BARRIERS IDENTIFICATION FOR IMPLEMENTING COLD CHAIN MANAGEMENT: VEGETABLE EXPORT (YUNNAN-THAILAND)

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ABSTRACT

The main objective of this research is to study the inter-relationships among the barriers to implement CCM on exported vegetable from Yunnan to Thailand. Further, it attempts to identify the critical barriers. To address the vagueness and imprecision of human beings' assessment under the uncertain environment, fuzzy set theory is incorporated with the proposed Decision Making Trial and Evaluation Laboratory (DEMATEL) model in this study. Through literature review, 13 industrial experts and 2 academic experts' opinions, 10 barriers are selected and validated. The result of the fuzzy DEMATEL reveals that "high capital cost and operating cost", "lack of government support " and "lack of trained personnel" are the critical barriers. A SIPOC map is applied to show the current process of vegetable trade exported from Yunnan to Thailand and then the main activities affected by the critical barriers are presented. Next, SWOT analysis and TOWS analysis are utilized to deploy strategies for the industry sector to overcome internal barriers "high capital cost and operating cost" and "lack of trained personnel". In addition, this study has proposed strategies for government sector to promote the implementation of CCM on exported vegetable from Yunnan to Thailand.

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ABBREVIATION

CC	=	Cold Chain
CCM	=	Cold Chain Management
FAO	=	Food and Agriculture Organization of the United Nations
WITS	=	World Integrated Trade Solution
MRLs	=	Maximum Residue Limits
TFNs	=	Triangular Fuzzy Numbers
SCM	=	Supply Chain Management
DEMATEL	=	Decision Making Trial and Evaluation Laboratory
MCDM	=	Multiple Criteria Decision-Making
GSCM	=	Green Supply Chain Management
AHP	=	Analytic Hierarchy Process
ANP	=	Analytic Network Process
GRA	=	Grey relational analysis
TOPSIS	=	Technique for Order Preference by Similarity to an Ideal Solution
VIKOR	=	VlseKriterijumska Optimizacija I Kompromisno Resenje
ISM	=	Interpretive Structural Modeling
BNP	=	Best Nonfuzzy Performance
DMAIC	=	Define-Measure-Analyze-Control
PEST	=	Political Economic Socio-cultural and Technological
RFID	=	Radiofrequency Identification
GSNN	=	Global Navigation Satellite System
SMAS	=	Safety Monitoring and Assurance System
3PL	=	3rd Party Logistics
GAP	=	Good Agricultural Practices
GMP	=	Good Manufacturing Practice
ISO	=	International Organization for Standardization
HACCP	=	Hazard Analysis and Critical Control Points
WSN	=	Wireless Sensor Networks

CHARPTER I

INTRODUCTION

Background of the Research

Nowadays, the vegetable export trade between Yunnan and Thailand has become a critical impetus to the economic development of Yunnan province, China, as it has significantly contributed to solve unemployment problem, trade balance, economic growth and higher living standard of people. Due to the geographical location and zero-tariff policy support advantages, Thailand has emerged the major export market of Yunnan vegetable export industry. According to the Yunnan customs, the export volume of vegetable from Yunnan to Thailand shows an increasing trend over the few years (Yang, 2014). However, this industry still suffers an issue of high post-harvest loss ranging 20%-30% (Du, Wei, & Gao, 2008), some varieties are up to 40% while the losses in developed countries only ranging from 5%-15% (Madrid, 2011). The issue of post-harvest loss could cause lower or loss value for sale of enterprise directly as well as lower export performance. Facing the fierce market competition, Yunnan vegetable export industry has to execute a competitive pattern to successfully reduce the loss. Meaningfully, it can contribute to enhancing market competitiveness and driving the growth of economy in Yunnan province better.

An efficient Cold Chain Management (CCM) is one of useful principles to reduce post-harvest losses (FAO, 2015), which has received growing attention among the practitioners and academicians over the past decade. CCM is a term that specifically used in context of a variety of food, pharmaceutical industries and chemical industries, which is a special supply chain for perishables to maintain the stable temperature for products (Bharti, 2014). The intention of introducing CCM is to insure perishable products in a good condition for long periods by preserving the quality and wholeness (Bogataj, Bogataj, & Vodopivec, 2005). The existing studies on CCM mainly focused on improvement the practical performance of cold chain in the fields of agriculture and biological science, medicine and engineering overall.

Despite the significant benefits and the increasing recognition of the importance of CCM, vegetable export industry is extremely difficult to implement CCM due to numerous barriers. From the previous literatures (Bag, 2016; Miller, 2016), it is evident that many variables can act as barriers influencing the implementation of CCM. In most of actual cases, it is not always capable to overcome all the barriers simultaneously, due to constraints in human beings' limited resources, time and capability (Dos Muchangos, Tokai, & Hanashima, 2015). A more feasible method is to just focus on some critical barriers which have most influences on other barriers and system and to address them first (Q. Zhou, Huang, & Zhang, 2011), so the measures of overcoming of barriers would be more purposefully and effectively. Based on the above points, the identification and prioritization of the barriers that hinder the implementation of CCM are required. Meaningfully, it would provide a more effective, efficient and systemic way to overcome the barriers to implement CCM with the limited resources.

Barriers in a system are often interrelated, and a barrier may trigger another one or influenced by another (Dos Muchangos et al., 2015). Moreover, each barrier has different influence of intensity to the network, which increases the complexity to analysis. Therefore studying the inter-relationships among barriers can help identify the critical barriers (Bacudio et al., 2016). Few studies and methods have the capable of demonstrating the inter-relationships among the barriers of implementation of CCM from the extant literatures. Decision Making Trial and Evaluation Laboratory (DEMATEL) is one of the useful methods that support take inter-relationships into account among criteria and enables to identify the major problem (Shieh, Wu, & Huang, 2010; Dos Muchangos et al., 2015; Bhanot, Rao, & Deshmukh, 2017). Further, to deal with the imprecise judgement of human beings under the uncertain environment, fuzzy logic are incorporated into DEMATEL, namely, fuzzy DEMATEL, which is applied to help address the problem in this study.

In short, this study is going to identify barriers to implement CCM in Yunnan vegetable export industry targeting Thailand market through the fuzzy DEMATEL. The specific aims of this search are described in next section.

Objectives

1. To study barriers to implement CCM on exported vegetable from Yunnan to Thailand.

2. To study inter-relationships among barriers to implement CCM on exported vegetable from Yunnan to Thailand.

3. To identify the critical barriers to implement CCM on exported vegetable from Yunnan to Thailand.

4. To develop strategies to overcome the critical barriers to implement CCM on exported vegetable from Yunnan to Thailand.

Research Significances

1. This study would achieve a better understanding for the complex barriers for implementing CCM on exported vegetable from Yunnan to Thailand.

2. The result of the study could be the guidance for decision makers to develop the strategies to overcome the barriers that hinder the implementation of CCM. It could also be helpful to utilize the limited resources to feasibly reduce the postharvest loss in Yunnan vegetable export industry.

3. Last, this study can be used as valuable strategic reference for vegetable export industry in other regions that plan to implement CCM.

Scope of Work

This research will conduct two times' questionnaires in order to investigate the barriers to implement CCM of Yunnan vegetable export enterprises that target at Thai market.

CHARPTER II

LITERATURE REVIEW

In this section, relevant principles that are applied in this study and related literatures are reviewed. Firstly, the works of vegetable export industry, principles of Cold Chain Management, and the barriers for implementing CCM in previous works are shown firstly. Secondly, the principles and applications of DEMATEL model and fuzzy logic in existing papers are reviewed respectively, among which the advantages and disadvantages of these two tools are also discussed. Lastly, this section in turn reviews SIPOC model, SWOT analysis and TOWS analysis as well.

Vegetable Export Industry

1. Overview of Vegetable Export Industry

The vegetable export industry is thriving since 21th century with expansion of transnational companies as well as vegetable importers are expanding operations to meet new consumer demand. The increasing consumer demands for health, freshness, nutrition and safety has stimulated the development of this industry over the recent years. The expansion of international vegetable trade have contributed to the increase of agricultural gross value of production in many areas (Craig, & Lucy, 2007). The top exporters of vegetable mainly distribute in America, Europe and Asia region. America, Brazil, China, Canada, Indonesia are the major exporters of vegetable in the word as shown in figure 1. In developing countries, vegetables have been become an important commodities for they to seek the diversify exports. Recently, owe to the promotion of information technology applied in harvesting, preservation, transportation and quality control in accordance with international standards, some vegetable export industries in developing countries like China, India and Vietnam have started to penetrate into advanced markets.

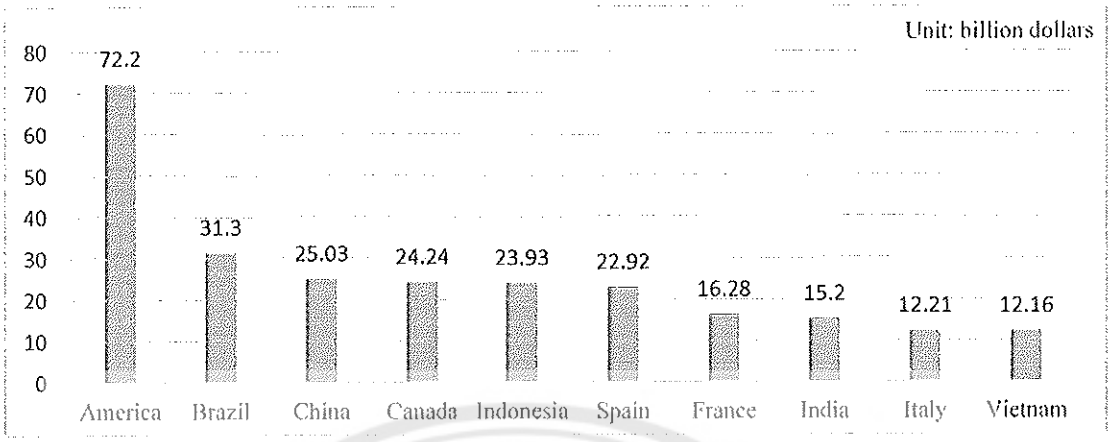

Figure1 Export Value for Leading Vegetable Exporters in 2016

Source: World Integrated Trade Solution, 2017

Export-oriented vegetables are produced for multiple supply chains, including small-holder farmers and large-scale contracted farmers (Mausch, Mithofer, Asfaw, & Waibel, 2009). Farmer is the player who in the upstream of the vegetable export supply chain. They plant and sell vegetable to the exporters, sometimes there would be the collectors acting as the intermediaries. The produce destined for foreign market is mainly supplied through export companies (Mausch et al., 2009). Vegetable export companies play dominant role in processing, packing, storage, and transport to importer. With respect to processing conditions, vegetables destined for export are subjected to more stringent than domestic-oriented vegetable since export-oriented vegetable are involved more procedures and handoffs such as cut, trimmed, cleaned, washed, classify and sanitized etc. Beyond that, vegetable export companies also do implementation of procedures, standard and safety issues. The downstream players of vegetable exporters are importers. Exporters, importers and super markets are regarded as the major market players (Dastagiri, 2017). Importers buys the product and does trading activity to supermarkets, local small markets. Finally, supermarkets, local small markets will supply imported vegetable to consumers, as shown in figure 2.

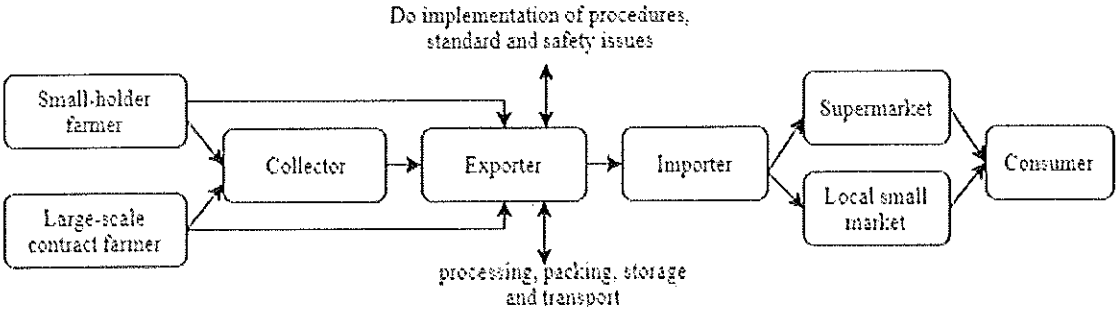

Figure 2 Flow of Vegetable in Export Supply Chain

Source: Dastagiri, 2017

Farmers in developed countries are in a more advantageous position than farmers in developing countries. Farmers in developed countries enable to keenly insight into importance of connecting customers directly of exporters, which help them avoiding the intermediaries. Scientific plan with the close connection with association make them more precisely forecast the demand and predict market signal in international market. This has made them realize a higher income that farmers those in developing countries.

Quality and food safety are among the most important determinants of the sustainable export of vegetables in the country (Dinh, 2016). On the one hand, to guarantee the quality of vegetable, exporter need to have the aid of modern advanced preservation methods. On the other hand they also face multiple requirements when do the trade in international markets. For example, they shall executive maximum residue limits (MRLs) standard, which is a maximum concentration of pesticide residue that is permitted by law to remain in a crop in trade. Since high concentration of pesticide residues on crops can be a health hazard to consumers, a legal limit of pesticide residue was established for each crop, that is MRLs. Obey MRLs is mandatory for reliability as exporters vegetables in international trade markets. Besides, hygiene requirements, heavy metals, food additives, traceability are also standards and regulations that exporter shall obey.

For the large-scale vegetable exporters, they have gained a great awareness of international market expectations. Many of them have established or joined the

associations which can effectively promote their products, due to the associations have a acute perception of their respective industries, international market conditions as well (Meade, Baldwin, & Calvin, 2010).

All the vegetables have a strict finite lifespan or called holding life and are in a condition of decline after the moment of harvest. Due to the internal high moisture content and respiration of vegetable, it is easy cause high losses after harvest (Kumar, Basavaraja, & Mahajanshetti, 2006). Even though vegetable exported have a relatively high value, many studies have shown high rates of loss in export trade. For instance, in Lao PRD cabbage post-harvest loss was estimated about 52.5% in the export trade (Thongsavath et al., 2012) and the losses of vegetable and fruit of Indonesia in export trade was estimated about 28% (Der, 2015).The loss of vegetable in export trade in turn can lead to a series of negative impacts, which including lower of export performance, lower customers satisfaction degree, increase proportion in food waste, as well as increase environmental pollution pressure (Munhuweyi, Opara, & Sigge, 2016). In generally, although vegetable has a lower loss rate in export supply chain than those sale in domestic market due to more modern management , the losses in this industry still huge. Losses of vegetable can occur at any stage of the export supply chain (Gustavsson, & Cederberg, 2011), therefore a proper post-harvest management is required.

Nevertheless it revealed that about 95% of research funding mainly focused on increasing production for agricultural produce while less than 5% funding were used to conduct the research that related to post-harvest issue during the past 30 years (Kitinoja, Saran, Roy, & Kader, 2011). Due to the low level of post-harvest management and few attention were paid to the post-harvest loss issue, reducing vegetable in vegetable export industry is still a grave challenge in many countries.

2. Exporting Vegetable from Yunnan to Thailand

China is a large vegetable producer, as well a leading vegetable exporter in the world. Figure 3 exhibits that in 2016 China's total export value of vegetable up to 25.03 billion dollars. According to WITS data, in 2016 the top partner countries and regions to which China exports vegetable include Hong Kong, China, Vietnam, Japan, United States and Thailand. Among that, China has gained 1.68 billion dollars in vegetable export trade with Thailand, as exhibited in figure 3.

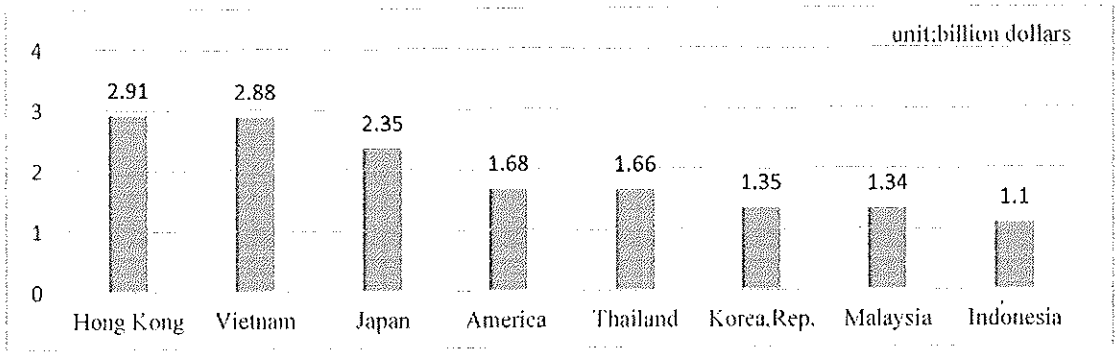

Figure 3 2016 Vegetable Export Value and Major Export Destinations of China

Source: WITS, 2017

As noted in chapter 1, Yunnan vegetables have successfully accessed to Thailand market with a significant share of the market in established export market over the past few years, due to the geographic advantages and zero-tariff policy support. The export trade of Yunnan vegetable have been steadily expanding as shown in figure 4. For this reason, China's vegetable export company in Thailand was identified as the huge threat to the profitability of other countries' exporters (Craig, & Lucy, 2007). The variety of exported vegetable includes Chinese cabbage, cabbage, purple cabbage, cauliflower, snow beans, sweet bean, potato, broccoli, parsley, spinach, ginger, carrot and so on. Yunnan Tonghai Jinshan vegetable wholesale market and Yunnan Dianxi vegetable wholesale market are the major collection and distribution points in exporting vegetable to Thai market. In China, these two markets are selected as top 50 vegetable wholesale markets in China .

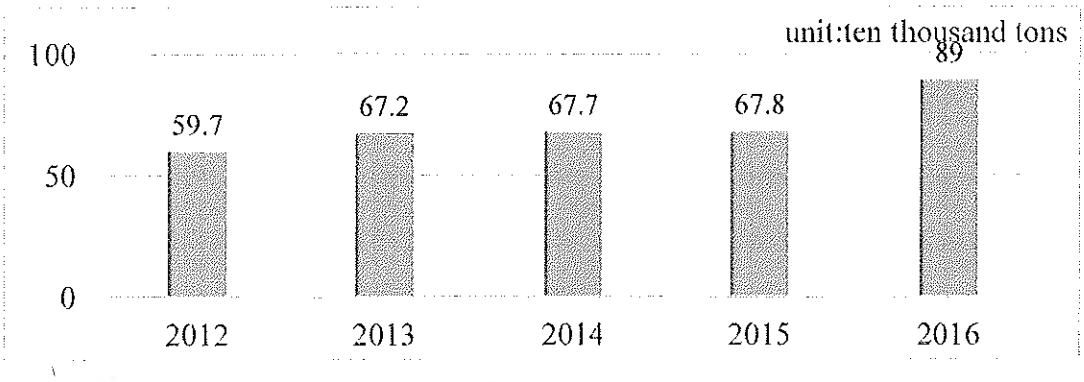

Figure 4 Export volume of Yunnan Vegetable from 2012-2016

Source: Yunnan province Kunming customs

Cold Chain Management

1. Concepts and Overview of CCM

The term "cold chain (CC)" are universally used in food, pharmaceutical and chemical industries. In the early stage, cold chain simply meant storing at a specific temperature in refrigerates vehicles and warehouses. Today, it is described as an environmentally supply and distribution chain, which keeps quality of products within a specific range of parameters that include temperature, humidity, atmosphere, packaging and other conditions (Castiaux, 2010).

The concept of Cold Chain Management (CCM) started being mentioned as a managerial principle since 1980s. With the evolution of CCM, different statements on concept of CCM have been given by the scholars and organizations from their perspectives.

