# CHAPTER 2

# Literature Reviews, Principles and Theory

The chapter contains the reviewing of literature and research evidences based on three concepts and two theories. Three concepts are explored under the heading of a performance measurement (PM), methods of evaluation, and multivariate methods of analysis. The theory of multiple criteria decision-making (MCDM) and the principle of structural equation modeling (SEM) are also reviewed. Those three concepts, one theory, and one principle are analyzed and critiqued in the chapter. The contents of this chapter will be transferred evidences into the construction of the new integrating performance measurement model of the Thai's frozen shrimp supply chain. Furthermore, this chapter will guide the researcher to design the research methodology for answering with the research questions and meeting with the research objectives.

## 2.1 Literature Review

In this literature review section, the researcher provides literatures that relevance with the research. This section composes of two parts. The first part represents details of the performance measurement (PM) in term of the definition, key performance measurement indicators (KPIs) in general supply chain performance measurement and in environment dimension, and the summarizing of literature reviews on the currently performance measurements. The second part of this section presents methods that use to assess supply chain performance including of methods that use to test validity of the conceptual performance measurement framework and also use to confirm the conceptual performance framework. This part is also provide theoretically acceptable evidences on the basis of performance measurement foundations. Moreover, the literature reviews in this section explain essential methods to evaluation performance measurement of supply chains and guide the research on how to construct a new integrating performance model for using to evaluation the Thai frozen shrimp supply chain.

### 2.1.1 Performance Measurement (PM)

The Supply Chain Management (SCM) has been considered about the attention both in the popular business process and in the academic research (Gunasekaran, Patel, & McGaughey, 2004; Lambert & Cooper, 2000;). It also has stability increasing of the importance in the business administration field due to the increasing of competitiveness in the global market (Xu et al., 2009). SCM is defined as the partnership or alliance is known as supply chain, and the planning, organizing, and control of the activities in this supply chain (Chan et al., 2003). Thomas and Griffin (1996) stated that the SCM is defined as the way to manage materials, products, and information flows from the raw material suppliers to final customers. According to Lopez et al. (2010) SCM was emerged as the best practice in order to improve business processes and develops customers, supplier and third party partners' relationships. Furthermore, an interesting of the successful glowing of the SCM has been found in the agro food industry, both in developed and developing countries (Van der Vorst, 2006). To success in SCM, the Performance Measurement (PM) in the supply chain is considered as the important element of the corporate performance. Therefore, a performance evaluation or a PM in supply chain can contribute to the development and improvement of SCM (Chan & Qi, 2003).

The PM in supply chain can be defined as the process of quantifying of the efficiency and the effectiveness of past actions (Neely et al., 1995). The definition of the PM can also be defined as a process of assessing and evaluating of the effective and efficient utilizing on people, resources, and technology of the organization. Moullin (2003) cited in Striteska and Spickova (2012) defined the definition of performance measurement is "Performance measurement is evaluating how well organizations are managed and the value they deliver for customers and other stakeholders". In addition, the PM is the one of many essential components in a general management system that can be formed in to a performance management system. According to Aramyan, (2007) presented and referred other wordings in the context of performance scheme that it must be identified as "Performance indicators are the criteria with which the performance of products, services, and production processes which can be evaluated".

The Performance Measurement System (PMS) is the system that enables an organization to monitor the significant performance indicators of products, services, and production processes.PMS composed of a performance conceptual model, the PM and aggregation method, and example performance measurements (Chan & Qi, 2003). According to Chan et al. (2003) the PM in a supply chain can be classified broadly into two measurement categories: qualitative measurements (such as customer satisfaction and product quality) and quantitative measurements (such as the order-to-delivery lead time, supply chain response time, flexibility, resource utilization, delivery performance, etc.). Quantitative performance measuring metrics of supply chain can be further classified into two broad categories: financial and non-financial performance measurement.

In the tradition PM, the organization of PM only is focused on financial performance. It is not enough provide the explicit of the existing performance of organizations and it is not enough to satisfy the performance measurement in the new economic because many organizations and the markets increased the need in the complexity business (Striteska & Spickova, 2012).Therefore, many researchers intended to measure performance in both of financial and non-financial dimensions. For this reason, the quantity of publications on the performance measurement has been increasing and covering not only financial dimensions but also non-financial dimensions (Beamon, 1999; Sen & Yeng, 1998).

### 2.1.2 Key Performance Measurement Indicators (KPIs)

In the tradition performance measurement, KPIs were used to evaluate a supply performance in individual case indicators especially in the financial dimension such as general companies use the revenues as performance indicator to assess their the financial performance and to compare with their competitors. Beamon (1998) grouped KPIs in to the resource, output, and flexibility. While Chan et al. (2003) grouped KPIs into two dimensions such as quality (cost, resource utilization) and quantity (quantity, flexibility, visibility, trust, innovation). Gunasekaran et al. (2001) evaluated the SCM and developed the performance measurement framework encompassing on the strategic, operational and tactical levels. The framework deals with a range of costs, including suppliers cost, delivery cost, customer services cost, inventory cost, and logistics costs.

