index (CI) = 0.06343; Average Random Index (RI) = 0.9; Consistency Ratio (CR) = 0.070;

The factors were shown in table 5. include 4 main factors: A-D. We have only presented the value of one side metric because else side came from a pairwise comparison. Obviously, a Quality and safety factor (0.518) is the most important of KPA follow by cost factor (0.296), Responsiveness (0.136), and Traceability (0.049), respectively. Furthermore, the weights of main factor were shown in table 6.

Table 6. Weight of KPA

Code	Factor	Weight
A	Quality and safety	0.518
B	Cost	0.296
C	Traceability	0.049
D	Responsiveness	0.136

Among compared sub-factors within the same level and same group as show in table 7-9. to achieve their relative weights. This paper has included four groups of sub-factors; Quality and safety, Cost, Traceability, and Responsiveness.

Table 7. Sub factor pairwise comparisons of cost KPA

	B-1	B-2	B-3	B-4
B-1	1	5	3	7
B-2		1	1/3	3
B-3			1	5
B-4				1

Note: Consistency Index (CI) = 0.564; Average Random Index (RI) = 0.118; Consistency Ratio (CR) = 0.043;

Table 8. Sub factor pairwise comparisons of traceability KPA

	C-1	C-2	C-3
C-1	1	3	5
C-2		1	3
C-3			1

Note: Consistency Index (CI) = 0.105; Average Random Index (RI) = 0.580; Consistency Ratio (CR) = 0.033;

Table 9. Sub factor pairwise comparisons of responsiveness KPA

	D-1	D-2	D-3
D-1	1	7	3
D-2		1	1/5
D-3			1

Note: Consistency Index (CI) = 0.032; Average Random Index (RI) = 0.580; Consistency Ratio (CR) = 0.056;

The summation of weights of each sub-factor must be equal to the weight of the main factor in that group like the total weight of B-1, B-2, B-3, and B-4 must be consequently equal to the weight of B.

Table 10. Weight of sub-KPA

Code	Factor	Weight
A-1	Rate of returned product	0.518
B-1	Operation cost	0.167
B-2	Inventory cost	0.035
B-3	Distribution cost	0.078
B-4	Cost of expired/wasted product	0.016
C-1	No. of point monitoring	0.031
C-2	No. of information	0.013
C-3	Degree of automation	0.005
D-1	Lead-time	0.088
D-2	Customer complaint	0.010
D-3	On time delivery	0.038

In table 10, we can identify that rate of returned of product (0.518) is the most important form overview of quality and safety (A). The second-ranking was prioritized by Cost and could be classified and rank to 4 sub-factors: Operation cost, Distribution cost, Inventory cost, and Cost of expired/wasted product at 0.167, 0.078, 0.035, and 0.016 weighted scores respectively. The Third-ranking is Responsiveness could be classified and rank to 3 sub-factors: No. of point monitoring, No. of information, Degree of automation at 0.031, 0.013, and 0.005 weighted scores respectively. As last ranking is Traceability could be classified and rank to 3 sub-factors: Lead-time, On time delivery, Customer complaint at 0.088, 0.038, and 0.010 weighted scores respectively.

5. Conclusion

A cold chain is important for the export of longan fruit in Thailand, to reduce longan fruit losses, waste and meet consumers' needs in quality and safety, cold chain adds value to agricultural products, maintain products' quality, and extends the shelf life of products. This research aims to discuss the key performance attributes (KPA) that affect the efficiency of the cold chain for longan fruit exports in Thailand on the R3A route. We have considered the factor impact the performance cold chain for exported based on literature review of agriculture performance measurement supply chain. The factors were managed from frequently being used in the literature for mention the most useful factor. After that, we have interviewed export of longan fruit expert to consider the appropriate factor. Then, we group of the factor by regarding the implication of each aspect which refer to a priority of the factor based on the AHP method. Consequently, we have performed of decision-making criteria for weighting cold chain performance evaluation is separated into kinds of 4 main factors and 11 sub-factors. Subsequently, the expert has given of weighting each factor to pairwise comparison. For the weight presented a Quality and safety factor (0.518) is the most important of KPA follow by cost factor (0.296), Responsiveness (0.136), and Traceability (0.049), respectively. Therefore, the factor from the research can be applied to can facilitate decision-makers in understanding the structure of cold chain performance of the longan fruit exporting industry. In the future, this research combining with more data to see the actual effects should be made in each step of a research framework. We then will apply the decision criteria to a cold chain performance measurement for exported longan fruit industry in Thailand on the R3A route to prioritize and benchmarking in the same industry.

Acknowledgements

This project has received funding from the Excellence Centre in Logistics and Supply Chain Management of Chiang Mai University. Then, authors are grateful to the Graduate School and Department of Industrial Engineering, Faculty of Engineering for their the supporting of this research work.