Bogataj (2005) defined CCM is "the process of planning, implementing and controlling efficient, effective flow and storage of perishable goods, relative services and information form one or more points of origin to the points of production, distribution and consumption in order to meet customers' demand".

Daniel, & Maunu (2013) described "CCM is the management of all processes in temperature-controlled transfer of materials from original manufacture, to suppliers, to a consumer, which includes processes of storage and transit."

National Centre for Cold-Chain Development (NCCD, 2015) of India stated: "cold chain is an environment controlled logistics chain, ensuring uninterrupted care from source-to-user, consisting of storage and distribution related activities in which the inventory is maintained within predetermined ambient parameters."

To put it briefly, a temperature-controlled supply chain for perishable products is referred to as a cold chain. All the activities carried out in an unbroken cold chain are defined as CCM. A typical cold chain is composed of three major elements:

1. Trained Personnel: person who manages and controls the storage and distribution of products

2. Transport /Storage Equipment: tool that used for storing and transporting the products

3. Handling Procedure: a set of actions aiming to manage the program and control distribution of products

These three major elements are required to be present at each point of cold chain. An absence of any major elements could cause a deficient cold chain system.

In the topic of equipment, a typical cold chain equipment consist of following equipment:

Pro-cooling facilities: A specialized cooling system designed to rapidly remove field heat from freshly harvested produce and thereby prepares the cargo for subsequent travel in the cold-chain

Cold storages: Environment controlled warehousing space with multiple chambers intended for storage of perishable products

Refrigerated trucks (carriers): The equipment in refrigerated transport system, with an insulated carrier and equipped with active refrigeration, served as temperature controlled carriage of perishable products

Warehouse: An insulated and refrigerated chamber which serves as a transient staging space.

Information management systems: a set of computer equipment and programs system which can help achieving temperature traceability of products or help the company acquire other information about the products

According to Joshi et al. (2009), a cold chain consist of pre-cooling facilities, cold storage, warehouse, refrigerate vehicle, packing, traceability retailers and consumers under the assist of information management system as displayed in figure 5.

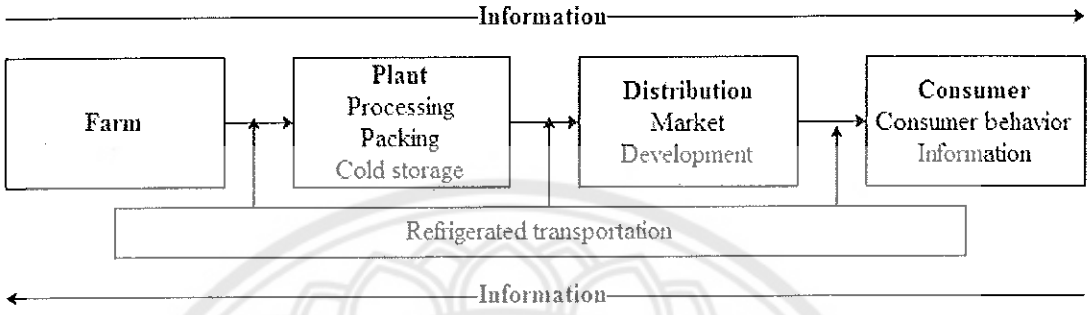

Figure 5 A Typical Cold Chain

Source: Joshi et al., 2009

It should be noted that cold chain's critical links include production, transportation, storage, distribution which covers delivery, temporary storage, display and selling aspects (FAO, & IIR, 2012). Meanwhile, CCM is a peculiar type of supply chain management (SCM). It also requires relative stakeholders in the cold chain to work close together to operate coordinately as even though very small variations in temperature can significantly affects the products' shelf life and value and many lead to resources waste or duplicate, performance dwindles. The efficiency and reliability of a cold chain depend not only on the quality and management of equipment, but also on the coordinating control of critical points in the cold chain at the interfaces between different stages (FAO, & IIR, 2012). Because of this coordinating the activities among multiple actors is essential to cold chain development (FAO, 2015).The basic difference between the supply chain of non-perishable substances and cold chain is the possibility of reduction in quality of products (NCCD, 2015). Cold chain does not alter the essential characteristics of the product handled. In spite of this, cold chain is tightly prescribed in most of developed countries. For instance, refrigeration is required to be applied throughout the whole cold chain within the food industry to ensure the food security (Mercier, Villeneuve, Mondor, & Uysal, 2017).

In the section of agriculture, as a kind of efficient management measure, CCM is a requirement for a successful post-harvest industry in any country (Jemric, & Ilic, 2012) due to its merit in reducing high post-harvest losses of farm produces. Moreover, it also contributes to improving products integrity, preventing pollution and increasing customer satisfaction (Sita Ram Jat, 2010; Liu, Xu, & Yu, 2016).

For worldwide trade networks, CCM is outstanding because of its unique characteristics, namely, its critical impacts on all food commodities. Modern cold chain system was adopted much earlier in export market of agricultural produce than in domestic market. CCM is capable to preserve the quality of perishable products that destined for export and avoid the loss of perishable products. Hence, CCM can severs the purpose to substantially boost export to profits as well (Freiboth et al., 2013).

Globally, at the present, the losses due to the lack of a cold chain more than 30% and can even reach 40% in some developing countries, especially for vegetable and fruits (Cavalier, Hadji, & Ozdemir, 2014). CCM is widely used in the export industry of developed countries to act as a crucial investment to prevent perishable food losses and expand profits (Kitinoja, 2013). Whereas CCM are still limited in most developing countries due to numerous existing difficulties and challenges and surely the loss of a large amount of food and money still occur. This make their export performances and competitiveness at a disadvantage. For most of vegetable export companies in developing countries, much reminded to be done. Identifying and removing the existing barriers are the fundamental task need to finish.

2. Process of A Typical Vegetable Export Cold Chain

According to Freiboth et al. (2013), a typical vegetable export cold chain consists of 5 primary steps, which starts after finishing harvesting.

The first step for vegetable is pre-cooling. Vegetable is rapidly moved to a refrigerate room after post-harvesting in order to remove the remaining field heat which can slow down the metabolism of vegetable. It is recommended to cool to their optimum storage temperature of approximately 2 °C to 6 °C. Reducing the delay from harvesting to pre-cooling is critical to prolong the shelf-life of vegetable significantly, as it is the period when vegetable at their highest temperature and loses at the highest rate. Pre-cooling is perceived as the most efficient quality enhancement for commercial producer in post-harvest chain. Not only that, it is also deemed as one of the most value-adding

activities in horticultural chain .Today, a variety of pre-cooling techniques are emerging, including room cooling, force-air cooling, vacuum cooling, etc. The selection of cooling technique mainly depends on the vegetable's sensitivity to chilling injuries and economic consideration.

The second step is packing process. Once finishing pre-cooling, the vegetable is moved to packing house for conducting packing process. The packing process normally involves trimming, sorting, grading, weighing and packing. The trimming and sorting process is significant for selecting good quality vegetable which are available and marketable. Using suitable packaging can help to avoid the vegetable from harm/damage during various handling operations along the transportation, distribution and marketing, protect against the small change of temperature. Packing process is finished either machine or by manually. It is necessary for the specialized personnel to conduct packing practice. The materials and labor cost make packaging becomes a costly part for operational level.

Next, vegetable is transferred to cold store for storage until the export date. It is recommend that maintain optimum storage temperature of 2° C to 6 °C and relative humidity of 80 to 95 % to keep vegetables fresh and reduce product moisture loss. Table 1 shows the storage requirement of selected vegetable.

Table 1 Storage Requirement of Selected Vegetable

Vegetable	Storage Temperature(°C)	Relative Humidity (%)
Chinese Cabbage	0	90-95
Cauliflower	0-4	9-98
Broccoli	0	90-95
Celery	30	90-95
Potato	12	90-95
Spinach	0-1	95-100
Chinese chives	1-2	95-100
Carrot	5-15	85-90
Onion	0-4	45-60

Source: China Cold Chain Logistics Development Report, 2016

Then, vegetable transported to the refrigerated warehouse where in import country by using refrigerated containers or refrigerated trucks. Before that, customs clearance is done with vegetable. The distribution center acts as the core role in CCM system (Mercier et al., 2017). Generally, the vegetable would be holding stored in refrigerated warehouse until transported and bought by the retailer or consumer finally. The whole storage process keeps in the state of a temperature range 0 °C to 10 °C. A typical vegetable export cold chain can be illustrated in figure 6.

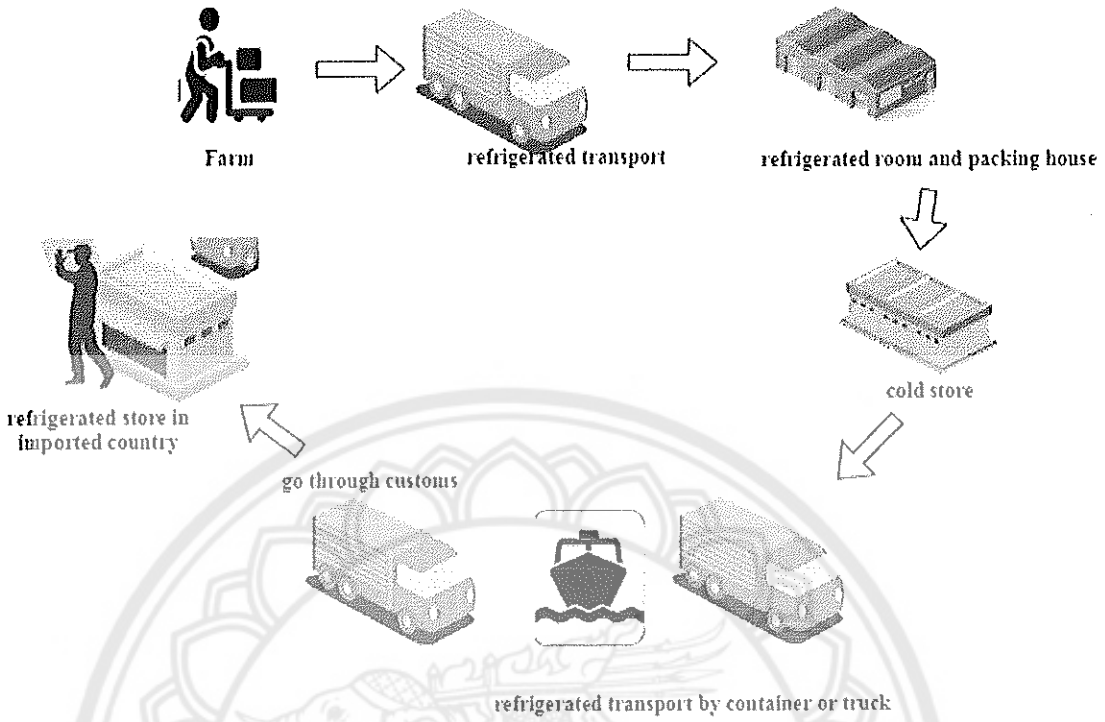

Figure 6 Process of A Typical Vegetable Export Cold Chain

From the figure 6, it shows that achievement of a good temperature control of vegetable during cold store and transportation is the main task that needs to consider. It highly depends on management and monitoring of time-temperature, which requires measuring and recording vegetable's ambient accurate temperature information. Besides, more and more information like humidity, or tamper needs to be collected and made available so that they can provide data for further analysis and optimization of production practices (Mahajan, & Fias, 2011). If the cold chain is broken, the damage it causes would be irreversible. Therefore, timeliness and responsiveness is of vital importance for the food cold chain management. In this context, a high degree of combination of process and technology is required. Today, CCM is becoming mature with the application of advanced technological tools, such as Radiofrequency Identification (RFID) technique, Safety Monitoring and Assurance System (SMAS), Time-temperature Indicators and Integrators (TTIs) and Novel time-temperature monitoring etc. These modern techniques can assist achieving the real-time recording,

tracing and tracking the product's information and reduction the quantity of with zero shelf life and improve entire post-harvest management level (Mahajan & Fias, 2011).

Combined with the above, cold chai has the characteristic of irreversible and each step in the cold chain has a critical impact on the products, any break in the cold chain would cause the loss of quality or total loss of products (Freiboth et al., 2013). The integration of the multiple process and the high requirement of specific technology are pre-requisite. The equivalent studies in developing countries are all of these decide the fact that there are quite a number of barriers to hinder the implementation of efficient CCM, which results in concept of CCM is not yet widely accepted by vegetable export industry in many areas, especially in developing country. The overall identification of these barriers is crucial to arrive at reasonable measures to overcome them.

Identification of Barriers for Implementing CCM

Despite the widespread awareness on the need for an efficient CCM in organizations, the implementation is still at a low level in many developing countries due to a number of barriers (Jat, 2010).Compared with domestic vegetable trade ,the export trade of vegetable often involves quite long journey times and frequent handling operations, which makes effective cold chain management more difficult (Irving, 2007). It is important to identify these barriers so that decision makers may develop strategies to overcome them efficiently. Quite a few studies have been conduct to explore the barriers to implement CCM focusing in different areas. A targeted literature review was conducted to present different barriers to implement CCM in related industries. 17 primary barriers were identified from the extant literature as shown in table 2.

Table 2 A List of Barriers in Previous Literature

Code	Barriers	Sources
1	Lack of trained personnel	Jat (2010); FAO (2015); Miller (2016); Shashi (2016); Dong, & Han (2017)
2	Lack of coordination between stakeholders	FAO (2015); Brison, & Tallec (2017); Mercier et al. (2017)
3	High capital cost and operating cost	Jat (2010); Lan, & Tian (2013); Miller (2016)
4	Lack of quality and safety measures	Joshi et al. (2009); FAO (2015)
5	Lack of top level commitment	Jayant, & Azhar (2014); Gorane, & Kant (2015); Parmar, & Shah (2016)
6	Lack of IT implementation	Aung, & Chang (2014); Weng, An, & Yang (2015); Dong, & Han (2017)
7	Lack of industry standards of implementation of CCM	Bharti (2014); FAO (2015);Qu (2015); Liu, Xu, & Yu (2016); Dong, & Han (2017)
8	Manager's limited awareness on CCM concept	Silvia (2008); Joshi et al. (2009); Liu et al. (2016)
9	Unawareness of customers	Ovca, & Jevsnik (2009); Joshi, Banwet, & Shankar (2010)
10	Lack of government support	Bharti (2014); FAO (2015); Liu et al. (2016); Miller (2016); Shi (2016)
11	Poor cold chain infrastructure	Liu et al. (2016); Y. Li, Xu, Gong, Sun, & Zhao (2016)
12	Lack of integrated planning	Negi, & Anand (2015b); Qu (2015); Shi (2016)
13	Shortage of power to run	FAO, & IIR (2016); Bharti (2014)
14	Disbelief about benefits of CCM	Lan, & Tian (2013)
15	Lack of reliable third-party logistics	FAO, & IIR (2012); Y. Li et al., (2016); Liu et al. (2016); Dong, & Han (2017)
16	Lack of capacity in maintenance of CC facilities	FAO, & IIR (2012); Bharti (2014); FAO (2015); Ashok, et al. (2017)
17	Lack of awareness about the use of IT	Sheng, & Wang (2014); Negi, & Anand (2015a)

Lack of adequate infrastructure along with high capital cost and operating cost, lack of government policy and regulatory support were often the biggest bottlenecks for efficient and strong cold chain (Bag, 2016; Miller, 2016; Li et al., 2016). In addition,

lack of cooperation between significant role players was key barrier responsible for high food loss in cold chain as well (Jemric, & Ilic, 2012). Lack of industry standards of implementation of CCM, technology can't be applied in many type of food and lacking overall integrated planning were the barriers that hinder the development of CCM in transit transport and storage in China, Near East and North Africa area (FAO, 2015; Qu, 2015). Besides, lack of capacity in the management and maintenance of cold chain infrastructures were also critical barriers to implement CCM in many developing countries (FAO, 2015). What deserves to be mentioned is that a few researchers have turned to study the multiple inter-relationships among barriers. For instance, Joshi et al. (2010) applied ISM fuzzy-MICMAC model to explore the barriers that influence the efficiency of a cold chain for vegetable and fruit sector in India. Bag (2016) studied the contextual relationships between 10 identified barriers influencing green cold chain management practices in the agriculture industry of India by using ISM technique.

Up to now, although numerous of studies have been conducted to explore the different barriers influencing the implementation of CCM, there are still some limitations in this field. In the theoretical section, few of them took into account the relationships or the characteristics of the barriers nor identified the critical barriers. The extensive literature showed that researches on barriers to implement CCM were still not deepen enough and can't provide a clear identification. In the practical section, few researches focused on the barriers of CCM of Yunnan vegetable exported to Thailand from extant literature. This study is to fill in this gap. The result of present study would be helpful for the decision makers to achieve a better understanding for the complex barriers to implement CCM on Yunnan vegetable export to Thailand. Furthermore, it would be helpful to develop strategies to overcome the barriers of implementation of CCM

DEMATEL

Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique is a mathematical procedure that proposed by Fontela and Gabus in 1976 (Falatoonitoosi et al., 2013). The primary functions of DEMATEL include: ranking factors, clarifying problem's factors, identifying the main problem and analyzing structure of the problem. DEMATEL is regarded as a potent tool for building and analyzing a visualizing

structural model involving causal relations among factors of a complex system (Bhanot et al., 2017). DEMATEL is based on the combination of graph theory specifically and matrix form. The matrix in DEMATEL represents the contextual relation and strength of influence of the factor in system. The outcome of the DEMATEL allows us easily identify strength of the influence a factor has on other factors and influences receive from other factors thereby it is able to assist identifying the efficient solutions.

The specific steps involving applying the DEMATEL method are discussed as follows.

Step1: Set up direct-relation matrix. Determine intensity of relations among the factors: in conventional DEMATEL there are five scales that determine the scores of relationships between each pair of factors.

0=No influence

1=Very low influence

2=Low influence

3=High influence

4=Very high influence

Assume there are H experts and n factors to be considered in the system. Each expert compares pairwise factor to illustrate the degree of a factor i influences factor j. For now a_{ij} donates pair wise comparisons between any two factors and it is assigned score ranging from 0, 1, 2, 3, 4. For respondent k, the form of the matrix is shown in (1).

$$A_k = \begin{bmatrix} 0 & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & 0 & a_{23} & \cdots & a_{2n} \\ \vdots & 0 & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 0 \end{bmatrix} \quad (1)$$

Step2: Find the average matrix A: calculating all expert's opinions by averaging the H, and get the all the scores:

$$[a_{ij}]_{n\times n} = \frac{1}{H}\sum_{K=1}^{H}[X_{ij}]_{n\times n} \quad (2)$$

Step3: Normalize the initial direct-relation matrix. The values in normalized matrix D would falls between zero and one (H.-H. Wu, & Chang, 2015), which is gotten from following formula:

$$S = \frac{1}{max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}} \quad (3)$$

$$D = A \times S \quad (4)$$

Step4: Calculate the total relation matrix. The total relation matrix T is achieved from the following formula:

$$T = D(I - D)^{-1} \quad (5)$$

I: Identity matrix

T: Total relation matrix

The sum of rows and sum of column of the total relation matrix T are compute as an R vector and S vector.

$$[R_i]_{1 \times n} = (\sum_{j=1}^{n} t_{ij})_{n \times 1} \quad (6)$$

$$[S_j]_{1 \times n} = (\sum_{i=1}^{n} t_{ij})_{1 \times n} \quad (7)$$

R_i denotes the total effects given by factor s i to other factor j=1,2,3,4.....n, similarity S_j denotes total effects received by factor j from factor i=1,2,3,4.....n. When i=j, the sum $(R_i + S_j)$ called "prominence", it gives an index that presents the total effects both given and received by factor i, which proves the degree of importance role of factor i in the system. The result of $(R_i - S_j)$ is called "relation", which shows the net effects that factor i donates to the system.