In 2004, Gunasekaran and his research team added metrics for measuring the performance in supply chain in terms of plan, source, make and delivery into a strategic, an operation and tactical levels. Bhagwat and Sharma (2007) proposed the BSC method which used to group the KPIs in terms of the financial and non-financial measurements by addressed the dimensions of cost, time, quality and flexibility. Theeranuphattana and Tang (2008) that referred to Chan and Qi's series of research which were published in 2003 and 2005 respectively, grouped KPIs in terms of the customer-facing and the internal-facing that based on the first level of a SCOR model. Next in 2007, Hwang and his team of researchers studied and grouped KPIs in terms of customer relationships, cost and assets, which was similar to Adisak's grouping. Furthermore, Shepherd and Gunter (2006) categorized KPIs in terms of cost, time, quality, flexibility, and innovation. Cai et al. (2009) and Baemon (1998) categorized KPIs in terms of resource, output, flexibility, innovation and information. Summaries of each author's main groups of KPIs are presented in Table 2.1. In Table 2.1, it is summarized that the main popular KPIs are categorized as flexibility, cost, responsibility, quality, reliability and innovativeness and also shown the overall of supply chain performance measurement dimensions of a performance measurement in supply chain.

Moreover, environmental management has become important for manufacturers as they face intense scrutiny from diverse stakeholder groups, including end consumers, industrial customers, suppliers, and financial institutions. In recent years, environmental management has evolved to include boundary-spanning activities such as the ones developed by Olugu et al. (2010) in KPIs in forward chain and backward chain for the automobile GrSCM while Zhu et al., (2008) suggested that internal environmental management, green purchasing, and eco-design should occupy an important place in environmental management. All of this suggestion has impact to GrSCM in Chinese manufacturing. Moreover, measurement items, such as waste water, air emission, solid wastes, energy consumption, and toxic materials directly impact on environmental management. Vachon and Klassen (2008) adopted environmental management into a green supply chain management (GrSCM) in order to achieve corporate profit and market share objectives by reducing environmental risks and impacts while improving ecological efficiency of these organizations and their partners. They further that SCM must extend their efforts to improve environmental practices

across their supply chain. Therefore, many processes which directly affect the environment should consciously be avoided at the expense of social benefits and environmental impacts. Specifically, food supply chains which have a process from upstream to final stream process, and reversed flow. Shang, Lu, and Li (2010) showed outcome of dimension in term of green manufacturing and packaging, Environmental participation, green marketing, green supplier, green stock, green eco-design. From the Kyoto agreement, one of the key and fundamental management aims to reduce gas emission, particularly carbon dioxide, organizations have become focused on carbon footprint. Defra (2006) suggested 22 environmental performance indicators in four categories that should be considered to UK business in term of emission to air, emission to water, emission to land, and resource use. Moreover, carbon footprint was one of key strategic environmental measures for supply chain and supply chain benchmarking. Carbon footprint can measure in unit such million tones or kilograms per annum. Therefore, carbon footprint was a useful key measure to evaluate and to calculate carbon dioxide emissions across chains (Braithwaite & Knivett, 2008; Carbon Trust, 2008; Defra, 2007). Moreover, Giap et al. (2011) suggested that environmental KPIs in term of gas emission, water use, land use, chemical use are important to evaluate in respect of environmental aspect. According to Shaw, Grant, and Mangan (2010) developed the performance model framework that integrated an environmental measure within an exist supply chain performance frame work. This framework based on the BSC and was added environment perspective into BSC perspectives. Carbon trading indicator was added in a financial perspective and carbon emissions ratio was added in an internal business perspective (Shaw et al., 2010).

Table 2.1 The overall dimensions of supply chain performance measurement

| Study | financial efficiency | Flexibility | responsiveness | Quality | Innovativeness | Environmental indicators |
|---|---|---|---|---|---|---|
| Neely et al. (1995) | x | x | | x | | |
| Baemon (1998) | x | x | x | | | |
| Lambert et al. (1998) | x | | x | x | | |
| Baemon (1999) | x | x | | x | | |
| Van der Vorst (2000) | x | | x | x | | |
| Chan and Qi (2003) | x | x | | x | x | |
| Chan et al. (2003) | x | x | x | | x | x |
| Gunasekran (2004) | x | x | | | | |
| Lohman et al. (2004) | x | x | | | | |
| Shepherd and Gunter (2006) | x | x | x | x | | |
| Brawat and Shama (2007) | x | x | | x | | |
| Adisak and tang (2007) | x | x | x | | | |
| Chibba (2007) | x | x | | x | x | x |
| Defra (2006) | | | | | | x |
| Aramyan (2007) | x | x | x | x | | x |
| Defra (2007) | | | | | | x |
| Braithwaite and Knivett (2008) | | | | | | x |
| Zhu and Lai (2008) | | | | | | x |
| Schmidberger (2008) | x | | | x | | |
| Cai et al. (2009) | x | x | | | | |
| Kim (2009) | x | x | | x | | |
| Shaw et al. (2010) | | | | | | x |
| Giap et al. (2011) | | | | | | x |

A description of popular and significant KPIs could be identified in each popular category (Pungchompoo & Sopadang, 2010).

**Financial efficiency:** The profitability of an enterprise is directly affected by the cost of its operations. Therefore, profitability is an important factor that influences the whole supply chain performance. Because this characteristic, efficiency, is embedded in profitability, and it is linked to the performance measurement chain (Chan, 2003). It is consisted of: (E1.) Manufacturing costs, including labor, maintenance and re-working costs, purchased materials, equipment charges, and the supply's margin; (E2.) Distribution costs, including transportation and handling costs, safety stock cost, and duties; (E3.) Inventory costs, including work in process (WIP) and finished goods inventories. Zhang and Aramyan (2009) pointed out that the financial dimension is significant to performance measurement supply chain orientation. Two indicators are composed of 1) (E4.) Profit, which was supported by Chan and Qi, (2003), including the positive returns from a business investment after subtracting all expenses and 2) Return on investments (ROI) (E5), was also advocated by Bigliaridi and Bottani (2010), a measurement of a firm's profitability, measuring how effective the firm is in using its capital to generate profit. A profit indicator, which introduces new measures, is becoming a need because a majority of performance measures are related to costs, while reducing costs and making more profit is the main objective of any business.