References

- Aramyan, L. H., Oude Lansink, A. G., Van Der Vorst, J. G., & Van Kooten, O. (2007). Performance measurement in agri-food supply chains: a case study. *Supply Chain Management: An International Journal*, 12(4), 304-315.
- Badia-Melis, R., Mc Carthy, U., Ruiz-Garcia, L., Garcia-Hierro, J., & Villalba, J. R. (2018). New trends in cold chain monitoring applications-A review. *Food Control*, 86, 170-182.

- Chaowarut, W. (2011). *Performance measurement of supply chain management for exported frozen food=* (Doctoral dissertation, Chiang Mai: Graduate School, Chiang Mai University, 2011)
- Dabbene, F., Gay, P., & Sacco, N. (2008). Optimisation of fresh-food supply chains in uncertain environments, Part I: Background and methodology. *Biosystems Engineering*, 99(3), 348-359.
- Defraeye, T., Nicolai, B., Kirkman, W., Moore, S., van Niekerk, S., Verboven, P., & Cronjé, P. (2016). Integral performance evaluation of the fresh-produce cold chain: A case study for ambient loading of citrus in refrigerated containers. *Postharvest Biology and Technology*, 112, 1-13.
- Freitas Borghi, D., Guirardello, R., & Filho, L. C. (2009). Storage logistics of fruits and vegetables: effect of temperature. *Chemical Engineering Transactions*.
- Fearne, A., & Hughes, D. (1999). Success factors in the fresh produce supply chain: insights from the UK. *Supply chain management: an international journal*, 4(3), 120-131.
- George, M. (2000). *Managing the cold chain for quality and safety*. Teagasc, National Food Centre.
- Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. *International journal of production economics*, 87(3), 333-347.
- Jiang, Y. M. (1999). Purification and some properties of polyphenol oxidase of longan fruit. *Food Chemistry*, 66(1), 75-79.
- Joshi, R., Banwet, D. K., & Shankar, R. (2011). A Delphi-AHP-TOPSIS based benchmarking framework for performance improvement of a cold chain. *Expert Systems with Applications*, 38(8), 10170-10182.
- Kaya, E., Caliskan, F. D., & Gozlu, S. (2007, August). Manufacturing performance criteria: an AHP application in a textile company. In *Management of Engineering and Technology*, Portland International Center for (pp. 1186-1194). IEEE.
- Kuo, J. C., & Chen, M. C. (2010). Developing an advanced multi-temperature joint distribution system for the food cold chain. *Food control*, 21(4), 559-566.
- Lee, A. H., Chen, W. C., & Chang, C. J. (2008). A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. *Expert systems with applications*, 34(1), 96-107.
- Mahmoodzadeh, S., Shahrabi, J., Pariazar, M., & Zaeri, M. S. (2007). Project selection by using fuzzy AHP and TOPSIS technique. *World Academy of Science, Engineering and Technology*, 30, 333-338.
- Mangina, E., & Vlachos, I. P. (2005). The changing role of information technology in food and beverage logistics management: Beverage network optimization using intelligent agent technology. *Journal of Food Engineering*, 70(3), 403-420.
- Montanari, R. (2008). Cold chain tracking: a managerial perspective. *Trends in Food Science & Technology*, 19(8), 425-431.
- Office of the Permanent Secretary Ministry of Commerce (2016-2017) Longan exported report. http://www.ops3.moc.go.th/infor/menucomth/strul_export/export_topn_re/report.asp (last accessed 5-October-2018).
- Opara, L. U. (2003). Traceability in agriculture and food supply chain: a review of basic concepts, technological implications, and future prospects. *Journal of Food Agriculture and Environment*, 1, 101-106.
- Saaty, T. L., & Decision, H. T. M. A. (1990). The analytic hierarchy process. *European Journal of Operational Research*, 48, 9-26.
- SCG Logistics (2015) Cold Chain Logistics The Cool solution for Food Industry <https://www.scglogistics.co.th/blog/detail/76?lang=en> (last accessed 1-October-2018).
- Van Der Vorst, J. G. (2006). Performance measurement in agri-food supply-chain networks. *Quantifying the agri-food supply chain*, 15-26.
- Van Rijswijk, W., & Frewer, L. J. (2008). Consumer perceptions of food quality and safety and their relation to traceability. *British Food Journal*, 110(10), 1034-1046.
- Vickery, S. K., Jayaram, J., Droge, C., & Calantone, R. (2003). The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. *Journal of operations management*, 21(5), 523-539.

Biographies

Narathip Titlo is currently studying in the Master degree, Department of Logistic and Supply Chain Management, Faculty of Engineering from Chiang Mai University, Thailand. Her received the Bachelor Degree in a department of Modern Management and Information Technology, College of Art Media and Information Technology from Chiang

Mai University, in 2016. Her interest supply chain and logistics management, Cold chain management, and Multiple criteria decision making.

Apichat Sopadang is an Associate Professor in the department of Industrial Engineering and a head of Excellence Center in Logistics and Supply Chain Management (E-LSCM), Chiang Mai University. His research interest focus on supply chain and logistics management, and multiple criteria decision making.