Step5: Construct cause-effect diagram

In a cause-effect diagram, the horizontal axis is obtained from $(R_i + S_j)$, and the vertical axis is obtained from $(R_i - S_j)$. If $(R_i - S_j)$ is positive, it shows factors i affects others factors and then factor i falls in cause group. If $(R_i - S_j)$ is negative, it shows factor i is influenced by other factors and then the factor i falls in effect group. And afterwards, the decision maker can put forward the managerial implication bases on the cause-effect diagram. The flow chart of applying DEMATEL model is depicted in figure 7.

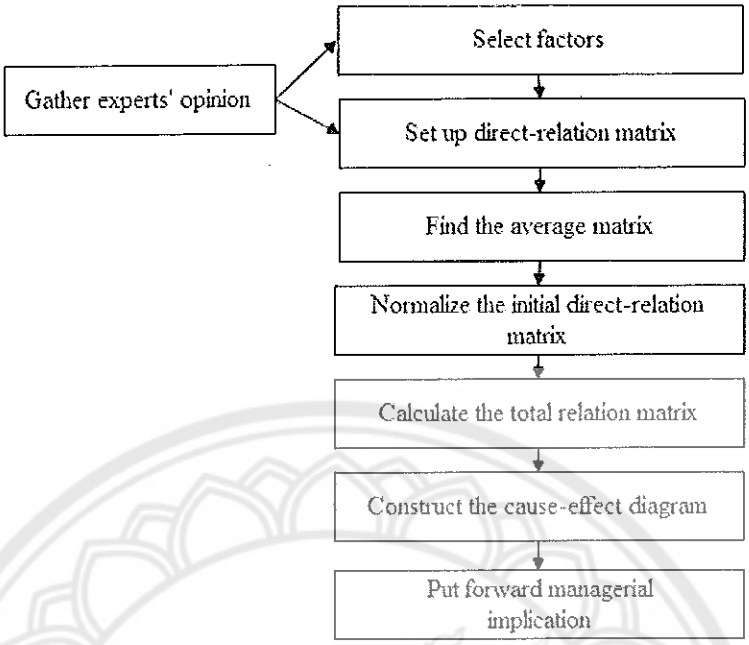

Figure 7 Flow Diagram for Applying the DEMATEL Model

Each multiple criteria decision-making (MCDM) tool both has advantages and disadvantages, as well as DEMATEL. DEMATEL model has significant advantages: firstly, it allows considering the interdependence among the factors of a system through a causal diagram, which is unlike the traditional MCDM methods like the analytic hierarch process (AHP) which often assume independence among factors (Dos Muchangos et al., 2015). Moreover, DEMATEL allows for a broader discrimination of measures (Shao et al., 2016). Last but not least, it does not need large amounts of data (Govindan, Khodaverdi, & Vafadarnikjoo, 2015). However, since DEMATEL focuses on the identification of influential factor in the horizontal direction, it can't provide a vertical hierarchy structure as interpretive structural modeling (ISM) does (Shih-Hsi Yin, 2012) . Apart from it, it can't handle the linguistic imprecision and ambiguity of experts' judgments (Govindan et al., 2015).

Due to the significant advantages of DEMATEL, it has been extensively accepted as one of the best tool to in many management fields, such as information technology management, project management, strategy management (Mehregan et al., 2012), sustainable management (Wu, Zheng, & Wu, 2013), supply chain management (Anand et al., 2014) etc.

Fuzzy Logic

Fuzzy logic was developed based on the concept of membership function aiming to take linguistic variables into consideration under fuzzy circumstance. It can measure ambiguous concepts associate with human's linguistic judgment. Fuzzy logic is necessary for handing problems .Because in the real world, human's judgment in decision making are often tend to give a linguistic evaluation based on experience rather than judge by precise value. These linguistic evaluations are always ambiguous and difficult to estimate by exact numerical value (Lin, 2013). The application of fuzzy logic enables research result more comply closely with human thought patterns and more accuracy (Tsai et al., 2015) and assist making decision under fuzzy environment.

Fuzzy number is one of the most essential mathematical concepts concerning fuzziness. Because the form of fuzzy numbers is not suitable for matrix operations, in fuzzy aggregation process must contain a defuzzification procedure (Gharakhani, 2012). Defuzzification refers to the selection of a specific crisp element based on the output fuzzy set, which converts fuzzy numbers into crisp scores (CFCS). In fuzzy set theory, there are trapezoidal fuzzy number, rectangular fuzzy number and triangular fuzzy number and so on. It is found that in practice, the triangular fuzzy numbers(TFNs) is the most common method used for defuzzification (Mahmoodi & Jahromi, 2014). $z_{ij}^k = \left(l_{ij}^k, m_{ij}^k, r_{ij}^k\right)$ indicates the fuzzy judgments of evaluator k (k=1,2,3…,p) about the degree to which the factor i affect the factor j . The CFCS method includes the following 5 steps.

Step 1: Standardize the fuzzy numbers

$$xl_{ij}^k = (l_{ij}^k - minl_{ij}^k)/\Delta_{min}^{max} \quad (8)$$

$$\mathrm{xm_{ij}^k} = (\mathrm{m_{ij}^k} - \mathrm{minl_{ij}^k})/\Delta_{\mathrm{min}}^{\mathrm{max}} \quad (9)$$

$$\mathrm{xr_{ij}^k} = (\mathrm{r_{ij}^k} - \mathrm{minl_{ij}^k})/\Delta_{\mathrm{min}}^{\mathrm{max}} \quad (10)$$

Step 2: Calculate the left and right normalized value

$$\mathrm{xls_{ij}^k} = \mathrm{xm_{ij}^k} \div (1 + \mathrm{xm_{ij}^k} - \mathrm{xl_{ij}^k}) \quad (11)$$

$$\mathrm{xrs_{ij}^k} = \mathrm{xr_{ij}^k} \div (1 + \mathrm{xr_{ij}^k} - \mathrm{xm_{ij}^k}) \quad (12)$$

Step 3: Compute the total normalized value

$$x_{ij}^{k} = [xls_{ij}^{k}(1 - xls_{ij}^{k}) + xrs_{ij}^{k} \times xrs_{ij}^{k}] \div (1 + xrs_{ij}^{k} - xls_{ij}^{k}) \quad (13)$$

Step 4: Obtain the crisp score of the k^{th} expert's assessment

$$BNP_{ij}^{k} = minl_{ij}^{k} + x_{ij}^{k}\Delta_{min}^{max} \quad (14)$$

Step 5: Get the integrated scores by averaging the crisp scores of all K assessment

$$a_{ij} = \frac{1}{K}\sum_{k}^{1\le k\le K} BNP_{ij}^{k} \quad (15)$$

BNP: Best Nonfuzzy Performance

Fuzzy logic can't only take insufficient information and the evolution of available knowledge into consideration but also allow for imprecise information input and a few rules to encompass problems with great complexity (Velasquez, & Hester, 2013). However, fuzzy system can be difficult to develop in sometimes. In many practical cases, it requires numerous simulations before being able to use in the real world (Velasquez, & Hester, 2013).

Fuzzy logic has been employed in many different disciplines since its inception in 1965, such as engineering, economic (Bjork, 2012), environmental (Awasthi, Chauhan, & Goyal, 2010), social, medical, and management. Many studies have integrated fuzzy set theory with other techniques to assist decision making process. For the field of logistics and supply chain management, fuzzy theory are also applied widely, such as apply it to evaluate and select logistics provider or suppliers (H.-T. Liu, & Wang, 2009), select distribution center (Ou, & Chou, 2009; Turskis, & Zavadskas, 2010), select supply chain management strategy (Tseng, Chiang, & Lan, 2009; Dey et al., 2012).

In the next part, the overview of DEMATEL, fuzzy DEMATEL are presented respectively. Lastly, the application fields of hybrid DEMATEL are reviewed in this part.

As an effective multiple criteria decision making tool, DEMATEL has become very popular in the field of supply chain management during the past few years.

Wang, & Zhang (2010) proposed DEMATEL to identify the direct and indirect relationships and recognize the core issue in SCM. They claimed that the proposed DEMATEL model can turn a complicated system into a clear visual structure and identify core problems. Zhu, et al. (2014) applied DEMATEL to examine the cause-effect relationships among various implementation barriers from a remanufacturing supply chain perspective. Their research introduced a research framework to identify the key barriers to development remanufacture industry in China. Wang, & Hu (2015) used DEMATEL model to rank the influence factors and identify the major factors influencing the fruit and vegetable product cold chain logistics in the big Xiangxi region of China. Gandhi, & Magla (2015) used DEMATEL to evaluate factors in implementation of successful green GSCM. An empirical case study of an Indian manufacturing company was conducted to show the real-life applicability of DEMATEL in this paper. Ozcan, & Tuysuz (2016) proposed an integrated grey DEMATEL with grey relational analysis (GRA) model for the performance evaluation of retail chain in Turkey.

Many studies hybrid DEMATEL model with other techniques to achieve the goals of the research such as Najmi (2010) combined AHP and DEMATEL to measure supply chain performance, as same as Gandhi et al. (2016) integrated AHP and DEMATEL to evaluate success factors at the tactical, operational and strategic levels in GSCM adoption. They concluded that the proposed model was helpful to develop long-term decision strategies in efficiently managing a green supply chain. Fazli et al. (2015) extended DEMATEL and analytic network process(ANP) to identify main risks related to crude oil supply chain. The interdependencies between the risks were determined through DEMATEL, and then importance of each risk was ranking by ANP.

Fuzzy DEMATEL method enables to provide an overview of the way factors are relating with each other as well as enables to reflect the true states of factors roundly, improve the analysis result's precision and provide a more valuable reference to decision makers. Fuzzy DEMATEL was applied to many sections widely, including human resource management, strategy management, environment management (Tsai et al., 2015), project management, emergency management (Q. Zhou et al., 2011), marketing resource management (Altuntas, 2016), etc. In next part, the applications of DEMATEL in published literature are shown lastly.

Reviewing the methods among previous studies, most decision making methods utilized to evaluate a system were based on fuzzy sets and evaluate the criteria with words that are modeled with fuzzy sets. To incorporate uncertainties arising from multiple decision makers and to make the evaluation process more precise and more flexible, fuzzy or grey-DEMATEL in evaluation should be developed (Bacudio et al., 2016). Fuzzy DEMATEL was also obtained a wide range of applications in logistics and supply chain management section , such as evaluation supplier selection criteria (Chang et al., 2011; Gharakhani, 2012; Mavi, & Shahabi, 2015), evaluation the performance of supply chain management practices (Chiang, 2010; Alavi et al., 2012; Govindan et al., 2015; R.-J. Lin, 2013), identification supplier (Mavi et al., 2013), analysis barriers of green procurement (Dou, Sarkis, & Bai, 2014), solving transportation management issue (Wan, Wang, & Li, 2010; Hamidi, & Jamali, 2015; Parviz, Sadegh, & Zinat, 2016) and identification the barriers to implement reverse logistics (Garg, Luthra, & Haleem, 2016).

Furthermore, there are a great many methods that integrated with fuzzy DEMATEL, such as Akbar et al. (2014) developed ANP-DEMATEL-TOPSIS with fuzzy set methodology for supplier selection problem. They introduced fuzzy ANP to obtain the weight of the sub-criteria, and then applied DEMATEL to construct the structure of relationship map, and last applied fuzzy TOPSIS to rank the competing suppliers with the sub-criteria. Tadic et al. (2014) proposed a model that combined DEMATEL, ANP and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methods under a fuzzy context. This model was utilized as supportive tool to propose framework for the selection of the city logistics concept. This research showed the proposed model was successfully performed for the city of Belgrade.

Interpretive structural modelling(ISM) is a process that enables to develop a map of the complex relationships among many elements and provide fundamental understanding on the elements' hierarchy, sequence and intersection relationship (Dos Muchangos et al., 2015). Mehregan et al. (2014) utilized ISM-fuzzy DEMATEL to analyze interactions among sustainability supplier selection criteria. In this research, ISM was utilized to examine was there any relationship between pairs of the criteria before application fuzzy DEMATEL, and then fuzzy DEMATEL was utilized to determine the intensity of relationships. Chen (2016) utilized fuzzy DEMATEL and

ISM to study the relation between success factors for the implementation of the green supply chain platform of cross-industry in Taiwan.

What have been discussed above focused on the application of DEMATEL and fuzzy DEMATEL in the field of SCM. The literature that were reviewed can be summarized in table 3.

Table 3 The Applications of DEMATEL and Fuzzy DEMATEL in Literature

Model	Applications	References
DEMATEL	Recognize the core issue in SCM	Wang, & Zhang (2010)
	Examine the cause-effect relationships among implementation barriers remanufacturing in China	Zhu et al. (2014)
	Identified the major factors influencing the fruit and vegetable product cold chain logistics in the XiangXi region, China	Wang, & Hu (2015)
	Evaluate factors in implementation of successful green GSCM in Indian manufacturing company	Gandhi, & Magla (2015)
AHP-DEMATEL	Measure supply chain performance	Najmi (2010)
	Evaluate success factors at tactical, operational and strategic levels in GSCM adoption	Gandhi et al. (2016)
DEMATEL-ANP	Identify main risks related to crude oil supply chain	Fazli et al. (2015)
Grey-DEMATEL-GRA	Evaluate the performance of retail chain in Turkey	Ozcan, & Tuysuz (2016)

Table 3 The Applications of DEMATEL and Fuzzy DEMATEL in Literature (cont.)

Model	Applications	References
Fuzzy-DEMATEL	Evaluate supplier selection criteria on SCM	Chang et al. (2011); Gharakhani (2012); Mavi, & Shahabi (2015)
	Evaluate the performance of supply chain management practices	Chiang (2010); Alavi et al. (2012); Govindan et al. (2015); R.-J. Lin (2013)
	Evaluate the influence of effective factors in supplier selection of manufacturing industry	Mavi et al. (2013)
	Analyze barriers of green procurement	Dou et al. (2014)
	Solve transportation management issue	Hamidi, & Jamali, (2015); Parviz et al. (2016)
	Identify barriers to implement reverse logistic in Indian industries	Garg (2016)
Fuzzy ANP-DEMATEL-TOPSIS	Select suppliers	Akbar et al. (2014)
Fuzzy-DEMATEL-ANP- VIKOR	Select the city logistics concept	Tadic et al. (2014)
ISM-fuzz DEMATEL	Analyze interactions among sustainability supplier selection criteria	Mehregan et al. (2014)
Fuzzy DEMATEL-ISM	Identify critical success factors for the implementation of the GSC platform of cross-industry in Taiwan	Chen (2016)

From the extensive literature review, it found that DEMATEL and fuzzy DEMATEL have been applied widely in the researches which concerned with SCM field due to its significant advantages. Nevertheless, there are few study concentrated on the Cold Chain Management in context of vegetable export industry through the fuzzy DEMATEL methodology or other techniques. Cold Chain Management, as a special supply chain management pattern which is an effective way to reduce the post-

harvest loss of vegetable, there are a number of barriers to hinder the implementation of it. The identification synthetically of these barriers is required. Therefore, to achieve this goal, this study intended to identify the barriers to implement Cold Chain Management by utilizing fuzzy DEMATEL in vegetable export industry. The proposed fuzzy DEMATEL will be helpful for the identification of barriers efficiently and synthetically.

SIPOC Model

SIPOC model is a practical map of process developed by Deming. This model is used mainly in process management and improvement activity. The abbreviation "SIPOC" stands for suppliers, inputs, process, outputs and customers. Before putting forward a plan or make a action to improve, it is essential to make a clear understanding of the overview of the process. SIPOC is a such tool that can give team members who are unfamiliar with process a high-level understanding. The objectives of SIPOC are to identify all relevant elements (components) of a process and distinguish the connections. This tool is especially helpful when the improvement activity is targeted at a process with which the activity leader has little or no experience. Each element in SIPOC means.

1. Suppliers: refer to sources of key material, information or service, which visually depicts which suppliers provide input.

2. Inputs: items that involve in the process, such as data, products, materials, or something that is need to run in the process.

3. Process: main activities that transform inputs to output.

4. Output: end result of the process, can be products, service or information, etc.

5. Customer: the person who receive the outputs

Process mapping is the most important and powerful tool to improve the effectiveness and efficiency of a process. There are advantages for creating a process map:

1. It helps process members easily understand their roles in the process and how their process affects the entire supply chain.

2. It describes how the different activities are performed and how the work flows with a visualized way.

3. It can be utilized as an tool in training new people in the organization.

4. It can show user where can take measurements that will make the process run better.

SIPOC diagram is a such processing map used in identifying process flow in the macro view or perspective (Abdullah, et al., 2014), which is also a common tool used in the phase of measure of DMAIC (Define-Measure-Analyze-Control) methodology. SIPOC has been widely utilized in SCM for the issue of process improvement. Pratima, & Rajiv (2014) introduced a hybrid framework (SIPOC+DMAIC) to improve SCM process in terms of process/product quality, process capability and reduction in failure cost dimensions in a supply chain (SC) network. In this work, SIPOC diagram is used to categorize how various entities interact with each process, dividing the scope into convenient segments. Another example is Al-Aomar, & Hussain (2015) proposed a SIPOC-based construct of a hotel supply chain and identified types of waste at different construct elements. The constructs of the hotel supply chain based on SIPOC model in their study is served as foundation of categorizing hotel supply chain wastes using lean principles and providing guidelines for waste reduction using lean practices.

SWOT Analysis

The SWOT analysis was originally introduced by Albert S. Humphrey during 1960 and 1970, who was an American business and management consultant. SWOT analysis technique is a process of analyzing organization's current position in environment, which is considered as a precursor to the strategic planning process. Through SWOT analysis, strengthens, and weakness inside a organization and the opportunities and threats in the external environment can be identified and evaluated. SWOT analysis Acronym "SWOT" refers to strengths, weaknesses, opportunities and threat. The four letters means:

Strengths: mean the internal factors or aspect that an organization possesses to complete against its competitors.

Weaknesses: represent the factors or aspects that negatively affect product or service with regards to competitive environment.

Opportunities: define as a set of beneficial conditions for achieving goals

Threats: represent any improper or un-favorable force in the external environment that is harmful to the organization's strategy.

Strengths and weaknesses are internal elements of organization, hence they are within the control of the organization. They are both extremely sensitive to the formulation of strategies. These may include research and development, staff, capacity, enterprise culture, management, operational efficiency, finance.

Opportunities and threats are external elements of organization, which are outside the control of the organization. These may include economic situation, technology advances, political, competitive environment and so on.

After finish identifying or evaluating these aspects, strategies are formulated based on following principles : take advantage of strengthens, eliminate (overcome) the weakness, exploit the opportunities, and counter the threat (Pereira, Salazar, Abelha, & Machado, 2013).

SWOT is particularly popular because its simplicity and flexibility. It can be applied without extensive information systems and is capable of structuring a mixture of quantitative and qualitative information. The benefits of SWOT analysis are as follows:

1. Gain a overall perspective on the current state of the organization and the risks faces.

2. Enable to identify the major barriers to achieve the strategic objectives.

3. Enable to generate new method and solution for overcoming barriers and address problem.

4. Can assist planners to make decision in developing tactics and strategies.

At the same time, there are also some limitation in using traditional SWOT analysis:

1. Simply lists of issues and classifies them without further references, fails to provide solution.

2. May oversimplify the type and extent of strengths, weaknesses, opportunities and threats facing the organization.

3. There is no the priority and importance among factors listed in each of four grid so it can't provide the key solution for addressing the issue.

4. Can take a considerable amount of time and would be difficult to find the necessary data.

Many studies have made use of SWOT analysis with the goal of improving strategic planning and management levels. For example, Goranczewski, & Puciato (2011) identified the role of SWOT analysis in the formulation of tourism development strategies for destinations.