**Flexibility:** Beamon (1998) defined flexibility as the degree of choice in responding to random fluctuations in the demand pattern. It was used to measure the supply chain's ability to cope with volume and to schedule variations in production from customers as well as suppliers. Moreover, flexibility might be measured in terms of how much of an ordered volume can be changed during specific time periods, after the order date or before the delivery date. Carefully reviewed, flexibility indicators are composed of: (F1.) Volume flexibility, defined as the ability to respond to a change in demand could be calculated in terms of the demand variance, along with maximum and minimum profitable output volumes during any period of time (Lohman, Gortuin, & Wouters, 2004; Zhang & Aramyan, 2009). (F2.) Delivery flexibility, defined as the ability to respond quickly to tight delivery requests or delivery to a changed planned

delivery date, could be calculated by the ratio of the difference between the latest time period during which the delivery can be made and the earliest time period during which the delivery can be made, to the difference between the latest time period during which the delivery could be made and the current time period (Lohman et al., 2004; Zhang & Aramyan, 2009). (F3.) Customer satisfaction might be defined as the degree of customer satisfaction with the product and/or service received and can be applied to internal or external customers. Customer satisfaction is comprised of two elements: namely, pre-transaction satisfaction, and post-transaction satisfaction. The percentage of satisfied customers to the percentage of unsatisfied customers could also be calculated (Chan, 2003: Zhang & Aramyan, 2009). (F4.) Backorders are defined as the orders which are currently out of stock, but which are being re-ordered (with the customer willing to wait unit the re-supply arrives) and which will be available later. This concept was measured by the proportion of the number of backorders to the total number of orders (Zhang & Aramyan, 2009). (F5.) Lost sales, was defined as an order that was lost due to a lack of stock, and because the customer was not willing to wait or permit a backorder. Lost sales are measured in terms of the proportion of the number of lost sales to the total number of sales (Zhang & Aramyan, 2009).

**Responsiveness:** Baemon (1998) measured responsiveness, which was based on customer responding. It was composed of: (1) Fill rate maximization, which maximizes the fraction of the customer's order filled on time. (2) Product lateness minimization, which minimizes the length of time periods between the agreement of product delivery date and the actual product delivery date. (3) Customer response time minimization, which minimizes the length of time required between the time an order is located and the order time is received by the customer. Normally, it refers to external customers only. (4) Lead time minimization, which minimizes the length of time required from the time a product has started its manufacture until the time it is completely processed. (5) Customer complaints, defined as the registered complaints from customers about products or services (Zhang & Aramyan, 2009). Moreover, responsiveness is the level of confrontational attitude of an enterprise in regards to customer complaints, as well as increasing speed of delivery.

**Quality:** White (1996) suggested that there are eight dimensions of quality including performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. Garvin's eight dimensions can measure overall perceived quality by using subjective benchmark measures. In agro-supply chains, quality is an important measurement, especially in the cases of non-financial measures of specific products and the characteristics of production. Not paying attention to quality can cause hazardous infections in raw materials, especially through the insufficient application of the Hazard Analysis and the Critical Control Points (HACCP), which can lead to hazardous infections in final products (Loc, 2006). According to Zhang and Aramyan (2009), quality is composed of product quality and process quality. More details regarding quality are indicated in Zhang and Aramyan (2009). The conceptual framework which is comprised of the product quality indicators and the process quality indicators were shown in table 1. (Q1.) Appearance is relevant to all attributes of products. (Q2.) Product safety is defined as a product which does not surpass an agreeable level risk associated with pathogen or chemical and physical hazards, such as microbiological or chemical contaminants in products, and micro-organisms. (Q3.) Product reliability refers to compliance of actual product composition with the product description. (Q4.) Traceability is an ability to trace the production's history, application or location of products, using recorded identifications. (Q5.) Storage and transport conditions are described as transportation and storage of products that suit a good quality. (Q6.) Working condition is defined as a standard of condition which ensures a hygienic, safe working environment, with correct handlings and good conditions.



Environmental Indicators is (Q7.) Carbon footprint is all GHG emissions which can be calculated in terms of carbon emission and carbon emission content is shown in the tag on the product package. (Q8.) Energy use is defined as the content of energy which is used in all shrimp productions. (Q9.)Water use is defined as the content of water used in all shrimp productions. (Q10.) Chemical use is defined as the content of chemical used in all shrimp productions.

**Innovativeness:** In the ever-changing business environment, innovation is crucial - it is the tool of competition between rivals in the global market (Cai et al.,

2009; Chan, 2003). The researchers present two indicators of innovation: (1) the quality and quantity of new products launched. They can be compared to a number of products launched by a particular company within a specific period, and (2) the use of new technology, which can be measured, based on the decreased amount of time required to produce an existing product.