SWOT tool has been developed continuously in practical applications. Some researchers have integrated it with PEST analysis. In PEST-SWOT analysis, the external environments including political, economic, social, technological and scientific factors are first scanned. Afterwards SWOT analysis would be conducted. For example, Vanags, & Jirgena (2008) applied PEST-SWOT method to evaluate factors influencing competitiveness of agricultural sector in Latvia. To increase the adaptability of SWOT analysis, the so-call "advance" SWOT analysis is introduced. Since "ordinary" SWOT analysis is based mainly on qualitative analysis, some researchers integrated factors listed in SWOT with personal experience, order, weighting, emphasize detail, rank and prioritize to quantify the SWOT analysis. For instance, Moghaddaszadeh et al. (2015) prioritized strategies by giving weigh to the factors in SWOT and applied it to a Persian food industry. In their study, the new SWOT model helped reducing strategies from 34 strategies to 13 applicable ones. As another example, Taleai et al. (2009) develop a hybrid method, SWOT-AHP analysis, to eliminate the weakness in the measurement and evaluation steps of the SWOT analysis. The challenges and prospects of adopting geographic information systems in developing countries are investigated in this study. In addition to examples given, there are a number of researches applying SWOT in conjunction with different MCDM technique for ranking the determined factors or strategies, e.g. SWOT-ANP, SWOT-TOPSIS, Fuzzy ANP-SWOT, Fuzzy AHP-SWOT and so on (Gorener, 2012; Moghaddaszadeh et al., 2015).

TOWS Analysis

As mentioned in last section, a SWOT analysis helps assessing organization's current internal and external situation, but it can't provide concrete solution or strategic actions to take. In this case, TOWS analysis or called TOWS matrix is commonly used as a complementary tool of SWOT analysis in strategic management process, which was

proposed by Heinz Weihrich in the year of 1982. When use properly, TOWS enables to provide a good foundation for strategy formulation.

TOWS matrix formulates strategies through taking systematically relationships between strengths, weaknesses, opportunities, and threats into account. Different with SWOT analysis, opportunities and threats are explored first in TOWS analysis and weakness and strengthens are examined later. In TOWS matrix, by combining organization's external variables with organization's internal invariables, a structure for formulating strategies would be obtained, in which four basic strategies are put forward. The TOWS matrix makes it possible for decision makers to analyze the situation of organization and to develop tactics, strategies and effective measures that can fulfil organizational objectives and the mission.

The four kinds of strategies under TOWS analysis as summarized below.

1. SO (maxi-maxi) strategy: take advantage of internal strengths to maximize external opportunities

2. ST (maxi-mini) strategy: take advantage of internal strengths to minimize (overcome or avoid) external threats

3. WO (mini-maxi) strategy: minimize internal weaknesses by taking the advantages of external opportunities

4. WT (mini-mini) strategy: minimize internal weaknesses as well as external threats

The major advantage of this technique is the influence of prioritized internal and external factors embedded in alternative strategies. The primary disadvantage of the TOWS matrix is that certain combinations are not considered such as SW or OT (Ravanavar, & Charantimath, 2012).

As an important strategic management planning tool, TOWS analysis has been employed in plenty of studies with purpose of developing strategies and gaining competiveness of organizations. For example, Ravanavar, & Charantimath (2012) used TOWS analysis to formulate 12 alternative strategies with looking to the immediate concern for sustainability of rural engineering college. Alaaraj, & Hassan (2014) proposed strategies for the successful implementation of e-government in Lebanon through TOWS matrix. TOWS analysis has been successful applied in SCM field, such as establish logistics development strategies in the medium or small cities (Zi, Guo, &

Chen, 2012), make airport logistics development strategy and to identify environmental strategic options for green supply chain in pulp and paper industry (Anker, & Sorgard, 2012) etc.

Whereas, the same as SWOT analysis, there are also some limitations with it. One of important limitations is that TOWS doesn't analytically determine and assess the importance of the factors or variables in TOWS matrix. Therefore, some researchers modified TOWS analysis by incorporating it with quantified analytical method analysis to eliminate this deficiency. Pholpuntin et al. (2014) presents a method of incorporating quantitative and qualitative analysis on the basis TOWS model to match the business's internal strength/weakness with the external opportunity/threat towards Thai food businesses in Lao PDR and Cambodia. With the market analysis based on TOWS matrix, marketing implications for promoting Thai food businesses into markets are gained in their work.

CHAPTER III

RESEARCH MATHODOLOGY

This chapter presents the research procedure of this research. It starts with a general methodology framework of this study, after that the details on each step are described in order.

The overall research procedure of this research encompasses 7 steps. Firstly, relevant literature are reviewed broadly to identify primary barriers for implementing CCM. Secondly, the primary barriers are validated through expert's opinions. Thirdly, initial degree of influence are determine based on opinions of selected experts. After that, the proposed fuzzy DEMATEL model is applied to identify inter-relationship among the barriers. Then a cause-effect diagram is constructed on the basis of outcome of model, followed by developing strategy to overcome the critical barriers with the aid of SIPOC model, SWOT analysis and TOWS analysis tools. Finally, discussion and conclusion of this research are presented. The methodology framework of this research is depicted in figure 8.

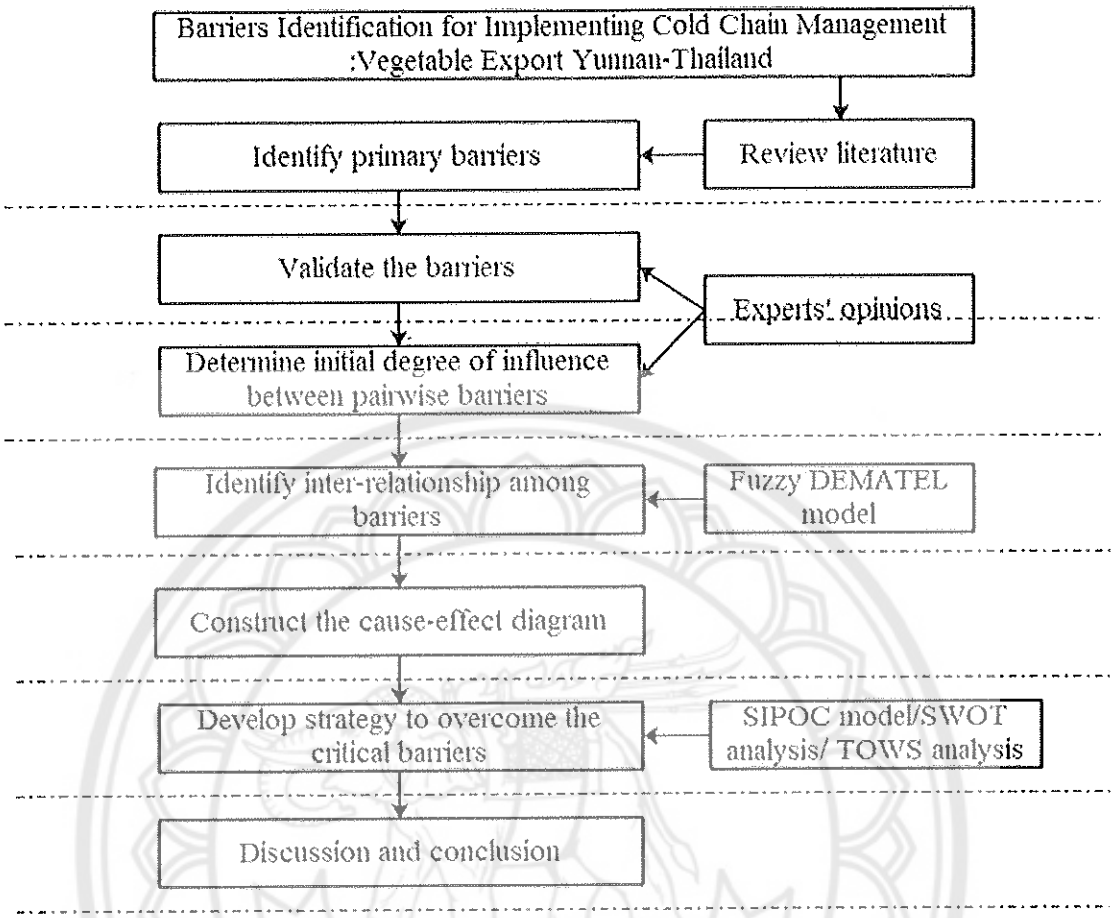

Figure 8 The Proposed Methodology Framework of the Study

Review the Literature

Firstly, a systematic literature review is conducted for the purposes of collecting and identifying primary barriers for implementing CCM within the relevant research areas. A series of searches is carried out on electronics academic databases in order to broadly search papers, and so on. The following selection inclusion criteria are used to choose articles in analysis: (a) The articles contain specific keywords "Cold Chain Management" "Cold Chain" "Challenge in cold chain" "Challenge" "Barrier to implement Cold Chain Management" and "Barriers of cold chain logistics" or articles' title includes one of these compound terms. (b) The literature search is limited to sources published in the last 10 years. (c) The articles in references sections of the previously retrieved articles. During the review, more priorities are given to recent articles than older articles. The step of systematically reviewing literature is important for it shows

how this research is connected with the existing knowledge, it is a form of secondary study as well.

Validate the Barriers

After exploring the primary obtained from the first step, the second step is about to validate the primary barriers based on opinions of experienced managers who come from Yunnan export vegetable companies in Simummuang market, Thailand. The author chooses to collect data in here because Simummuang market is the largest fresh vegetable wholesale market in Thailand and a majority of large-scale Yunnan vegetable export companies are gather in here. Data derived from here are representative. What's more, it is available for author to launch the investigation. The chosen participants all are managers who have rich working experiences. The data collection in this phase are derived through a semi-open survey questionnaire and interview (seen in appendix section). They are asked to choose or add any barrier relevant to implementation of CCM in the industrial context. The survey questionnaire is organized, in which all of the barriers in extensive literature that the author have reviewed are listed. The primary barriers which are firmly believed by more than 50% of survey respondents would be validated as the barriers for implementing CCM on exported vegetable from Yunnan to Thailand.

Determine Initial Degree of Influence between Pairwise Barriers

In the third step, industrial and academic experts in the field of CCM are asked to conduct pairwise comparison between barriers which have been validated in last step. To obtain experts' assessments on initial degree of influence between pairwise barriers, a structured survey questionnaire is designed and distributed. There is a m*m matrix structure (m refers to the number of barriers) along with 5 scales of linguistic terms contained this structured survey questionnaire. The 5 scales of linguistic terms used are :no influence, very low influence, low influence, high influence and very high influence, respectively (seen in appendix section). The result of the questionnaire would input the proposed model. The selected experts all have rich work experiences or research experiences.

Identify Inter-relationships among the Barriers

In this step, the proposed fuzzy DEMATEL model is used to analyze the collected data to identify the inter-relationship among the barriers. Firstly, the matrixes obtained from last step are converted into TFNs set, and then defuzzify TFNs into the crisp scores and get integrated scores through CFCS. When get the integrated scores, the initial direct-relation matrix is imported to DEMATEL model formula. In the process of calculation, MATLAB (Matrix Laboratory) software is explored to calculate the related matrix. A total relation matrix is acquired from output of model, from which shows strength of total influences a barrier has on other barriers and total influences receive from other barriers.

Construct Cause-effect Diagram

To visually depict the characteristics of barriers, a cause-effect diagram is constructed in this step. Base on the total relation matrix got in last step, calculate the relation score "S" and prominence score "R". A cause-effect diagram can be constructed by mapping the dataset of (R+S, R-S) with Microsoft Excel tool. From the constructed cause-effect diagram, the barriers in cause group and effect group can be identified. The barriers that in the cause group and get the high relation score are identified as the most influential barriers and critical barriers in the system.

Develop Strategy to Overcome the Critical Barriers

When it comes to final objective of this research, the strategies for overcoming the critical barriers are developed by applying SWOT analysis and TOWS analysis tool. Before that, a SIPOC flowchart is mapped to show the whole vegetable export process from Yunnan to Thailand and serve as the basic of generating strategies. SIPOC model is a visual tool for documenting a process, which helps to clearly show present vegetable export process and analyze the main activities that are influenced by critical barriers. SWOT analysis would be utilized to analyze the current strengths, weaknesses, opportunities and threats of elimination of critical barriers and TOWS analysis would be applied to assist formulating the strategies. SWOT analysis and TOWS analysis are deemed as useful tools to formulate strategy in strategic planning.

Conclusion

In this step, a conclusion regarding on the whole research is also given in this section. Finally, the future research directions of this thesis is mentioned in this section as well, which are obtained from the limitations about this study.

CHAPTER IV

BARRIERS FOR IMPLEMENTING CCM AND DISCUSSION

This chapter focuses on presenting the findings from analysis of collected data and the findings from the application of the proposed model in this study. According chapter 3, there are 7 steps in research procedure and these findings are presented in order. The discussion on the findings is conducted in the final section of this chapter.

Primary Barriers

In this step, a systematic literature review is conducted and there are 17 variables are identified as primary barriers to implement CCM from relevant 61 papers. Firstly, use the key words "barrier for implementing CCM", "cold chain challenges and issues" "Cold Chain Management" "cold chain" "challenge in cold chain" "barrier to implement Cold Chain Management" and "barriers of cold chain logistics" to search papers in authoritative databases. The databases used include : Scopus, Science Direct, IEEE, Emerald Insight, Google Scholar and so on. Relevant 88 papers were found in this step. Secondly, to search the targeted articles more roundly, the author has searched the articles in references sections of literature mentioned in last step, 6 papers were found from this channel. Thirdly, select the papers that were produced in 2007-2017 years only. After reviewing, it was found that totally there are 61 articles that are conform to criteria above, from which 17 primary barriers were identified. All the primary barriers were mentioned as the barriers, obstacles, difficulties, challenges, blocks or bottlenecks that hinder the execution of CCM by researchers or scholars in the published literature. The selected 17 primary barriers and number of papers mentioning these barriers are shown in table 4.

Table 4 Primary Barriers for Implementing CCM in Literature Review

	Barriers	Number of papers
1	Lack of trained personnel	7
2	Lack of coordination between stakeholders	6
3	High capital cost and operating cost	10
4	Lack of quality and safety measures	2
5	Lack of top level commitment	5
6	Lack of IT implementation	6
7	Lack of industry standards of implementation of CCM	7
8	Manager's limited awareness on CCM	4
9	Unawareness of customers	2
10	Lack of government support	6
11	Poor CC infrastructure	16
12	Lack of integrated planning	2
13	Shortage of power to run	2
14	Disbelief about benefits of CCM	1
15	Lack of reliable CC 3PLs	8
16	Lack of capacity in maintenance of CC facilities	4
17	Lack of awareness about the use of IT	3

Validated the Barriers

Totally, 15 survey questionnaires are finished by managers from 13 different Yunnan vegetable export companies and 2 academic experts. The characteristics of the 15 respondents are shown in table. Survey result shows that 10 variables are validated as the barriers for implementing CCM on exported vegetable from Yunnan to Thailand by more than 50% of respondents. These 10 barriers are "lack of trained personnel", "high capital cost and operating cost", "lack of top level commitment", "lack of IT implementation", "lack of industry standards of implementation of CCM ", "lack of coordination between stakeholder", "unawareness of customers", "lack of government support ", "poor cold chain infrastructure" and "lack of capacity in maintenance of cold

chain facilities". The overview of the survey result is displayed in table 5. Next, details of survey results on the 10 selected barriers are to be given .

Table 5 Characteristics of Study Sample

Respondents	N	Characteristics (working experiences)	n	%
Industrial experts	13	>5 years	9	60%
		<5 years	4	26%
Academic experts	2	>20 years	1	7%
		>5 years	1	7%

Table 6 Validation Result Based upon 15 Respondents' Opinion

	Barriers	Respondents	%
1	Lack of trained personnel	10	67%
2	High capital cost and operating cost	13	87%
3	Lack of top level commitment	9	60%
4	Lack of IT implementation	10	67%
5	Lack of industry standards of implementation of CCM	10	67%
6	Lack of coordination between stakeholder	11	73%
7	Unawareness of customers	8	53%
8	Lack of government support	11	73%
9	Poor cold chain infrastructure	12	80%
10	Lack of capacity in maintenance of CC facilities	9	60%

1. There are 10 (67%) respondents regarded "lack of trained personnel" as the challenge for the company in terms of executing CCM. Trained personnel or called skilled human resources are someone who operate or guide the cold chain. In CCM, a key component is the personnel who operate and guide the cold chain with their capabilities, behavior, expertise and culture level. The trained personnel should have an understanding on the importance of CC, a knowledge of specific to vegetable storage

and handling practices, know how to operate the related system and facilities, have the ability to respond to breaks in the cold chain etc.

2. There are 13 respondents which occupy 87% of total survey sample considered "high capital cost and operating cost" is the barriers for the company to implement CCM. The cost of a reliable cold chain would be economically sustainable only when production reaches a threshold in terms of volume and quality of products FAO, & IIR (2012). Usually, high capital cost and operating cost is a huge pressure for the enterprises. The high cost comes from : high energy cost, high cost of land for cold storage yard, high cost for purchasing CC equipment.

3. There are also 9 respondents considered "lack of top level commitment" is the barrier for the company to executive the CCM. "Top level management commitment" in here means enthusiastic participation, attitude to change, initiative, priority in terms of implementing CCM of highest-level executive in company. "lack of top level commitment" means top level management resist towards implementation of CCM practices. Commitment from the top is always in the list of critical success factor or the key barrier in the management field from extensive literature review.

4. There are 10 respondents considered the current status "lack of IT implementation" of company is also the barrier to implement CCM. Modern information technology systems applied in context of agricultural produce cold chain include temperature monitoring system, warehouse management system (WMS), transportation management system (TMS), radio frequency identification technology (RFID) and traceability system, etc. The application of information technology can contribute to realizing information traceability and monitoring dynamic status about the products, enhancing the performance of cold chain.

5. There are 10 respondents thought the current status "lack of industry standards of implementation of CCM " is the obstacle for the organization to implement CCM. "Standard" is defined as a level of quality, a moral rule that should be obeyed. The term "standard" in here means the regulation controlling the process to make all the exported vegetable in a level of quality, which cover processing, logistics, temperature, packing. For example, packaging materials specifications, quality inspection standard. In addition the appropriate and applied regulations, backed up by technical standards such as cold chain logistics operation best operating standards. The well-know

international standard such as GAP (good agricultural practice), GMP (good manufacturing practices), and ISO (international organization for standardization). Apart from above standards, HACCP (hazard analysis and critical control points) is used as accreditation system. The normative cold chain standard is the guarantee to develop cold chain in agricultural produce export industry. Lack of industry standards of implementation of CCM or necessary supervision makes there is not the standard and regulation for the company to executive, which leads to company according to their own operation standard, rely on company's self-discipline or experience to maintain the quality of the product.

6. There are 11 respondents which accounts for 73% of total survey sample considered "lack of coordination between stakeholder" as the obstacle for the company to implement CCM. Coordination means the act of making stakeholders involved including the farmers, collector, exporter and importer in terms quality control or temperature control activity or others' activity. Coordination is required after vegetable harvest in farm until they reach consumers.

7. There are 8 respondents thought the "unawareness of customers" is the major barrier for the company to carry out the CCM as well, which hold 62% of total respondents. Unawareness of customers refers to customers don't know about CCM vegetable or its benefits. Customer's awareness means if customer demands cold chain products and the company has to change technology and organization for innovative CCM products. The respondents indicated that Thailand markets is more tend to choose pay for the low cost vegetable rather pay fees for quality vegetable. This kind of low consumption habit makes companies refuse to conduct a high initiative investment pattern.

8. The survey result shows that there are 11 respondents recognized that "lack of government support " is a significant inhibitor for the company to implement CCM as well. Government support or called initiative system in this context means a set of official plans, policies to encourage, attract the company to carry out CCM. Experiences of other countries suggest that government initiative system or program to promote cold chain usage play a significant role in its successful implementation. The support mainly covers in provision of funding opportunities, training, effective taxation policy, import duty, education, legislation and capacity building, etc (FAO, 2015). "Lack of

government support " refers to government doesn't make industry friendly policies towards CCM and doesn't give special benefits to those organizations implementing CCM. When there are not enough support from government, there is no possibility and reason for company to engage in CCM practices after all CCM requires input high capital, technology and manpower.

9. There are 12 respondents which makes up a high proportion of total respondents (80%) deemed the present "poor cold chain infrastructure" has hinder company to carry out CCM. The chief reason is the available CC facilities including refrigerated truck, cold storage, warehouse can't meet the efficient cold chain demand to make the vegetable achieve the stable low temperature especially in season of sales. Cold chain infrastructure is the important supporter for vegetable in the link of storage and distribute.

10. There are 9 respondents deemed "lack of capacity in maintenance of CC facilities" also has limited the establishment of cold chain system in company. Some cold chain equipment including the cold storage, that were built many years ago are currently "out-of-order" or not functioning properly because of lack of capacity and management in maintenance.

Other 7 primary barriers "lack of quality and safety measures", "manager's limited awareness on CCM", "lack of integrated planning", "shortage of power to run", "disbelief about benefits of CCM", "lack of reliable third-party logistics" and "lack of awareness about the use of IT "are chosen only by a small number of respondents, which account less than 50% of total sample. Hence, these 7 primary barriers are not identified as the barriers to implement CCM in this study.

Critical Barriers

Determine initial degree of influence between pairwise barriers. Email questionnaire was used as major tool to collect data from experts. A 10*10 pairwise comparison matrix was produced and contained in the questionnaire. Finally, the survey questionnaire were received from 7 respondents, from which opinions regarding the initial degree of influence between pairwise barriers were obtained (seen in appendix). The 7 respondents are made up by 5 industrial and 2 academic experts.

Identify Inter-relationships among the Barriers. In this step, fuzzy DEMATEL model is applied to identify inter-relationship among the barriers, which is made up by 5 phases as described below:

Phase 1: Convert the linguistic terms into corresponding TFNs. According to experts' assessment, the linguistic terms were converted into corresponding TFNs data sets provided in table 7.

Table 7 Linguistic Terms and TFNs Used in Present Study

Linguistic terms	Corresponding TFNs
No influence(No)	(0, 0, 0.25)
Very Low influence(VL)	(0, 0.25, 0.5)
Low influence(L)	(0.25, 0.5, 0.75)
High influence(H)	(0.5, 0.75, 1.0)
Very High influence(VH)	(0.75, 1.0, 1.0)

Phase 2: Defuzzify TFNs into the crisp score and get integrated scores. Formulas (8)-(14) were used to defuzzify the fuzzy linguistic value and get crisp score. After that, formula (15) was used to average the crisp scores of 7 experts' assessment. The initial direct-relation matrix was acquired in this phase as shown in table 8.

Table 8 The Initial Direct-Relation Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.000	0.399	0.467	0.431	0.599	0.433	0.131	0.199	0.334	0.367
B2	0.133	0.000	0.566	0.334	0.366	0.533	0.466	0.366	0.634	0.300
B3	0.734	0.267	0.000	0.363	0.467	0.336	0.131	0.367	0.401	0.234
B4	0.233	0.369	0.434	0.000	0.434	0.367	0.233	0.334	0.369	0.233
B5	0.467	0.297	0.367	0.400	0.000	0.657	0.199	0.267	0.466	0.366
B6	0.099	0.366	0.336	0.199	0.266	0.000	0.269	0.233	0.269	0.199
B7	0.267	0.064	0.500	0.401	0.300	0.267	0.000	0.303	0.434	0.201
B8	0.500	0.334	0.533	0.300	0.533	0.233	0.099	0.000	0.699	0.267
B9	0.301	0.334	0.531	0.433	0.500	0.299	0.366	0.466	0.000	0.303
B10	0.269	0.133	0.401	0.233	0.300	0.167	0.234	0.133	0.369	0.000

Phase 3: Normalize initial direct-relation matrix. The normalized initial direct-relation matrix was produced through formulas (3) and (4).

1. Calculate the sum of rows and sum of columns in initial direct-relation matrix.

2. Select the maximum sum between sum of rows and sum of columns.

3. Use each score in initial direct-relation matrix to divide the maximum sum.

It was found that the maximum sum is 4.14. Then use each score in initial direct-relation matrix to divide 4.14, from which got the normalized matrix as presented in table 9.

Table 9 The Normalized Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.000	0.096	0.113	0.104	0.145	0.105	0.032	0.048	0.081	0.089
B2	0.032	0.000	0.137	0.081	0.088	0.129	0.112	0.088	0.153	0.072
B3	0.177	0.065	0.000	0.088	0.113	0.081	0.032	0.089	0.097	0.057
B4	0.056	0.089	0.105	0.000	0.105	0.089	0.056	0.081	0.089	0.056
B5	0.113	0.072	0.089	0.097	0.000	0.159	0.048	0.065	0.112	0.088
B6	0.024	0.088	0.081	0.048	0.064	0.000	0.065	0.056	0.065	0.048
B7	0.065	0.016	0.121	0.097	0.072	0.065	0.000	0.073	0.105	0.049
B8	0.121	0.081	0.129	0.072	0.129	0.056	0.024	0.000	0.169	0.065
B9	0.073	0.081	0.128	0.105	0.121	0.072	0.088	0.112	0.000	0.073
B10	0.065	0.032	0.097	0.056	0.072	0.040	0.057	0.032	0.089	0.000

Phase 4: Use Calculate the total relation matrix. The total relation matrix T is achieved from the formula (5):

$$T = D(I - D)^{-1}$$

Remark: D: normalized matrix I: Identity matrix T: Total relation matrix.

MATLAB software was explored to compute total relation matrix. The procedure of computing as follows:

1. Import the normalized matrix (D)into MATLAB. Start with inputting "[" command and then in turn input the first row score in normalized matrix D(0.000 0.096 0.113 0.104 0.145 0.105 0.032 0.048 0.081 0.089). Use the space key to separate the scores in the same row. After that using ";" to acts as separator between the first row score and second row score, then input the second row score (0.032 0.000 0.137 0.081 0.088 0.129 0.112 0.088 0.153 0.072)in the same way. Take this as the example until all the scores in normalized matrix are input in the MATLAB. Finally, input "]" command, a completed matrix is constructed.

2. Produce a 10*10 identity matrix I. Command :I=eye(10). According to the MATLAB' operation rule, the command of constructing a identity matrix is to input the "eye(n)", from which we can obtain a n*n identity matrix. Now there is a 10*10

normalized matrix and it needs to produce a 10*10 identity matrix correspondingly to finish the computation, so the "n" in here is 10.

3. Command: T=D*inv (I-D). Input "T", "=", "D", "*" and "inv (I-D)" orderly. According to MATLAB's operation rule, the $(I - D)^{-1}$ can be achieved by inputting the "inv (I-D)" command. The outcome of computing total relation matrix T is shown in table 10.

Table 10 Total Relation Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.259	0.311	0.431	0.352	0.439	0.377	0.212	0.273	0.391	0.292
B2	0.315	0.240	0.482	0.356	0.417	0.414	0.298	0.331	0.480	0.292
B3	0.417	0.288	0.331	0.341	0.418	0.356	0.209	0.308	0.405	0.267
B4	0.290	0.285	0.396	0.235	0.378	0.336	0.216	0.283	0.372	0.244
B5	0.362	0.296	0.417	0.350	0.316	0.423	0.229	0.291	0.420	0.294
B6	0.203	0.232	0.303	0.223	0.272	0.191	0.186	0.211	0.281	0.189
B7	0.282	0.203	0.383	0.305	0.328	0.290	0.146	0.259	0.357	0.220
B8	0.392	0.316	0.470	0.347	0.453	0.353	0.216	0.246	0.489	0.288
B9	0.346	0.309	0.464	0.369	0.438	0.361	0.268	0.342	0.337	0.289
B10	0.242	0.184	0.315	0.232	0.281	0.229	0.176	0.189	0.297	0.144

The each score in total relation matrix means the effect that barrier n (n=1 ,2, 3, 4...10) in the left-hand columns gives to other barrier that in the right-hand. For example, 0.311 means effect that barrier B1 gives to barrier B2, meanwhile, it also means that the degree of barrier B2 that receives from barrier B1 is 0.311.

Use formulas (6)-(7) to calculate the prominence and relation. The sum of rows and the sum of columns in total relation matrix are denoted as vector R and vector S. The result that R plus S is denoted as prominence score, and the result that R minus S is denoted as relation score, as presented in table 11.

Table 11 The Prominence and Relation

	R	S	R+S(prominence)	Rank	R-S(Relation)	Rank
B1	3.336	3.108	6.444	4	0.288	4
B2	3.625	2.663	6.288	6	0.962	1
B3	3.340	3.993	7.333	2	-0.652	9
B4	3.033	3.110	6.143	7	-0.077	5
B5	3.398	3.737	7.135	3	-0.339	8
B6	2.291	3.330	5.621	8	-1.039	10
B7	2.773	2.156	4.928	9	0.617	3
B8	3.570	2.731	6.301	5	0.839	2
B9	3.523	3.830	7.353	1	-0.307	7
B10	2.289	2.519	4.808	10	-0.230	6

The "prominence" score indicates the degree of importance for a barrier in the entire system or degree of central role that the barrier plays in the problematique, and "relation" represents the net effect of a barrier contributes to the system.

Phase 5:Construct cause-effect diagram. A cause-effect diagram can be constructed by mapping the dataset of (R+S, R-S) as presented in figure 9.

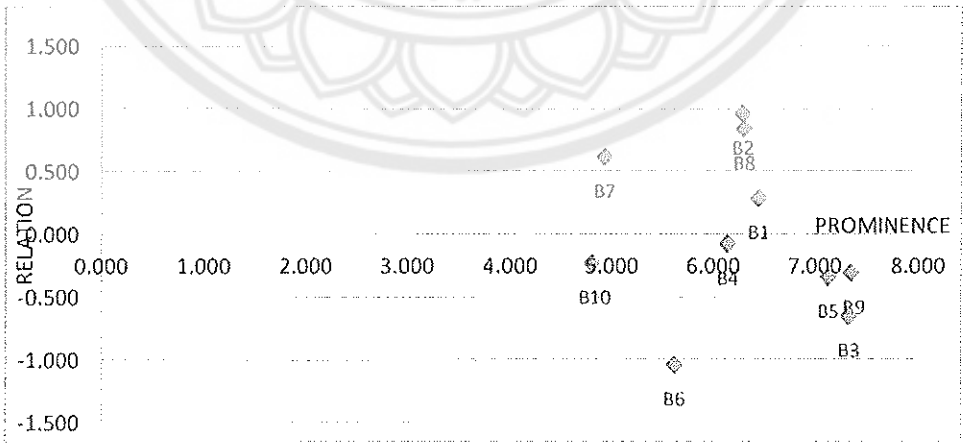

Figure 9 Cause-effect Diagram

This figure 9 provides a clearer visualization of the interrelationships among the 10 barriers. The cause-effect diagram reveals that six barriers, namely, B3, B4, B5, B6, B9 and B10 are categorized into effect group. These barriers tend to be easily influenced by other barriers as their (R-S) scores are negative, which indicates the influential impact (R) of these barriers are lower than their influenced impact (S). In addition, figure 9 indicates that B1, B2, B7, B8 are categorized into cause group. For sure, barriers in cause group have more influential impact (R) than influenced impact (S), which tend to influence other barriers in system.

Generally, cause factors have net impact on the whole system, variation in them can change system performance greatly. When deciding the critical barriers we should give more attention on them. From the cause-effect diagram depicted in figure 9, it exhibits B2 is the most influential barriers as in ranking of relation (net effect) score as it got the highest score (0.962). Hence, B2 can be taken into consideration as the critical barrier.

Likewise, barrier B8 possesses relation score (R-S) is as high as 0.839 (seen in table 11), which ranks second place among the cause group. Consequently, B8 can be selected as the critical barriers.

B7 falls in cause group and have a relatively relation score, but its prominence score is very low, ranking 9th in terms of prominence score. As above mentioned, prominence score presents the degree of central role that the barrier plays in the problematique. Thus, when deciding the critical barriers, it should also give fully consideration on their prominence score. Hence, B7 can't be defined as the critical barriers.

Different with B7, B1 has a prominence score is at the fourth rank with 6.444 and its R score and S score which are 3.336 and 3.108, respectively are both very high among other barriers. In addition, it falls in cause group, and its relation score in the fourth. So it should be considered as a relatively influential barrier and critical barriers. B9 and B3 rank the first and second in the prominence ranking, but their influential impacts are negative and they are defined as effect barriers. Therefore, B9 and B3 are not considered as the critical barriers.

Simply put, the result of this research suggests that "high capital cost and operating cost" (B2), "lack of government support " (B8) and "lack of trained personnel"

(B1) are the most critical barriers for the implementation of CCM on exported vegetable from Yunnan to Thailand, implying that managers needs to address these barriers more carefully.

Discussion

In regards to the result acquired from data analysis above, the following discussion is presented. The vegetable export trade between Yunnan and Thailand is growing rapidly and has great potential to expand . There are still some gaps like the post-harvest loss issue affect the performance of Yunnan vegetable export industry. The reduction of post-harvest loss is essential for the industry. Although CCM is an efficient strategy for achieving reduction of post-harvest loss of vegetable, it is quite challenging to implement CCM both executive and managerial levels. The implementation of CCM is found to be not a simple process and it still needs much analysis. To formulate strategies for implementing CCM, it is essential for the companies or policy makers of government to understand inter-relationships among barriers and the characteristics of the barriers themselves that hinder the implementation of CCM (Joshi et al., 2009). "high capital cost and operating cost", "lack of government support" and "lack of trained personnel" have been identified as the critical barriers to implement CCM on exported vegetable from Yunnan to Thailand in last section .

This result was compatible with research result of Bag (2016) where ''lack of government support system'' was recognized as the barriers with the high influence and strong driver power to implement CCM (Bag, 2016; Shi, 2016; Wang, & Hu, 2016). This finding indicates that the government's policy and regulatory support plays a vital role in adopting CCM for companies. This study also confirms to the research of Joshi et al. (2009) which observed that barrier "high capital cost and operating cost" was the biggest bottleneck for efficient CCM.

With regards to the barrier "lack of trained personnel", it has been identified as the obstacle to hinder the development of cold chain in the some studies such as in study of Shashi and study of Dong & Han (Shashi, 2016; Dong, & Han, 2017). However, its significant characteristic in problematique wasn't be explored in depth from the perspective of quantitative analysis in previous literature. It is worth noting that this barrier is observed as one of critical obstacle to implement CCM in this study. This

finding has stress the role of human resource in implementing cold chain, implying that it would need to give the priority.

CHAPTER V

STRATEGIES FOR OVERCOMING CRITICAL BARRIERS

The critical barriers to implement CCM on exported vegetable from Yunnan to Thailand have been identified in the last chapter. This chapter aims at formulating strategies to overcome the critical barriers through SWOT analysis and TOWS analysis. Before formulating the strategies, SIPOC diagram is applied to show the process for exporting vegetable from Yunnan to Thailand and then the main activities affected by the identified critical barriers are presented.

Introduction

As the final objective all previous analysis lead to strategy analysis how to overcome barriers for implementing CCM. Once the critical barriers are identified, it is essential for managers or stakeholders to seek strategies for overcoming them to drive the CCM can be successfully implement. At the same time, many existing literature cites that cold chain is often presented a needed solution to reduce spoiled or damage in vegetable export between Yunnan and Thailand but there is little research focus on discussing method to implement them concretely. This research attempts to contribute in this regard based on the findings from previous chapter. The different suggestions to ensure successful implementation of CCM in previous would be used as guideline in this study.

The Pareto principle or "80/20 Rule" points out that 80% of problems usually stem from 20% of the cause which indicates the most critical factors should receive the most attention in this context, based on an efficient use of resources. Therefore, priority and focus should be given to the critical barriers. So, the strategic solutions proposed in this section is about to focus on the 3 identified barriers : lack of government support, high capital cost and operating cost, lack of trained personnel.

Before formulating strategies, it is necessary to clearly know what to measure and the process of the problem so that enable to identify the key points in process and complete collection of reliable data. Mapping the process can show how things really are and it can generate quick wins to drive the change, which is also often served as the

basics of data collection in quality improvement management. Accordingly, in this section, SIPOC diagram is applied to show the current process of vegetable trade exported from Yunnan to Thailand first. Followed by presenting the main activities affected by the identified 3 critical barriers. After that SWOT analysis is conducted to analyze the current position of Yunnan vegetable export industry. Base on the TOWS matrix, the strategies for overcoming the identified critical barriers are proposed.

1. Process of Exporting Vegetable from Yunnan to Thailand

During September 2016, the author have ever made a visit to the vegetable export companies in Yunnan and conducted a primary interview with the CEO and managers in order to make a understand of current status and process handling process for exporting vegetable from Yunnan to Thailand. To show the export process more fully, author have also reviewed the latest relevant reports, papers, news etc. A SIPOC flowchart is mapped to show the whole vegetable export process, which begins with collection of vegetable and end with completion of transaction in Thai wholesalers market. The SIPOC map focus on the suppliers, inputs, process, outputs, and customers, as shown in figure 10.

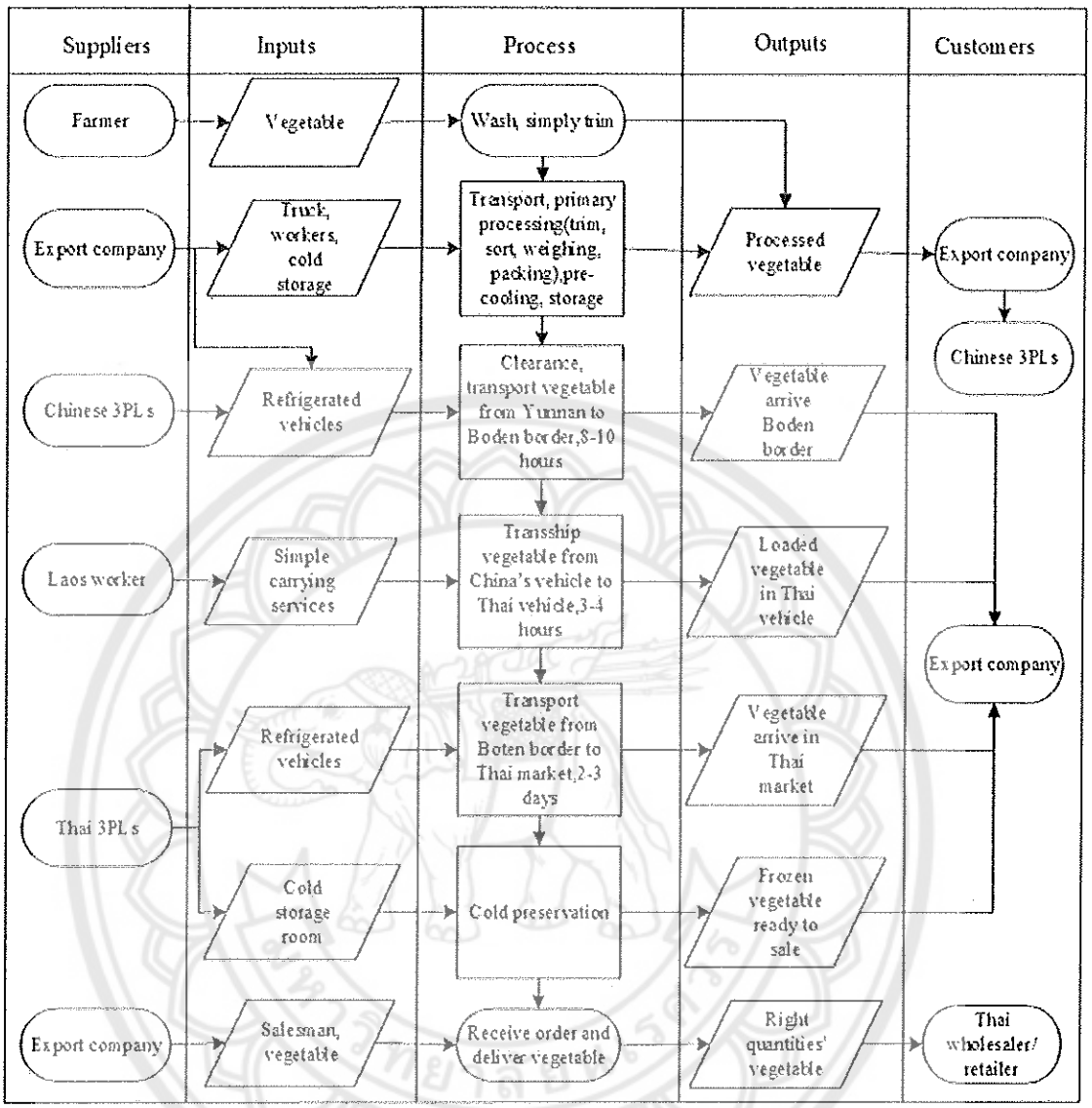

Figure 10 Process of Exporting Vegetable from Yunnan to Thailand SIPOC Diagram

The whole export procedure contains 6 major processes, which begin with company purchases the vegetable. Once procurement department of the company decides to purchase the farmer's vegetable, the company would send the truck to the production zone field where the vegetable grow to collect vegetable. During the collection, the farmers would conduct simply trim with vegetable. Another case is that farmers transport the trimmed and washed vegetable to local wholesale vegetable market and then the export company would finish transaction with farmers in here.