### 2.1.3 Summary of the Current Literature of the Performance Measurement in Supply Chain

According to current literature reviews on the performance measurement in supply chain, it would be stated that the research in the performance measurement area was conducted in many research contexts. During years 1890 to 2011, the variety survey researches on performance measurement in supply chain were conducted. The researcher applied the searching technique of the free text option in the Google Scholar Database to select evidences. The key words, the title and contents related to "performance measurement" were used for retrieving relevant data. The reason that the researcher fixed search term with the title is to check for the existing evidences that relevance to the performance measurements. The results indicated that most evidences retrieved from the title and contents regard to the performance measurement were discussed mostly on supply chains, business, manufacturing, environmental and agricultural contexts. It is noted that the research on the performance measurement has continued to increase annually. The most interesting research evidences that is presented in Table 2.2 is the available papers about "supply chain performance measurement" and "environmental and carbon footprint". However, there have searching limited in term of the researcher unable to assess evidences since many articles are available only abstract. There have also lacked of specifically research evidences that can mentioned excitingly of the performance measurement in supply chain (including the performance measurement of the Thai's frozen shrimp supply chain). Therefore, given the limitation of the systematic searching and of evidences and no research evidence about the performance measurement of supply chain, the new research study on the developing of the integrating performance measurement model for using to evaluate specifically with the Thai's frozen shrimp supply chain is urgently required. The conducting of the current study will therefore fulfill the new knowledge

and specific needed evidence in the area of the performance measurement from this research literature reviews.

Table 2.2 Number of performance measurement articles

| Study area | 2011 | 2010 | 2000- 2009 | 1990- 1999 | 1980-1989 | 1970-1979 | 1960-1969 | 1950-1959 | 1940-1949 | 1930-1939 | 1920-1929 | 1900-1909 | 1890-1899 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All in titles | | | | | | | | | | | | | | |
| Supply chain | | 15 | 163 | 8 | | | | | | | | | 1 | 187 |
| Business | 2 | 15 | 151 | 51 | 4 | 1 | | | | | | | | 224 |
| Manufacturing | 3 | 6 | 00 | 2 | 1 | | 1 | | | | | | | 23 |
| Agricultural | | | 3 | 1 | 1 | | | | | | | | | 4 |
| Environmental | | 5 | 6 | 8 | 8 | | | | | | | | | 47 |
| Green supply chain | | | 7 | | | | | | | | | | | 7 |
| Carbon footprint | | | | | | | | | | | | | | 0 |
| "Supply chain performance measurement" +Environment +Carbon footprint | | | | | | | | | | | | | | 0 |
| All in paper content | | | | | | | | | | | | | | |
| Supply chain | 4 | 71 | 66 | 1 | | | | | | | | | | 168 |
| Business | 4 | 39 | 70 | 1 | | | | | | | | | | 030 |
| Manufacturing | 3 | 31 | 79 | 2 | | | | | | | | | | 32 |
| Agricultural | 7 | 6 | 52 | 6 | | | | | | | | | | 21 |
| Environmental | 2 | 20 | 43 | 1 | | | | | | | | | | 84 |
| Green supply chain | 1 | 9 | 67 | 3 | | | | | | | | | | 99 |
| Carbon footprint | 1 | 4 | 2 | | | | | | | | | | | 6 |

*Retrieved March 10, 2011, from scholar.google.com*

## 2.2 Models and Methods to Assess Supply Chain Performance

Different methods exist that lead to the development in a supply chain performance measurement (SCPM). Some of the most well known in the last decade are Economic Value Added (EVA), Activity Based Costing (ABC), the Supply Chain Operations Reference (SCOR) Model, the Balanced Scorecard (BSC), Multi Criteria Decision Method (MCDM), Data Envelopment Analysis (DEA), and Structural Equation Modeling (SEM). The review in this section informs and discusses different measurement methods in two categories: Traditional measurement methods and Modern measurement methods that including the advantages and disadvantages of these measurement methods.

### 2.2.1 Traditional Measurement Methods

Focused on short term financial as profits and revenues, two financial indicators present little the company success and lead to long value of its shareholders. Therefore, Economic Value Added (EVA) was proposed to estimate company economic base on the assumption of shareholder value increasing. EVA is less useful to measure supply chain performance but it and included to other measurement method (Lapide, 2000). The EVA can explicit cost of capital and allows project to be considered separately (Aramyan, 2007).

Another traditional method is the Activity Based Costing (ABC) method is not only based on accounting methods but also involves breaking down activities into individual task or cost drovers, while estimating the resources. This approach is suit to assess productivity and costs of supply chain process. It is accurately to assess cost of services for specific customer or cost of marketing of specific products (Lapide, 2000). The advantage of ABC method provides a better understanding of performance by looking at the same number in a different way (Aramyan, 2007).

According to the SCOR model, (2005) the SCOR model was developed from the Supply Chain Council on 1996, which explains that the SCOR model is a management tool that has been developed and endorsed as the diagnostic tool for supply chain management. Widyaningrum and Masruroh, (2012) informed that the SCOR could use to evaluate performance in term of plan, source, make, delivery, and return that are cover the whole business process in supply chains. At the same reason, Theeranuphattana and Tang (2007) applied the SCOR in level 1 together with Fuzzy AHP for prioritizing performance indicators and also compared the results with the study of Chan and Qi (2003). Moreover, Alberto et al. (2011) analyzed the problem and improved the SCM information system by using the SCOR and the business process approach. To evaluate performance in the systematic approach, Graig and Hannes (2005) proposed a performance measurement framework by grouping KPIs from variety studies. The framework was measured and based on the SCOR model by consisting of two dimensions (qualitative and quantitative dimensions), and five main criteria.