After company transporting the vegetable to the company, the workers of company conduct the primary processing with vegetable in the area where is close to the cold storage before conducting pre-cooling process. The primary processing includes: trim, sort, grade ,weighing, and packing. After finishing the primary process, the vegetable would be delivered into cold storage to conduct pre-cooling process in quantity. Most often, during this process, different kinds of vegetables are handle in a big single commodity storage. In order to prevent injure or damage by freezing, quilt is often the good tool for keeping warm. Vegetable would be kept in cold storage after finishing the primary processing.

When export date arrives, vegetable leave the cold storage and are transported to Boten (China-Laos border) by using refrigerated trucks. The logistics services and clearance in this process are provided by China's 3PLs, and there is a few companies using self-run logistics as well. It takes 8-10 hours from cold storage to Boten border.

When the refrigerated trucks arrive the Boten border (China-Laos), vegetable are transshipped to refrigerated trucks of Thai 3PLs by Laos worker with simple facilities, which takes around 3-4 hours. Few modern facilities are used in the transshipment process.

Thai 3PLs is the carrier who transports the vegetable from Laos-Thai border enter into Thai market. R3A high way is used as main land route. It totally takes 2-3 days from Boten to Thai market. Thai 3PLs offer the clearance service to the customer.

Once vegetable have arrived Thai local wholesale market, part of vegetables would be sale direct to Thai wholesalers or Thai retailers. As regards vegetable remained unsold, they would be kept in Thai 3PL's local cold storage room where near the wholesale market.

When export company receives a purchasing order from Thai wholesalers or retailers, right quantities' vegetable would be delivered to buyers. The whole export process is finished in this time.

2. Main Activities Affected by Critical Barriers in Export Process

The current process of exporting vegetable from Yunnan to Thailand is gained in the part of 1. This part aims to present the main activities that affected by the 3 identified critical barriers along the process as listed in table 12.

Table 12 Main Activities Affected By The Critical Barriers In the Process

Barriers	Activities affected by the critical barriers
High capital cost and operating cost	1.Introduction of capital-intensive equipment in transporting and primary processing process. 2.Consuming energy in the process of transport, primary processing and storage.
Lack of government support	1.Introduction of capital-intensive CC equipment . 2.Address land-use problem for enterprise. 3.Cultivation of CC trained personnel.
Lack of trained personnel	1.Operating CC practice. 2.Managing CC.

2.1 Barrier "high capital cost and operating cost"

2.1.1 "High capital cost and operating cost" in introduction of capital-intensive equipment in the processes of transport and primary processing. Current transportation pattern handled with vegetable still can't meet the requirement of cold chain execution. Strictly, vegetable harvested should be rapidly moved to refrigerated room by refrigerated truck to pre-cooling instead of using ordinary truck. Besides, current a series of primary process done with vegetable such as trim, sort, grade, weighing, and packing are handled in a open air environment without temperature control, which would cause vegetable miss optimum period for removing field heat, as well as cause a loss in shelf-life of vegetable. However, there are few high-level, scaled, intensive constant temperature workshop equipped with cold chain equipment in Yunnan. In some area, there is only one this type of processing workshop in the whole city (Xing, 2017). Base on above, more refrigerated trucks and constant temperature workshop should be available. For SMEs, the lower margins have limited their abilities

to increase investment. Refrigerated trucks not only require a higher expenditure (higher 60% than ordinary truck) but also consume more energy than ordinary trucks during transport, which makes many enterprises unwilling to use them for low-value agricultural products like the vegetable. Likewise, the cost for building such constant temperature workshop is higher 60%-80% than the general workshop. What's more, the operating cost and maintenance cost are also large expenditure. All of these have affected the enthusiasm of investing of enterprise to a large extent.

2.1.2 "High operating cost" in consuming energy in the process of transporting, primary processing, and storage. On the one hand, energy is the major cost in the operating cost. In transport link, the energy expense of using refrigerated truck is higher 30% than ordinary truck. Operating cost of running a cold storage or a constant temperature workshop include: cost of energy, cost of labor, cost of management and financial cost. Among these costs, cost of energy is the major cost of operating cost, which makes up around 45%-50% of total daily cost of operating as shows in figure 11, compared to 10 % in the West. On the other hand, the existing refrigeration facilities and equipment are generally outdated, which have increase the operation cost indirectly as they cost more electricity energy (Liu, & Li, 2015). These factors make the business of operating cold chain one of high entry barrier.

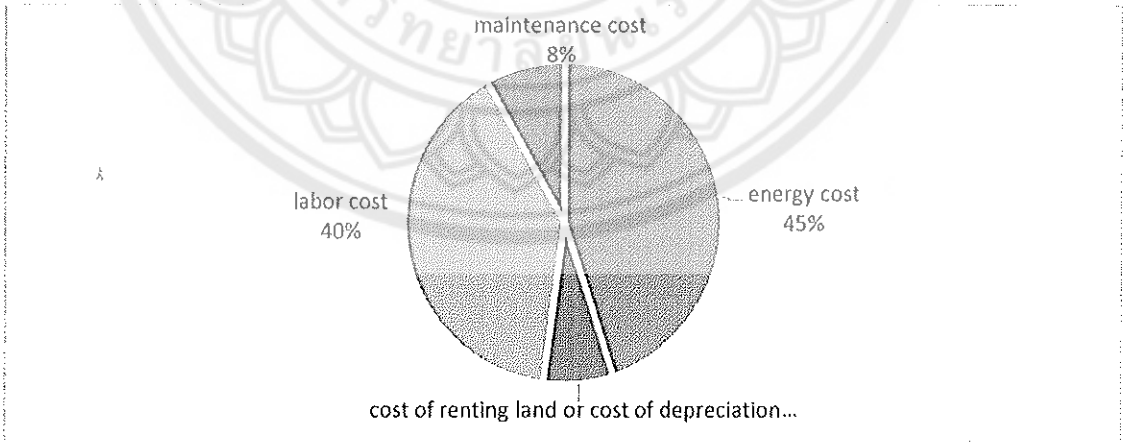

Figure 11 Proportion of Total Daily Operating Cost of Cold Storage

Source: China Logistics Industry Investment Promotion Report, 2015-2016

2.2 Barrier "lack of government support"

2.2.1 "Lack of government support" in introduction of capital-intensive CC equipment in process of transporting and primary processing process. The introductions of CC equipment like constant temperature workshop or refrigerated truck are so expensive and slow to ramp up. The existing supporting policies are mainly focusing on increasing credit support and reducing taxes and fees in some links. Compared with of countries who have succeeded in driving the popularization of CCM on agricultural produce, the support in introduction of capital-intensive CC equipment from Yunnan government is limited.

2.2.2 "Lack of government support" in address problem of land-use. Most of the cold storages used are single-function and they can't provide multiple temperature for the different vegetables. Some large-scale companies in Yunnan are still running low in cold storage capacity especially for large orders. Even though some companies have a plan to establish the own new-style high-tech cold storage, there is not the suitable land for the implementation of the plan due to the tense land resources (Liu, 2017). Though some preferential land polices have been formulated by government, some respondents desire they can get more support from government in the utility of the land.

2.2.3 "Lack of government support" in cultivating trained personnel. Cold chain talent especially vegetable cold chain trained personnel is shortage in Yunnan area. Up to now, there are only one university opening cold chain major in entire Yunnan province. More talent cultivation policies are needed from government.

2.3 Barriers "lack of trained personnel"

2.3.1 "Lack of trained personnel" in operating cold chain along the whole process. Few enterprises can achieve monitoring and tracking temperature in real-time in procedures of primary processing, transport and storage. Real-time temperature tracking with the assist of temperature monitoring system is the urgent demand for development of export vegetable cold chain. Only strictly and efficiently monitor status of vegetable along entire export process, can it ensure the quality of vegetable, gain better reputation for the company and expand business in foreign market. As for most of the enterprises, dynamic temperature monitoring under which vegetable is blank along export chain. What's more, employee who knows how to operate advanced cold

chain equipment is also shortage. To fill in the gap, the specialized cold chain talent who acquire the skill of operating the temperature monitor system and advanced cold chain equipment are needed.

2.3.2 "Lack of trained personnel" in managing the cold chain along the whole process. The comprehensive managers who acquire the knowledge of CCM and risk management are shortage in present Yunnan vegetable export industry (Tang, 2014).

Strategies for Overcoming Critical Barriers

For the enterprises, "high capital cost and operating cost" and "lack of trained personnel" are internal elements of organization, so they are within the control of the organization. Strategies to overcome them for enterprise can be developed through SWOT analysis and TOWS analysis. Barrier "lack of government support" is external element of organization and it is out of control of the organization. Although this research can't analyze government's current environment, this study also tries to proposed some strategies by combining with government officials' opinions to serve as the reference for the government . This part is structured into two sections. The first section aims to formulate the strategies to overcome the internal barriers for the enterprises and the second section aims to formulate the strategies for the government.

1. **Strategies Based on SWOT and TOWS Analysis for Enterprises Sector**

To overcome the two internal barriers efficiently and effectively, strategic planning is essential. Before formation of the strategies to overcome these two barriers, it is necessary to evaluate and understand Yunnan vegetable export industry's current position with the intent of maximizing industrial performance. SWOT analysis is a preliminary decision-making tool which set the stage for developing strategies. Following by a TOWS analysis, which is utilized to act as supplement of SWOT analysis and facilitate the strategies.

In this part, SWOT analysis for overcoming the critical barriers is conducted. With SWOT analysis, an overview of strengths, weaknesses, opportunities and threats characterizing the internal and external environment of elimination of barriers are provided. The summary of the SWOT analysis is shown in table 13.

Table 13 SWOT Analysis for Overcoming Critical Barriers for Implementing CCM

Strengths	Weaknesses
1. Strong vegetable production and enjoy a huge market share in Thai market. 2. Large-scale companies have strong capability for investment. 3. Has a strong sense of competition. 4. Many employees are young and have a good ability to learn new things. 5. There have been some industry associations founded that are related to vegetable export trade.	1. SMEs are constrained by financial capability to make huge investment. 2. Insufficient awareness of the benefits of updated CC technology, some existing CC equipment are old style, high energy consumption 3. Has no experiences in training skills for employees.
Opportunities	**Threats**
1. New cold chain technologies constantly appear in China. 2. Constantly emerging 3PLs cold chain logistics enterprises. 3. There is a growing interesting in cultivating of skilled CC talents in universities. 4. Targeted CC associations have emerged in Yunnan.	1. Scientific research level is low, there is a small number of research on cost item . 2. Skilled cold chain trained personnel in talent market are shortage. 3. Limited experiences and references in making policy for supporting CCM in government sector. 4. Cost of energy and cost of construction land are rising.

Strengths

1. The unique geographic location of Yunnan enables it with suitable climate, which are well suitable for producing various vegetable and makes Yunnan has a strong production. With high quality and price advantage, Yunnan vegetable export industry enjoy a huge market share in Thai market.

2. Through few years of development, some large-scale enterprise have strong capability for investment, and they are expanding their business to other Southeast Asia countries market including Vietnamese, Singapore, Myanmar and so on .

3. The growing market share in foreign market indicates that this industry has a strong sense of competition. In 2016, the vegetable export volume of Yunnan reach 89 ten thousand tons.

4. Many enterprises were set up after year 2010. There is a team made up by young employees with a good ability to new things.

5. To drive the healthy development of industry, there have been some industry associations that are related to vegetable export trade established, such as Yunnan province vegetable circulation association, association of the industrialization of agriculture and agricultural produce processing leading enterprises in Yunnan province, TongHai vegetable association and so on.

Weaknesses

1. There are some large-scale enterprises having strong financial capability, like Songwei agricultural produce import and export company, Tonghai county donglv food company, Maoyuan fruit and vegetable import & export company. Meanwhile, there are also some SMEs are constrained by financial capability and difficult to make huge investment.

2. Some existing CC equipment in cold storage of are old style which cause high energy consumption. Sometimes, insufficient awareness of the benefits of updating CC technology has hindered enterprises update and upgrade CC equipment.

3. Cold chain operation skill and management skill are fairly new concept for the most of enterprises, so experiences in training employees is lacking.

Opportunities

1. New cold chain technologies constantly appear in China. Over years of development, China has constantly made some progresses in cold chain logistics technology. By the end of 2016 year, 501 practical items of CC technologies have gained the technology patents in China. The new breakthroughs are mainly in the fields of refrigeration system technology, preservation, packing technology and temperature sensor technologies.

2. Constantly emerging CC 3PLs enterprises in recent years. 3PLs have achieved great development and are gradually making for maturity in Yunnan. It is an essential operating subject of cold chain logistics.

3. Cold chain industry is a sunrise industry in China areas and cold chain concept is on the rise in Yunnan. More and more universities are interesting in studying the model of cultivating CC talents. From statistics of CNKI, 64% of papers on the investigating cultivating CC talent are produced in the last three years, which implies that there is a growing interesting in cultivating CC talent among China's university.

4. Targeted cold chain associations have emerged in Yunnan, such as frozen food association of Yunnan, Agricultural Cold Chain Logistics Professional Committee of ACCC, Yunnan Association of Refrigeration.

Threats

1. Scientific research level is low. Unfortunately, in China there are few publications on total cost analysis of agricultural produces CC . Searching from Scopus database, it is found that from 2007 year-2017 year there are only 84 papers related to CC cost research, 19 papers on CC controlling cost produced in China. Searching from CNKI, a Chinese authoritative database, it shows that there are only 27 papers targeting at studying on vegetable cold chain cost analysis. It should be noted that there is not any paper evaluating the cold chain cost analysis of vegetable trade between Yunnan and Thailand are insufficient. This gap is a constraint for investors and operators to enter .

2. Trained personnel both on operation and management level are shortage in talent market. This is because there are few university and college have the ability of cultivating specialized cold chain talent. In Yunnan, there is only one university setting up specialized cold chain course, which accounts for 1.3% of total universities (77 universities). As for the enterprise, it needs to spend a long time to cultivate CC talent.

3. Limited experiences and references in making policy for supporting CC in government sector. China was late to start developing cold chain than developed countries and initial development is slow. Relevant supporting policies and regulations are not completed enough. So far, in China there are only 5 documents targeting at promoting agricultural produces CC from year 2008-2017.

4. Cost of energy and cost of land is rising. The average growth rate of energy is 3.5% per year, which contributes to increasing of operating cost (China Materials

Storage &Transportation Association, 2014). The rising of cost of energy can make the profit margin reduce. The price of construction land in China has been increasing at an 10% speed for the last few years.

In the lights of SWOT analysis, a TOWS matrix was constructed to combine external and internal factors listed in SWOT analysis in order to deploy strategies. The constructed TOWS matrix is shown in table 14.

Table 14 TOWS Matrix for Overcoming Critical Barriers for Implementing CCM

	Opportunities(O)	Threats(T)
External factors	1. New CC technologies constantly appear in China. 2. Constantly emerging CC 3PLs enterprises. 3. There is a growing interesting in cultivating of skilled CC talents in universities. 4. Targeted CC associations have emerged in Yunnan.	1. Scientific research level is low, there is a small number of research on cost of CC vegetable. 2. Trained CC human resources in talent market are shortage. 3. Limited experiences and references in making policy for supporting CC in government sector. 4. Cost of energy and cost of construction land are rising.
Internal factors		
Strengths(S)	SO(maxi-maxi)	ST(maxi-mini)
1. Strong vegetable production and enjoy a huge market share in Thai market. 2. Large-scale companies have strong capability for investment. 3. Has a strong sense of competition. 4. Many employees are young and have a good ability to learn new things. 5. There have been some industry associations related to vegetable export trade.	1. Partner with university or relevant associations, cultivate specialized CC talent.(S3S4O3O4)	1. Invest in feasibility study, improve research level on CC vegetable cost analysis.(S2T1) 2. Make use of industry associations as platform to reflect the demands for supports to government sector.(S1S5T3)
Weaknesses(W)	WO(mini-maxi)	WT(mini-mini)
1. SMEs are constrained by financial capability to make huge investment. 2. Insufficient awareness of the benefits of updating CC technology, some existing CC equipment are old style, high energy consumption 3. Has no experiences in training skills for employees.	1. Conduct cost-benefits analysis of updating equipment, accelerate update of equipment.(W2O1) 2. Increase outsourcing to CC 3PLs to reduce the investment cost in transport link. (W1O2)	1. Cooperate with university, and government to explore vegetable CC cost-effective investment model and strengthen ability of cultivating talent.(W2W3T1T2T4) 2. Joint invest with peers to introduce capital-intensive CC equipment.(W1T3)

Base on the TOWS matrix analysis, this research has proposed the following strategies. Because large-scale enterprises and SMEs are totally different in financial condition, capability for investment and management level, the following strategies are deployed in accordance with the enterprises' scale respectively as well, as shown in table 15. Meanwhile, a SIPOC diagram is used to illustrate to clearly point out the strategies' role in the process of exporting.