The balance scorecard (BSC) concept is widely used to evaluate the particular business process and the SCM (Bhawat & Shama, 2007; Kaplan & Norton,

1992). The BSC is a standard method to measure a performance from four different perspectives: financial, internal business process, the customer, and learning and growth. Kaplan and Norton (1992) found strategic maps and shown causal relationships between metrics. The association with different perspectives could build a cohesive and integrative view of the firm strategy. Four key themes were created including the customer value, operational excellence, and community relationships. Bhagwat and Sharma (2007) suggested that the BSC was adopted as the foundation for the strategic management system and widely promoted this through their articles (Bhagwat & Sharma, 2007; 2007a; 2010). The advantage of the BSC is clarify on vision and strategy adopted, is consistency monitoring of strategy, shows cause and effect relationships as instrument for management. Therefore, the BSC is not only helps organizations with to improve the progress of monitoring of their operations but also it can effectively help them for improving their internal and external business functions such as engineering and design applications, production, quality improvement, materials management, quick response, gaining lost market shares and proper implementation of business strategies.

### 2.2.2 Modern Measurement Methods

The performance measurement of supply chain is necessary element since the measurement can affect decision-making throughout the evaluation of the past behavior and the opportunity of benchmarking (Van der Vorst, 2006). For the efficiency and effectiveness of the supply chain, many studies applied the MCDM, such as the analytical hierarchy process (AHP) (Bhagwat and Shama, 2007) and Fuzzy set theory which can be applied to many fields. For example, Kruien and Qureshi (2012) integrated the BSC and the AHP to measure and to prioritize green supply chain performance of 3 companies. Kainuma and Tawara applied a multiple attribute utility to assess supply chain performance in concept of lean and green supply chain management. Hwang and Hwang (2006) used fuzzy–AHP and the fuzzy set method to analyze the selective school food service problem. Four alternatives of results of the research were comprised of 1) outsourcing, 2) partial ownership, 3) short-term contracts and 4) making production while the attributes are cost, quality and product flexibility, respectively. Results of the study of Hwang and Hwang (2006) gave the similar results through two different methods, which chosen outsourcing as the solution to the food service problem. In a new product development problem, Ko (2010) applied fuzzy set

theory to the DSM method. Given the successful results of those two studies, Karakas et al. (2009) integrated the fuzzy set theory with the optimization method, based on ABC, for optimal product mix decisions. Furthermore, Chan and Qi (2003) introduced an innovative method–decreasing vagueness of human judgment. In multi-attribute decision method (MADM), the fuzzy set theory could be used to combine with. Instantly, fuzzy multi-attribute decision making (FMADM), which was based on selective criteria from the BSC model, may be used with fuzzy–AHP method of the weight-giving. The Fuzzy–Topics is to help suppliers prioritize a problem, and it based on BSC criteria (Kamalabadi et al., 2008). The fuzzy-AHP was developed to evaluate efficiency and effectiveness performance measurement model of organizations (Chan & Qi, 2003). However, all methods described above have two weak points (Kim, 2009; Zhu et al., 2008). Firstly, a performance model, which used to test the research instrument, should provide the good reliability and validity score, in case the data will be collected by using the survey questionnaire. Secondly, the performance model, which came from the decision-making method, could not show the correlation among factors in terms of the causal relationship.

In recently, a performance model can also be improved by using the appropriate statistic analyzing method. Tippayawong, Patitad, Sopadang, and Enkawa (2010) applied factor analysis (FA) to determine a performance structure of high-tech and low-tech industry groups and use to evaluate an operational performance in both industries by using the Logistics Scorecard model (SCM). The results not only showed that the high-tech industry group had significantly better than the low-tech industry group but also exposed all factors that were differently in terms of IT utilization. Wen (2010) evaluated the performance of Taiwan electronic industry by using integrated methods between FA and AHP. This study showed a performance framework that is composed of 16 indicators in both of financial and non-financial dimensions and could categorized into four categories for prioritizing with AHP method to further his study. Furthermore, many studies had suggested for the usefulness of using a structure equation modeling (SEM) as the SEM was used to explain the relationship among multiple variables. SEM became being more popular tool than exploratory factor analysis (EFA). Therefore, SEM was used widely to apply in sociology, psychology, management and economic areas (Chinho et al., 2005; Kim, 2009; Li et al., 2009;

Punniyamoothy et al., 2011; Zhu et al., 2008). The SEM was described as the combination of the exploratory factor analysis and the multiple regressions. Moreover, it was used to test validity and reliability of the measurements. For this reason, many researchers used SEM to analyze and to test the model. In the SEM approach, the Confirmation Factor Analysis (CFA) is the useful method to confirm a research theory and to test validity and reliability of the research model. For example, Olugu et al. (2010) used the CFA for confirming KPIs in the close loop of the automobile green supply chain. Moreover, it can use to combine with MCDM method for selecting suppliers (Punniyamoothy et al., 2011). For example, Puuniyamoorthy et al. (2011) use 2nd CFA combined with Fuzzy logic in supplier selection while Tseng and Lee (2009) applied SEM to explain how human resource practices have effected to organizational performance. Li et al (2005) developed and validated six dimensions of SCM practices (strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices, and postponement by using SEM. To achieve of the explanation in the casual model, many studies applied LISREL software to calculate a statistical values (Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005; Punniyamoorthy et al., 2011; Tseng & Lee, 2009). Lin et al (2005) supposed SEM can help to explore all 6 hypothesizes that: H1) the influence of Quality Management (QM) to Organizational performance (QP); H2) QM practices and supplier participation are significantly correlated; H3) the level of supplier participation practice positively influences the degree of organizational performance ;H4) the level of supplier selection practice positively affects to the degree of organizational performance; H5) the degree of QM practice positively influences the degree of organizational performance and H6) supplier participation and supplier selection are significantly correlated. All 6 hypothesizes can be link causal relationship between supply chain quality management and organizational performance. To evaluate model, researchers collected data of from two countries which are Hong Kong and Taiwan with each approximate a hundreds of firms from delivery services. From the results all hypothesizes except H4 and H5 were accepted with x2 90.96 and all factor loadings and path coefficients significant and 0.05 in both of Hong Kong and Taiwan firms. Although H4 and H5 were rejected, the level of supplier selection practice and the degree of QM practice positively indirect influences to the degree of organizational performance. In summarizing, SEM relied on

several statistical testing for determining the adequacy of the model to fit with the data. SEM was also applied to estimate the degree in which the hypothesized model fitted with the data.

A Data Envelopment Analysis (DEA), the DEA was first introduced by Charnes and Cooper in 1978 as a linear programming (LP)-based on the methodology for performing analysis of how efficiently a company operates. Wong and Wong (2007) applied DEA method for measuring internal supply chain performance. The applied DEA in this research has two variables: input variables and output variables. Input variables are composed of cost, cycle time and production flexibility. Output variables are composed of revenue and the on-time delivery rate. A ratio between output and input is called the technical efficiency score. A calculation of the technical efficiency score (TE) will be efficiently considered if the TE score is equal to one. The results reflect the ability of a firm to have maximum outputs from a given set of inputs. Cost efficiency (CE) is the ratio of minimum cost to observed cost. CE provides the cost-efficient model, which is equivalent to the opportunity cost. Finally, the allocated efficiency (AE) reflects the ability of a firm to use the inputs in optimal proportions and assigns their respective prices. Thus, DEA has been proven reliable and flexible and has been an efficient tool for measuring supply chain performance. The DEA can measure multiple inputs and an output, which means can operate as a multi-criteria decision making (MCDM) tool. In a comparison of this inherited feature of DEA to other MCDM tools such as the analytic hierarchy process (AHP). The advantages of DEA enable managers to evaluate any measures efficiently as they do not need to find any relationship that relates them. Aramyan (2007) pointed out the DEA is suitable to be used in measuring supply chain efficiently because it can handle multiple inputs and outputs while it does not require prior unrealistic assumptions on the variables which are inherent in typical supply chain optimization models. For example, known demand rate, lead time.

## 2.3 Principles and Theory

### 2.3.1 Structure Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA)

Mueller (1996) observed that the SEM is the powerful multivariate data analysis in the social science research, especially, in the fields of sociology, psychology, and education. Many researches are used to applying SEM to estimate reliability and validity (Li et al., 2009; Olugu et al., 2010; Punniyamoorthy et al., 2011; Tseng & Lee, 2009; Vachon & Klassen, 2008; Xu et al., 2009; Zhu et al., 2008) because SEM is the statistical methodology that takes a hypothesis testing approach to allow a better conceptualization of the theory. In supply chain, SEM is adopted in many study areas such as Agro-food supply chain (Aramyan, 2007), GrSCM (Zhu et al., 2008), supplier selection (Punniyamoorthy et al., 2011), supply chain management practice (Li et al., 2009), and supply chain performance evaluation (Xu et al., 2009) to estimate reliability, validity, and confirmation of a measurement model too. SEM is the combining method from the path analysis and factor analysis. Moreover, SEM can take the confirmatory approach rather than exploratory approach and does not have any limitation on the number of variables. SEM is a tool that used to estimate the degree in which a hypothesized model fits the data. On the other hand, in a CFA, goodness-of-fit indexes are estimated for each latent variable as a distinct structural model. Therefore, SEM is very useful to explain the relationship among multiple variables after confirming a model by confirmatory factor analysis (CFA) or after irrelevant ones have been eliminated by factor analysis (FA). Three equation models are used SEM including measurement model (2.1), structural equation model (2.2) and measurement model (2.3).

Measurement model: $X = \Lambda_X \xi + \delta$ (2-1)

Structural equation model: $\eta = \beta\eta + \tau\xi + \zeta$ (2.2)

Measurement model: $Y = \Lambda_Y \eta + \varepsilon$ (2.3)

Variable definition:

$X$ - Observed exogenous variable.

$Y$ - Observed endogenous variable.

$\xi$ - Latent exogenous variable.

$\eta$ -Latent endogenous variable.

$\delta$ - Measurement error in an observed exogenous variable.

$\varepsilon$ - Measurement error in an observed endogenous variable.

$\zeta$ - Error term associated with the Latent endogenous variable.

In this model, Equation (2.1) and (2.3) describe the relationship between a latent variable and index. Equation (2.2) describes relationships among latent variables. Furthermore, most people like to think of SEM as CFA and multiple regressions because SEM is include of a confirmatory technique, but it also can be used for exploratory purposes. In comparison SEM and CFA, SEM extends the possibility of relationships among the latent variables and encompasses two components: (a) a measurement model (essentially the CFA) and (b) a structural model (Figure 2.1).