Table 15 A Summary of Strategies Based on TOWS Analysis for Industry Sector

	Strategies	Time frames of planning
1.	Partner with university or relevant associations, cultivate specialized talent (for both large-scale enterprises and SMEs).	Middle-term plan(2-4 years)
2.	Invest in feasibility study, improve research level on CC vegetable cost analysis (for large-scale enterprises).	Middle-term plan(2-4 years)
3.	Conduct cost-benefits analysis of updating equipment, accelerate update of equipment (for both large-scale enterprises and SMEs).	Middle-term plan(2-5 years)
4.	Joint invest with peers to introduce capital-intensive CC equipment (for SMEs).	Middle-term plan(2-5 years)
5.	Cooperate with university, academic institution and government to explore cost-effective vegetable CCM investment model and to improve ability of cultivating talent (for large-scale enterprises).	Long-term plan(5-10 years)
6.	Increase outsourcing to CC 3PLs to reduce the investment cost in transport links (for SMEs).	Short-term plan (1 year)

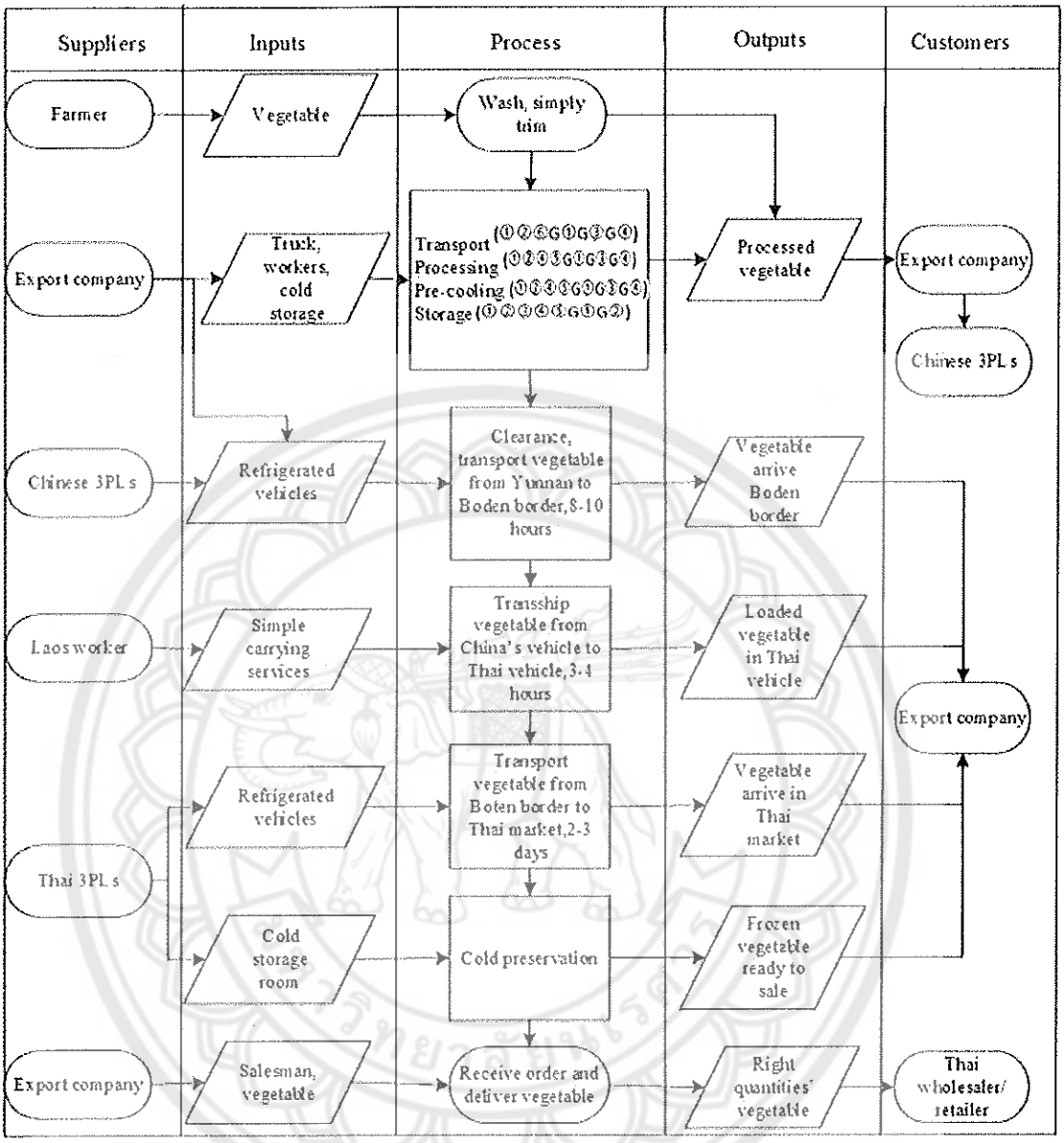

Figure 12 Strategies' Role in the Process of Exporting SIPOC Diagram

1. Strategy "partner with university or relevant associations, cultivate specialized talent" (for both large-scale enterprises and SMEs), a middle-term plan, spanning from 2-4 years. This strategy uses strengths 3 and 4 (strong sense of completion and have good ability to learn new thing) in combination with opportunity 3 and 4 (there is growing interesting in cultivating CC talent in universities and emerging targeted CC associations that have the ability to train CC skills).This strategy direct at

both large scale enterprises and SMEs. The details of the strategies are presented as follows:

1.1 "Carrying out on-the-job training to staff is a common solution to shortage of trained personnel. By partnering with university or relevant associations, employees can learn the specific cold chain operation or management skills from experts and instructor in educational or relevant industry associations. There should be two different training programs targeting cultivate technicians and comprehensive managers respectively. The skills of operating systemic temperature monitoring technology (e.g. RFID, TTI , WSN technique), skill of operating advanced refrigeration equipment according to characteristics of vegetable, and principle of general chemical should be covered in training for technicians. This strategy has the purpose of improving staff's cold chain operations skill in the process of transporting, primary processing, storage, as shown in SIPOC diagram. Principles of SCM, cold chain logistics management and risk management principles that may affect quality of vegetable are necessary in the training program for the managers, so that they can develop prioritized preventive and mitigation measures. This strategy tries to train them to master the cold chain's managerial skills along the whole export process. Strategy ① covers the every activities conducted with vegetable after they harvest from farm until vegetable are sold to Thai customers, as shown in figure 12.

1.2 Offer help with student training or create relevant internships strengthen their talent pipelines, the graduates are more likely to have the desired cold chain skill sets.

1.3 For university or other academic institutions, they can encourage the young teachers or instructors in the field of teaching agricultural produce CC course to take a temporary post in the enterprise, participate the operation of CCM so that can gather experiences. At the same time, it can infuse new blood into the operation and management in term of CCM of enterprise.

2. Strategy "invest in feasibility study, improve research level on CC vegetable cost analysis" (for large-scale enterprises), which is a 2-4 years' middle-term plan. This strategy uses strength 2 (large-scale enterprise have strong capability for investment)faces threat 1 (low research level on CC vegetable cost analysis). Previous research on cold chain cost analysis of vegetable trade between Yunnan and Thailand

are insufficient. The skeptical feeling of enterprises can significantly limit investors to make high the investment item like the cold chain. Large-scale enterprises can make use of advantage that having strong financial capability to fill in this gap by themselves. Through conducting feasibility study, investors can have a comprehensive understanding on the CC cost of vegetable trade between Yunnan and Thailand, including analysis of total investment cost, operating cost, managerial cost, return on asset and payback period capital, and corresponding predicted economic effects, etc. When there are enough information about cost and benefits of investment on vegetable cold chain, it will guide and drive investors to make the investment on the introduction of CC concept to an extent. The following activities would be improved through this strategy②: transporting vegetable from farm to company, primary processing, pre-cooling and storage, as shown in figure 12.

3. Strategy "conduct cost-benefits analysis of updating equipment, accelerate update of equipment" (for both large-scale enterprises and SMEs), a middle-term plan, around 2-5 years. This strategy uses opportunity1 (new CC cost-effective energy saving technology) to face weakness2 (enterprise's old style equipment, high energy consumption). As mentioned before, currently the energy cost in operating CC equipment is 45%-50%, which is higher 35%-40% than of developed countries. Some CC equipment in cold storage of enterprises are already aging and the adoption of upgrading equipment is slow and low, which causes the high energy consumption cost. Recent years, some new cost-effective energy savings technologies have constantly appear in China. Accelerate update of equipment can save energy around 30% or even more (China cold chain logistics development report, 2016). At present, one of important obstacles hindering enterprises update new equipment is there is insufficient awareness and recognition on cost-benefits on the new equipment. By adopting this strategy, enterprises can improve the understanding on the cost item, including the performance, rate of return and payback period of latest CC technology, which can drive enterprises that have the financial ability tend to invest new equipment, to adopt a more cost-effective operation model. Efficiently, it can contribute to reducing the high operating cost. Through this strategy, the cost for total consuming energy may can be saved to an extent and stimulate the improvement of CC technology of whole industry.

This strategy③ aims at reducing the high operating cost at storage process, as presents in SIPOC diagram.

4. Strategy "joint invest with peers to introduce capital-intensive CC equipment" (for SMEs), a middle-term plan, spending 2-5 years. This strategy focuses on reinforcing weaknesses 1 (SMEs are constrained by financial capability) to face threat2 and 4 (cost of energy and cost of construction land are rising). The introduction of cold chain equipment or facilities like building constant temperature workshop or new style cold storage would cause quite high capital cost and occupy expensive land resources. Most of enterprises are constrained by the limited capital and difficult to make such huge investment. To address the issues above, one option is to joint investment with peers. The amount of capital contribution should be equal for fairness and managerial convenience. Enterprises can clarify each party's concerned duty and rights by contract. Alternatively, the enterprises can rent the constant temperature workshop or cold storage to the third party user when the workshop or cold storage is idle in order to realize the maximization of utility in resources. This strategy ④ targets at overcoming the barrier "high capital cost and operating cost" at the process of pre-cooling and storage.

5. Strategy "cooperate with university and government to explore cost-effective vegetable export CC investment model and to improve ability of cultivating talent" (for both large-scale enterprises and SMEs), a long-term plan, 5-10 years. This strategy uses weakness 2 and 3 (high energy consumption, has no experiences in training skills for employees) to face threat 4 (cost of energy and cost of construction land are rising). Currently, the implementation of CC on agricultural produces is still in its infant stage in China. No matter in term of reducing extremely high cost efficiently or addressing the shortage of trained personnel or overcoming other barriers of implementing vegetable CC, relying on the unilateral power is impossible. Under this context, cooperation among university, academic institution and government would be a potent measure. For instance, jointly pilot the new equipment and technology, explore cost-effective investment model through jointly R & D, conduct workshop, seminar and training program, etc. This strategy ⑤ tries to overcome barriers "lack of trained personnel" and "high capital cost and operating cost" at the process of pre-cooling and storage.

6. Strategy "increase outsourcing to CC 3PLs to reduce the investment cost in transport links" (for SMEs), a short-term plan. This strategy takes advantage of opportunity2 (constantly emerging CC 3PLs enterprises) to face weakness (SMEs are constrained by financial capability) . SMEs enterprise can consider increase adoption of outsourcing during the vegetable transportation from farm to storage as shown in SIPOC diagram. Financially, outsourcing is an attractive option for the enterprises as it's a capital expense and comes without any overhead expense. Today 3PLs, especially transportation-type CC 3PLs have achieved great development in Yunnan and are gradually making for maturity. By increasing the this strategy ⑥ (adoption of outsourcing pattern), it can keep entire distribution stage of vegetable in a cold chain with a lower investment cost threshold.

2. Strategies for Government Sector

It is speculated that the reason the modern agricultural produce cold chain were not established in China was the government's limited implementation of the program (Asian Development Bank, 2015). In September 2014, the State Council of China formulated the medium and long-term plan for logistics industry, which calls for an accelerating strengthen the construction of cold chain logistics facilities related to fresh agricultural produces. This plan has promoted development of cold chain logistics of agricultural produce in China including in Yunnan province to a large extent. Though along with existing support environment, the result of this study shows "lack of government support" is still a critical barrier to implement cold chain in Yunnan vegetable export industry. It implies that enterprises still desire government can make further support policy for them to address the problem in developing cold chain. To gain the government sector's opinion about the barrier "lack of government support" and strategies for overcoming it, author has interviewed with a government officials who works in Yunnan Agriculture Department. During the interview, the following 2 questions were answered:

1. What's the your opinion on barrier "lack of government support" for implementing CCM on exported vegetable from Yunnan to Thailand?

Here are the answers from the respondent:

"The generalization of cold chain is an important measure to promote the development of modern agriculture and to improve the agriculture economic benefit.

Unfortunately, the currently the adoption of cold chain in agriculture product starts late in Yunnan province, including in vegetable export industry. The overall scale of it in vegetable industry is small and the professional level is low. The successful implementation of it should depend on market-based, government-led modern. We have realized that government sector should play a part in policy guidance to create a favorable environment for it. However, since cold chain concept comes late and we don't have rich experiences in making the policy to support it, it cause the existing related policies are not well-established enough and quite limited. Speaking objectively, implementing CCM requires high human, material and financial resources. When there are not attractive measures for enterprises, it is very difficult to put cold chain into vegetable export practice. I think its reasonable and it is not strange for the enterprise to think that "lack of government policy support" is an obstacle for enterprises to implementing CCM on vegetable export trade."

2. For better improve the incentive system for supporting enterprises to adopt CCM, what can government do you think in the near future ? Do you think the proposed 4 strategies (support introduction of CC equipment, address the land-use problem for enterprise, support university and college to cultivate CC trained personnel and support R & D on vegetable CC) are feasible or not to improve the current situation?

Here is the answer from the respondent:

"Actually, now the Yunnan government has set a goal that by the year of 2020, a cold chain service system that characterized with standard specification, safe and green, temperature is fully controlled and monitored should be basically completed. The issue of broken in chain could be addressed basically. Now, in some cities, we are rallying support for more fund and nation project for developing agriculture produce cold chain. What's more, we are arranging for special fund for introducing of facilities for processing and storage of agricultural produce and award for building new cold storage, but these policies are not completely extended in the whole provinces. In the near future, I think government can devote greater effort to make more areas in Yunnan benefits from these policies. As for the detail fund budget proportion that department can arrange, 6%-10% is possible in the next two years. As for the issue of land is the topic that government sector pay attention to all the time, but it can't be solved completely. In my opinion, Administrative of Land and Resource can also strengthen

the efforts to improve favorable land policies. Furthermore, I also think that the talent training mode issue is outstanding in implementing CCM on vegetable exported. To be specific, the current talent training mode can't meet the demand of developing cold chain logistics. In the task of cultivating specialized cold chain training talent, government would play a part in planning, managing and driving. Government can achieve the task by various measures such as policy guidance, education legislation, funding and so on."

For further improvement of incentive system of government, some strategies are put forward combining with government official's opinions above, as shown in table 16.

Table 16 A Summary of Strategies for Government Sector

Strategies	Time frames of planning
1.Support introduction of CC equipment	Middle-term plan (3-5 years)
2.Address the land-use problem for enterprise	Middle-term plan (3-5 years)
3.Support university and college to cultivate CC trained personnel.	Long-term plan (5-10 years)
4. Support R & D on vegetable CC	Long-term plan (5-10years)

1. Strategy "support introduction of CC equipment", which is planned as an intermediate-term planning and continues for 3-5 years. Overall, the possessive quantity of CC equipment in Yunnan falls behind developed countries and other provinces. For instance, the number of refrigerated trucks accounts for 0.42% of total numbers of vehicles, far less lower than Germany (2%-3%) and US (0.8%-1%). And the total cold storage capacity in Yunnan is 1.05 million tons, ranking 15th among 23 provinces, behind than most of other provinces in China (China Cold Chain Logistics Development Report, 2016). Foreign experiences indicate that government's strategy can significantly promote the enterprise to apply CC equipment. Japan's per capital refrigerated warehouse capacity is among the highest in the world, which is due to Japan government's strong support policy. For example, for enterprises that install CC equipment through lease terms, the Japanese government would provide half of the

leasing costs. Another case is that every year the government of France offers subsidies to stimulate CC equipment project with 25% of financial agricultural subsidies. Further more, the subsidies can reach 30%-50% in some areas with poor facilities. Many successful cases in foreign countries indicate that cold chain penetration especially in agriculture in any country is fully dependent on the support from cold chain facilities. The existing supporting polices of Yunnan are mainly focusing on offering loan facility and reducing taxes and fees: increase credit support, make the price of power and price of water basically the same with of industry, exempt pass fee with refrigerator car that transport the agricultural produce. There is no any specialized financial incentives for enterprises that introduce CC equipment. Yunnan government can use foreign experiences for references and enhance the support in introduction of CC equipment. The data of Yunnan Agriculture Department shows in 2016, 36.3 million yuan were used in construction of facilities for processing and storage of agricultural produce, which accounts for 4.6% of total actual budget (789.1 million yuan) of the department. Author thinks that agricultural department can appropriately increase the fund budget proportion (5%-10%)to support enterprise to introduce CC equipment like refrigerated truck, constant temperature workshop or new style cold storage by providing 10%-15% project subsidies. In addition, government can reference on what USA and India did-by tax preference measure: provide deductions in respect of profits from industrial undertakings related to cold chain, for instance deduct 100%-150% income tax for enterprises that set up and operating CC equipment for processing and storage of vegetable. At the same time, government can also incentivize enterprises to adopt energy efficient CC equipment in this link by setting up specialized award. For the enterprises who adopt advanced CC equipment that are relatively energy-saving, government provide more fund support for them. The investment cost of enterprise can be reduced and the rate of adopting advanced CC equipment can be increased through this strategy, so more vegetable export enterprise and 3PLs would have stronger will and enthusiasm to invest CC equipment. This strategy G① tries to improve the situation at the process of transporting, pre-cooling and storage.

2. Strategy "address the land-use problem for enterprise", a intermediate-term planning, spending 3-5 years. As mentioned before, now the difficulty of using land of enterprise still can't be solved due to the limited land resources in China. Current

landholding systems are not in favour of building big storage systems especially of agricultural land for industrial purposes. Since cold chain facilities are considered to be of commercial nature, finding land for them, especially in rural areas, is a challenging task. The high cost of industrial land become an equally important obstacle that hinder investors to construct the CC facilities like cold storage. Ministry of Land and Resources of PRC (2016) reports that the average price of industrial land in Yunnan (313 yuan/m^2) is higher than of neighboring provinces (Guangxi 287 yuan /m^2, Guizhou 258 yuan /m^2. Diminution of land for urbanization and increasingly limited land resources has led to rising rent for storage yard in Yunnan, which increase the cold chain cost for vegetable trade. Hence, it is of utmost importance that enterprises be allowed to establish cold storage units with ease through an effective land policy. This mandates government to strengthen the planning of land usage in order to meet the need on land for developing cold chain (Liu et al., 2016). So far, Yunnan government has released two land polices aiming at providing safeguard the construction. One is to implement policy of industrial land and permit enterprise who can't pay one-time the land-transferring fees pay 50% first, and the rest can be pay off within one year. The another one is to permit warehouse that is about to convert to as cold storage doesn't have to change land user and purpose in law tentatively. The respondents reflected that both of these polices is still far from solving land-use problem. More attractive preferential land polices may enable to address the problem. Thus, this study proposes some suggestions, for instance, give priority to approve construction land, reduce land occupancy charge, offer subsidy according to land transaction fee, lower land use tax, etc. By implementing this strategy G②, the total investment cost for using the land can be reduced, and it would also inspire investor's passion to build cold chain units at process of primary processing and storage.

3. Strategy "support university and college to cultivate CC trained personnel", a long-term plan, 5-10 years. According to the latest statistics by the Ministry of Education, China presently has 2914 universities and colleges. Only 28 universities and colleges set up cold chain major or courses, which accounts for 3.9% of total universities and colleges. Further still, only a few university and colleges' training schemes are specially aimed at agricultural produce CC. And there are only one university has setting up the cold chain major in Yunnan. Government can further increase education fund budget of expenditure to encourage university and college to

design specialized CC major (course), to encourage university and college to recruit domestic, foreign outstanding CC experts as teacher, to design and evaluate excellent CC course materials, to support qualified teachers participate national research projects, and to cooperate with foreign universities in terms of cultivating CC talent, etc. By implementing this strategy G③, university and college can strengthen their ability of cultivating specialized cold chain talents. More graduates can have the opportunity to acquire cold chain operation and managerial techniques to serve the development of agricultural produce CC logistics.