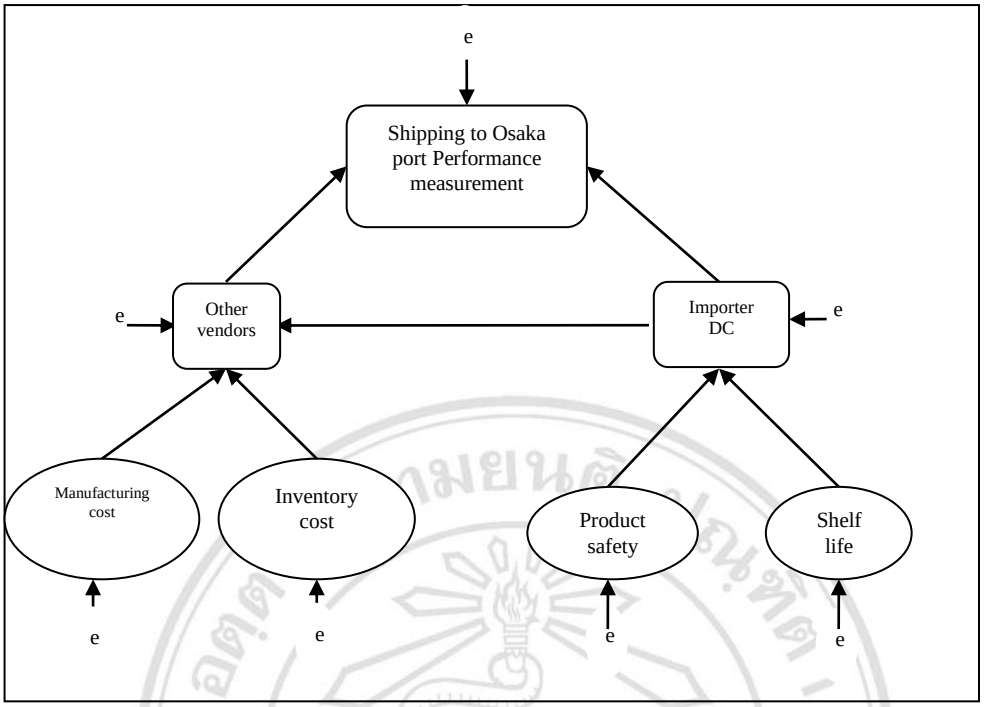


Figure 2.1 Example of Hypothesized structural equation model. Boldface arrows indicate structural component (e = error)

Moreover the new terms, measurement and structural, two other terms are associated with SEM: *exogenous* as independent variables and *endogenous*, similar to dependent or outcome variables. Exogenous and endogenous variables can be observed or unobserved, depending on the model being tested. Within the content of structural modeling, exogenous variables present those constructs that exert an influence on other constructs under study and are not influenced by other factors in the quantitative model. Those constructs identified as endogenous are affected by exogenous and other endogenous variables in the model.



CFA is a type of SEM. CFA was used to assess how well the observed variables, such as measurement items, reflect unobserved or latent variables in the hypothesized structure. A strong a priori basis from our previous research warrants the use of CFA instead of Exploratory Factor Analysis (EFA). Suhr (2006) indicates that CFA is a powerful statistical technique. CFA allows a researcher to test the hypothesis that there exists a relationship between the observed variables and their underlying latent construct. The researcher uses knowledge of the theory and empirical research, or

both to postulates the relationship pattern a priori and then tests the hypothesis statistically. Moreover, Suhr (2006) also indicates some similarities and differences between CFA and EFA, which one illustrated in Table 4. The equation model is used to calculate CFA in equation (10).

Table 2.3 Similarities and differences between CFA and EFA

| **Similarities between CFA and EFA** | **Differences between CFA and EFA** |
|---|---|
| • Both techniques are based on linear statistical models.<br>• Statistical tests associated with both methods are valid if certain assumptions are met.<br>• Both techniques assume a normal distribution.<br>• Both incorporate measured variables and latent constructs. | **CFA** requires specification of<br>• a model a priori<br>• the number of factors<br>• which items load on each factor<br>• a model supported by theory or previous research<br>• error explicitly EFA<br>• determines the factor structure (model)<br>• explains a maximum amount of variance |