4. Strategy "support R & D on vegetable CC", planned to be a 5-10 years' long-term planning. Counting papers from CNKI database during the last decade, it reflects currently China's scientific research level in the field of promoting agricultural produce cold chain is low. More specific, there are only 45 papers targeting at the cultivation of CC talents, 17 papers on the agricultural produce CC cost analysis, 28 papers on CC information technology, 39 papers on specialized CC technology, 20 papers on CC energy-saving. There are only 7 papers on researching agricultural produce CC which were produced by Yunnan academic institutions and got the Yunnan regional research funding support. According to statistical bulletin of Yunnan Provincial Science and Technology Department in 2016, 3.768 billion yuan were spent on R & D in the field of promoting agricultural produce CC, accounting for 0.93% of the total fiscal expenditure. The level of R & D on vegetable CC can be improved by means of appropriately increasing national and regional research funding and awards for scholars. The following type of research should be encouraged: research on controlling CC cost, average rate of return on investment (ROI) of CC, practical CC talent cultivation mode, agricultural produce CCM field, etc. Through this strategy G④, more sufficient information and research on vegetable CC logistics would be available to guide the investor and operators on how to ensure the cold chain temperature along the export process including in the process of selling, improve the feasibility and efficiency of implementing CCM on vegetable. In addition, government can conduct pilot project of new CC equipment aiming at identifying the good performing and cost-effective models of a given type. This kind of pilot enables evidence-gathering on performance, cost-effectiveness and usability of CC equipment. It can enable investors get more guidance about the CC equipment and lower the investment risk.

CHAPTER VI

CONCLUSION AND FUTURE RESEARCH DIRECTION

Conclusion

As is indicated in chapter 1, the objective of this thesis are to study barriers to implement CCM on exported vegetable from Yunnan to Thailand, to study inter-relationships among the them and to identify the critical ones. Besides, this research attempts it to develop strategies to overcome the critical barriers.

1. Barriers to implement CCM on exported vegetable from Yunnan to Thailand

To study the barriers to implement CCM on exported vegetable from Yunnan to Thailand, this thesis firstly conducts a systematic literature review to collect primary barriers. From extensive review of literature, 17 variables are listed as primary barriers. Then 10 barriers are validated as barriers for the implementation of CCM on exported vegetable from Yunnan to Thailand through 15 respondents' opinions . The 10 validated barriers are "lack of trained personnel", "high capital cost and operating cost", "lack of top level commitment", "lack of IT implementation", "Lack of industry standards of implementation of CCM ", "lack of coordination between stakeholder", "unawareness of customers", "lack of government support", "poor cold chain infrastructure" and "lack of capacity in maintenance of cold chain facilities".

2. The inter-relationships among barriers

To acquire the inter-relationships among the validated barriers, a MCDM tool –DEMATEL model is applied. Before that, the fuzzy set theory was incorporated with the traditional DEMATEL model in order to address the imprecision and vagueness of experts' assessment under fuzzy environment. Totally, 7 industrial and academic experts' opinions regarding the initial degree of influence between pairwise barriers are inputted into proposed model. Based on the net effect score and prominence score, a cause-effect diagram is constructed, in which the inter-relationships among barriers are shown clearly. This research concludes that six barriers: "lack of top level commitment", "lack of IT implementation", "lack of industry standards of implementation of CCM ", "lack of coordination between stakeholder", "poor cold chain infrastructure" and "lack

of capacity in maintenance of cold chain facilities" are easily influenced by other barriers in the system as all their net effect scores are negative, namely, -0.652, -0.077, -0.339, -1.039, -0.307 and -0.23 respectively. Besides, it concludes other 4 barriers: high capital cost and operating cost, lack of top level commitment, lack of government support, lack of capacity in maintenance of cold chain facilities tend to actively influence other barriers.

3. Critical barriers for implementing CCM

This study have identified 3 barriers as critical barriers. Barriers "lack of government support system" and "high capital cost and operating cost" got the highest net effect score0.962 and 0.839 in cause group, which means they are relatively influential in the system. In addition, barrier "lack of trained personnel" falls in cause group and possesses a high prominence score 6.444 which implies this barrier has the high degree of central role in the problematique. In view of above mentioned reasons, 3 barriers : high capital cost and operating cost, lack of government support system, and lack of trained personnel are identified as the critical barriers.

4. Strategies for overcoming critical barriers

Before developing strategies for overcoming identified critical barriers, a SIPOC map is applied to show the current process of vegetable trade exported from Yunnan to Thailand first. Based on the SIPOC diagram, details of impacts of critical barriers in weak links of CCM are presented. Next, with SWOT analysis, an overview of internal factors (strengthen and weakness) and external factors (opportunities and threats) of elimination of critical barriers are provided. After that, a TOWS matrix is constructed, in which the external factors and internal factors listed in SWOT matrix are combined. From TOWS matrix, 6 strategies are proposed for the industry sector: partner with universities and relevant associations to cultivate specialized talent, invest in feasibility study, conduct cost-benefits analysis of updating CC equipment, increase outsourcing to CC 3PLs to reduce the investment cost, joint invest with peers to in introduction of capital-intensive CC equipment, cooperate with university and government to explore cost-effective CC investment model and to improve ability of cultivating talent. Moreover, this study has proposed 4 strategies for the government sector: support introduction of cold chain equipment, address the land-use problem,

support university and college to cultivate cold chain trained personnel, and support D&R respectively.

Future Research Direction

Although this research was completed, it is not without its limitation, which should be noted as they can be addressed by the future research. The first limitation can be detected is the sample size of the company used in this study. Only 13 companies are used as respondents for the data analysis in this study due to the limited time and resources. This sample size may limit the generalizability of current findings. It can achieve more comprehensive investigation if there are more involvement of the companies in future study.

The second restriction is the component of the selected experts. Generally, the implementation of CCM of company would be affected by the role of government to an extent. However, none of the selected experts come from the government department in this survey investigation. A more rigorous and exhaustive method should involve the participant of experts of government department. Hence, it is suggested that the future research should collect the data from officials in the government department.

Finally, this study didn't thoroughly consider the barriers for implementing CCM in transshipment process at Boten area due to the limited resources. The "break" of CC in this process is still very difficult to avoid due to it extremely depends on the external status-promotion of infrastructure in Laos and Laos government positive support policy. Obviously, there is still a long way to go for Laos. It would be valuable to further study the solutions to eliminate backward transshipment in future research. In doing so, more advantageous implications would be generated.

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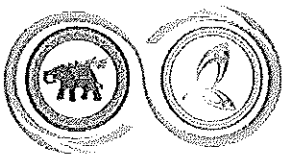
APPENDIX



School of Logistics and Supply Chain, Naresuan University

Questionnaire for Conducting Research

Barriers Identification for Implementing Cold Chain Management:

Vegetable Export (Yunnan-Thailand)

Description about Questionnaire:

Vegetable export industry is an important industry in Yunnan province of China because it has created a high export volume and a great deal of revenue to the area. Thailand is the major oversea market of Yunnan vegetable export industry. However, up to now, vegetable export trade between Yunnan and Thailand still suffers an issue of high rates of post-harvest losses, which has hindered the development of Yunnan vegetable export trade.

An effective Cold Chain Management (CCM) is an efficient way to reduce the post-harvest loss. Despite this, the concept of CCM is yet not widely accepted due to numerous barriers. The identification of these barriers is the first critical step to remove them. Therefore this research aims to identify barriers for the implementation of CCM on exported vegetable from Yunnan to Thailand, which would be helpful for achieving a better understanding on these barriers.

The relevant principles which are applied in this questionnaire are based on the extensive literature reviews which are related to CCM field. 21 primary barriers are identified from papers that belong to database of Google Scholar, Scopus, etc. The respondents of this questionnaire are managers or owners who come from different Yunnan vegetable export company that have export business relationships with Thailand market.

Thank you very much for your active participant. The result of the questionnaire will be kept anonymous and your answer will be kept confidential and used for academic propose only.

Questionnaire Details: this questionnaire is composed of 4 sections, namely:

Section 1: Primary information of respondents

Section 2: General background of company

Section 3: Details about the barriers to implement CCM from respondents' perspectives

Section 1: Primary information of respondents (Please fill in the primary information)

1.1 Position.....

1.2 Have worked in company for.....years

Section 2: General background of company

2.1 Name of the company.....

2.2 Address of the company.....

2.3 Company has been established for.....years

2.4 Total employees.....people

2.5 Exported vegetables include.....

Section 3: Details about the barriers to implement CCM from respondents' perspectives

3.1 Do you think following barriers are barriers that hinder the implementation of CCM in company or not? (If they are, please tick✓ in the blank)

Barriers	Description	✓
Lack of trained personnel	The personnel who have a knowledge of specific to vegetable storage and handling practices, knowing how to operated related facilities and have the ability to respond to breaks in CC is very limited.	
Lack of coordination between stakeholders	Coordination means the act of making stakeholders involved including the farmers, collector, exporter and importer in terms quality control or temperature control activity or others' activity.	
High capital cost and operating cost	The capital for investment and high operating cost is quietly high, which make uncertain of receiving proper of the preserved value	
Lack of quality and safety measures	Can't access to condition that a malfunctioning of vegetable occur.	

Barriers (cont.)	Description(cont.)	✓
Lack of top level commitment	"Top level management commitment" in here means enthusiastic participation, attitude to change, initiative, priority in terms of implementing CCM of highest-level executive in company. "lack of top level commitment" means top level management resist towards implementation of CCM practices.	
Lack of IT implementation	The application of IT in context of agricultural produce CC include temperature monitoring system, WMS, TMS, RFID and traceability system is limited.	
Lack of industry standards of implementation of CCM	The term "standard" in here means the regulation controlling the process to make all the exported vegetable in a level of quality, which cover processing, logistics, temperature, packing, etc.	
Manager's limited awareness on CCM	Managers don't understand or know the concept of CCM.	
Customer's unawareness towards CCM vegetable	Low demand from customers for CCM vegetable, prefer lower price vegetable with general quality.	
Lack of government support	Government regulations and police are not strong enough to support industries to integrated CCM resource and adopt CCM.	
Poor CC infrastructure	The available CC facilities including refrigerated truck and cold storage can't meet the efficient CC demand to make the vegetable achieve the stable low temperature.	
Lack of integrated planning in company	Integrated planning means combining planning to ensures participation of all stakeholders and relative departments into one effective unit.	
Shortage of power to run	The energy power for making sure the normal operation of the frozen system is shortage.	
Disbelief about benefits of CCM	Don't believe or doubtful about the benefits of adopting CC	
Lack of reliable CC 3PLs	As companies turn to exploit new foreign market, the use of CC 3PLs has been popular while few companies can provide properly integrated CC logistic service.	
Lack of capacity in maintenance of CC facilities	Some good facilities that were built many years ago are generally outdated or not functioning properly because of lacking of capacity in maintenance.	
Lack of awareness about the use of IT	Industries lack of acceptance of acceptance in information technology.	

3.2 Except the above barriers, what factor(s) do you think can be regarded as barrier for implementing CCM in company?

Section 4: Introduction on concept of Cold Chain Management

Cold Chain Management is "the process of planning, implementing and controlling efficient, effective flow and storage of perishable goods, relative services and information form one or more points of origin to the points of production, distribution and consumption in order to meet customers' demand".

School of Logistics and Supply Chain, Naresuan University

Questionnaire for Conducting Research

Barriers Identification for Implementing Cold Chain Management:

Vegetable Export (Yunnan-Thailand)

Description about Questionnaire:

Vegetable export industry is an important industry in Yunnan province of China because it has created a high export volume and a great deal of revenue to the area. Thailand is the major oversea market of Yunnan vegetable export industry. However, up to now, vegetable export trade between Yunnan and Thailand still suffers an issue of high rates of post-harvest losses, which has hindered the development of Yunnan vegetable export trade.

An effective Cold Chain Management (CCM) is one of most efficient ways to reduce the post-harvest losses. Despite this, the concept of CCM is yet not widely accepted due to numerous barriers. The identification of these barriers is the first critical step to remove them. Therefore this research aims to identify the barriers for the implementation of CCM on exported vegetable from Yunnan to Thailand, which would be helpful for achieving a better understanding on these barriers, as well as be helpful for removing these barriers more efficiently and purposefully.

The relevant principles which are applied in this questionnaire are based on the extensive literature reviews that relates to CCM field. The main objective of this questionnaire is to obtain the experts' opinions on the initial intensity of relations among pairwise barriers that have been validated. After this, data would be analyzed with the assistance of a model.

Thank you very much for your active participant. The result of the questionnaire will be kept anonymous and your answer will be kept confidential and used for academic propose only.

Questionnaire Details: this questionnaire is composed of 2 sections, namely:

Section 1: Primary information of experts

Section 2: Initial intensity of relations among pairwise barriers

Section1: Primary information of experts (Please fill in the primary information)

1.1 Position.....

1.2 Educational background.....

1.3 Have been worked for.....years

1.4 Work unit.....

Section 2: Initial degree of influence among pairwise barriers

For table 2, please conduct pairwise comparisons in terms of degree of influence between barriers (degree of a barrier i influences barrier j). Then fill in the corresponding blanks using the terms of 5 linguistic scale as presented in table1. For example, if you think the barrier "Lack of skilled human resource" has no influence on barrier "high capital cost and operating cost" then fill the character "No" in the corresponding blank as shown in the table. The rest of the comparison can be done in the same way until finish all the comparison in table 2.

Table 17 Terms Based on the Degree of Influence

Linguistic scales	Terms
No influence	No
Very Low influence	VL
Low influence	L
High influence	H
Very High influence	VH

Table 18 Initial Degree of Influence among Pairwise Barriers

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel										
High capital cost and operating cost										
Lack of top level commitment										
Lack of IT implementation										
Lack of industry standards of implementation of CCM										
Lack of coordination between stakeholders										
Unawareness of customers										
Lack of government's support										
Poor cold storage infrastructure										
Lack of maintenance of infrastructure										

Table 19 Survey Result Base upon Opinion of Expert 1

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	No	L	VL	H	VL	VH	No	H	H
High capital cost and operating cost	VL	-	L	VL	H	VL	H	L	H	H
Lack of top level commitment	L	H	-	L	H	L	H	L	H	H
Lack of IT implementation	No	L	L	-	H	L	L	VL	H	H
Lack of industry standards of implementation of CCM	VH	H	H	L	-	L	H	L	H	H
Lack of coordination between stakeholders	No	No	L	L	L	-	VL	VL	L	L
Unawareness of customers	No	VL	L	VL	H	L	-		H	H
Lack of government's support	VL	H	L	L	VL	VL	VH	-	VH	VH
Poor cold storage infrastructure	VH	L	H	L	VL	VL	VH	H	-	VL
Lack of maintenance of infrastructure	H	H	H	VL	H	VL	H	H	H	-

Table 20 Survey Result Base upon Opinion of Expert 2

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	VL	L	H	L	L	L	VL	L	VL
High capital cost and operating cost	VL	-	L	H	L	L	L	L	VL	VL
Lack of top level commitment	L	L	-	No	VL	VL	L	L	L	No
Lack of IT implementation	L	VL	H	-	VL	L	L	VL	VL	No
Lack of industry standards of implementation of CCM	L	L	L	No	-	VL	VL	L	L	L
Lack of coordination between stakeholders	VL	L	H	L	L	-	VL	L	L	L
Unawareness of customers	L	No	L	L	L	L	-	VL	L	VL
Lack of government's support	L	VL	L	VL	L	VL	No	-	H	No
Poor cold storage infrastructure	VL	VL	VL	L	VL	L	L	L	-	VL
Lack of maintenance of infrastructure	VL	VL	VL	No	VL	VL	No	VL	VL	-

Table 21 Survey Result Base upon Opinion of Expert 3

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	No	L	H	H	H	VL	L	L	L
High capital cost and operating cost	VL	-	L	L	H	L	VL	L	L	L
Lack of top level commitment	H	VL	-	L	H	L	VL	VL	H	L
Lack of IT implementation	VL	L	VL	-	H	VL	VL	VL	L	L
Lack of industry standards of implementation of CCM	H	H	VL	L	-	VL	L	VL	L	L
Lack of coordination between stakeholders	VL	L	VL	VL	L	-	VL	VL	L	L
Unawareness of customers	L	No	L	VL	L	L	-	VL	L	VL
Lack of government's support	L	VL	L	L	L	VL	VL	-	L	VL
Poor cold storage infrastructure	L	H	H	H	H	L	VL	VL	-	VL
Lack of maintenance of infrastructure	L	VL	V	VL	VL	VL	VL	No	L	-

Table 22 Survey Result Base upon Opinion of Expert 4

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	L	VH	No	H	No	No	No	No	L
High capital cost and operating cost	No	-	H	VL	VL	H	H	VH	VH	VL
Lack of top level commitment	VH	VL	-	L	L	VL	No	L	VL	VL
Lack of IT implementation	No	VL	VL	-	VL	VL	No	VL	VL	No
Lack of industry standards of implementation of CCM	L	No	VL	VL	-	L	No	VL	L	VL
Lack of coordination between stakeholders	No	No	VL	No	No	-	VL	No	VL	No
Unawareness of customers	VL	No	H	L	No	VL	-	VL	VL	No
Lack of government's support	L	VL	L	No	H	L	VL	-	H	VL
Poor cold storage infrastructure	VL	VL	H	VL	VL	No	No	L	-	VL
Lack of maintenance of infrastructure	VL	No	L	No	No	VL	VL	VL	L	-

Table 23 Survey Result Base upon Opinion of Expert 5

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	No	No	L	L	L	No	No	VL	L
High capital cost and operating cost	No	-	L	No	No	VL	L	No	VH	No
Lack of top level commitment	VH	No	-	L	L	L	No	VL	VL	VL
Lack of IT implementation	No	L	L	-	L	H	No	L	L	L
Lack of industry standards of implementation of CCM	VL	No	L	H	-	L	L	No	L	L
Lack of coordination between stakeholders	No	H	VL	No	No	-	No	No	No	No
Unawareness of customers	No	H	H	L	L	No	-	L	L	VL
Lack of government's support	L	H	L	VL	H	L	No	-	VH	H
Poor cold storage infrastructure	No	No	No	No	L	No	L	No	-	VL
Lack of maintenance of infrastructure	No	No	VL	VL	No	No	No	No	VL	-

Table 24 Survey Result Base upon Opinion of Expert 6

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCM	Lack of coordination between stakeholders	Unawarcness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	H	L	VL	VL	VH	No	No	VL	VL
High capital cost and operating cost	No	-	H	VL	No	No	L	No	H	H
Lack of top level commitment	H	No	-	VL	L	VL	No	L	L	VL
Lack of IT implementation	L	L	VL	-	L	L	L	L	VL	No
Lack of industry standards of implementation of CCM	L	H	H	VH	-	No	No	L	H	H
Lack of coordination between stakeholders	No	L	VL	L	L	-	L	VL	VL	No
Unawareness of customers	No	No	L	L	VL	No	-	VL	L	VL
Lack of government's support	L	L	H	L	H	No	No	-	H	No
Poor cold storage infrastructure	VL	VL	H	L	H	VL	H	H	-	VL
Lack of maintenance of infrastructure	VL	VL	L	L	H	VL	VL	No	L	-

Table 25 Survey Result Base upon Opinion of Expert 7

i \ j	Lack of trained personnel	High capital cost and operating cost	Lack of top level commitment	Lack of IT implementation	Lack of industry standards of implementation of CCMization	Lack of coordination between stakeholders	Unawareness of customers	Lack of government system	Poor cold storage infrastructure	Lack of maintenance of infrastructure
Lack of trained personnel	-	No	VL	No	H	No	No	No	VL	No
High capital cost and operating cost	No	-	L	VL	H	VH	H	L	L	No
Lack of top level commitment	VH	L	-	L	L	VL	No	L	VL	No
Lack of IT implementation	No	VL	H	-	VL	No	No	L	L	VL
Lack of industry standards of implementation of CCM	L	No	VL	VL	-	No	No	VL	L	No
Lack of coordination between stakeholders	No	No	VL	No	No	-	VL	No	VL	No
Unawareness of customers	VL	VL	VL	VL	No	VL	-	VL	VL	No
Lack of government's support	L	VL	L	No	VL	No	No	-	L	VL
Poor cold storage infrastructure	VL	VL	H	VL	VL	No	No	H	-	VL
Lack of maintenance of infrastructure	VL	No	L	No	VL	No	VL	VL	VL	-