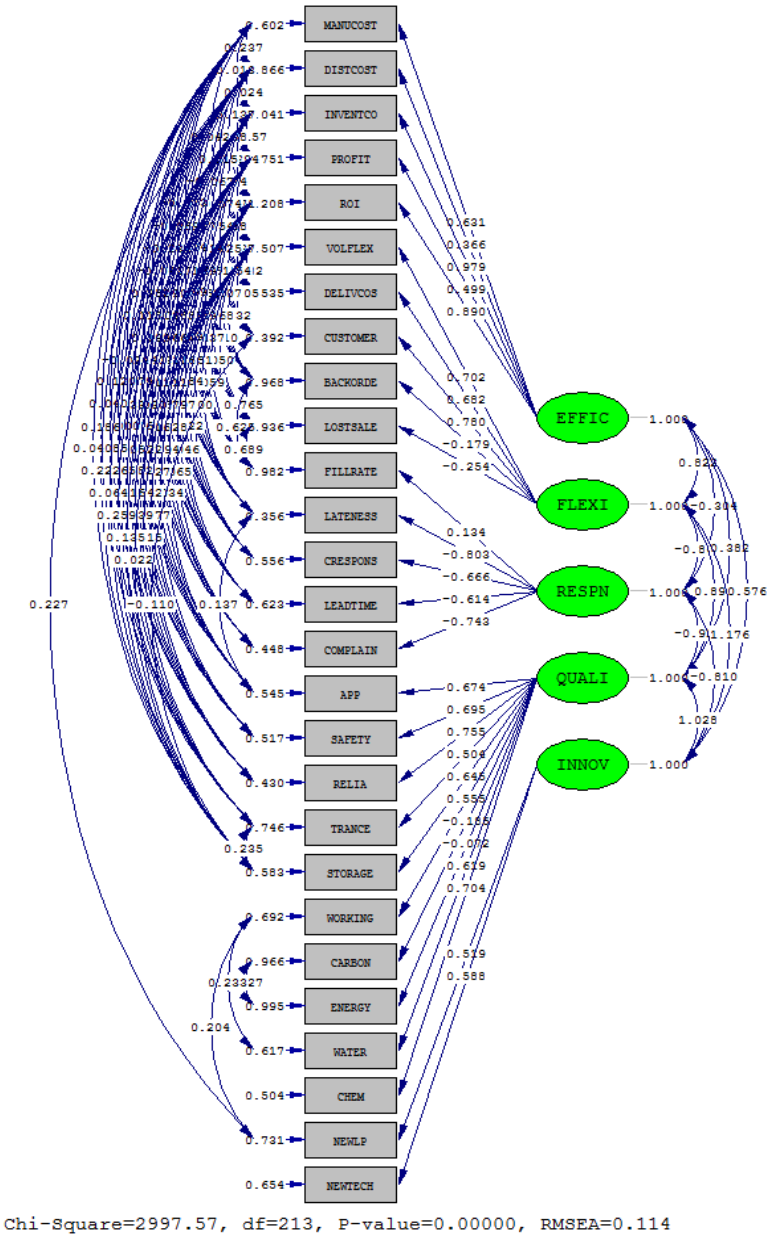




Figure 2.2 Example of a confirmatory factor analysis (e = error)

Figure 2.2 shows a CFA. The latent variables are five variables in a green circle. In the example applied, each latent variable is measured with 2-10 observed variables. The graphic representation in figure 2.2 is the hypothesized model that is to be tested to see how well it fits the observed data. Mathematical equations that exist describe the pictured relationships, but the presentation of these equations is beyond the scope of this study. This study refers to Mueller (1996), Li et al. (2009), which provide explanations of the mathematical models involved in CFA and SEM Moreover to

understand between the first CFA and the second CFA, the first order factor models are those in which correlations among the observed variables that they were collected from the raw data and can be explained by a group of latent variables. In turn, second order factor models are those in which correlation among the first-order factors that can be represented by a single factor. In addition, now latent variables are a dependent variable rather than independent variables in the model. Therefore in the 2nd CFA order, the 1st order of models will be operated as dependent variables; the notation of their observed indicators and measurement errors is consistent with a Y-model.

### 2.3.2 Multiple Criteria Decision Making Method (MCDM)

Decision making, in engineering design, in particular, can help to visualize a collection of activities that relate to the choice in the context of competing technical or functional requirements. The options may either be available or limit in number as shows in Figure 2.3: the multiple decision-making methods (MCDM) developed by Sen and Yang (1998). The field of MCDM is defined either as the multiple criteria decision aid or the multiple criteria decision analysis (MCDA). Belton and Stewart (2003) proposed the advantages of the MCDA, which emphasized the following points:

MCDA seeks to take explicit account of multiple, conflicting criteria in aiding decision making;

The MCDA process helps to structure the problem;

The models provide a focus and a language on the discussion;

The principal of MCDA aims to help decision makers learn about the situation of the problem, about their own and others values and judgments, and through organization, synthesis and appropriate presentation of information to guide them in identifying, often through extensive discussion, a preferred course of action;

The analysis serves to complement and to challenge an intuition, acting as a sounding-board against which ideas can be tested – it does not seek to replace intuitive judgment or experiences;

The most useful approaches are the conceptual transparency;

The previous point is notwithstanding, non-trivial skills necessary to make effective use even of such simple tools in the potentially complex environment.

The research selects the decision-making process in the presence of multiple, potentially conflicting criteria, which can be broadly classified as two types;

1. Selection of an alternative from a menu or catalog based on prioritized attributes of alternatives (For example, multiple attribute decision making or MADM)
2. Synthesis of an alternative or alternatives on the basis of prioritized objectives (multiple objective decision making or MODM)

Figure 2.3 clearly provides the comprehensive terminology summary of the multiple criteria decision-making process (Sen & Yang, 1998).

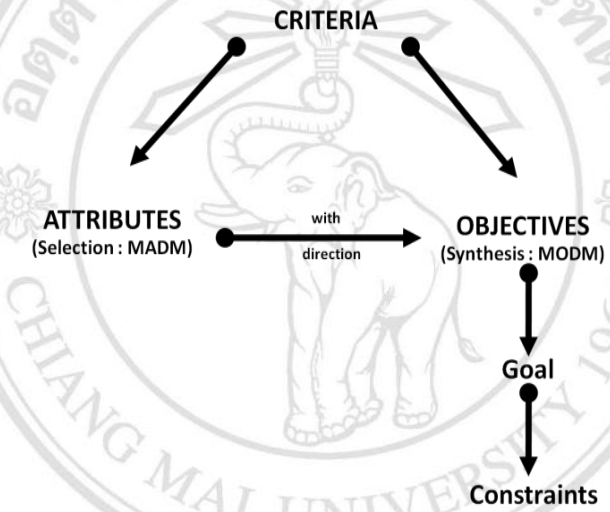


Figure 2.3 Multiple criteria decision-making

*(Source: Sen & Yang, 1998)*



**1) Multiple Attribute Decision Making (MADM)**

In a multiple attribute decision-making, (MADM) (Sen and Yang, 1998) problem usually comprises a finite number of explicitly given alternative designs and asset of performance attributes. Design selection involves either choosing the most favorable design from the alternative set of ranking or all alternative designs concerning all attributes. Figure 2.4 shows the MADM with *n* alternatives $(a_i, i = 1, \dots, n)$ and *k* attributes $(y_j, j = 1, \dots, k)$. Each pair of alternatives $(a_i, a_1, l = 1, \dots, n; i \neq l)$ is compared respectively with attributes $(y_j, j = 1, \dots, k)$. If $m_{ij}$ represents the relative

importance of $a_i$ over $a_1$ with respect to $y_j$, a pairwise comparison matrix for all the *n* alternatives in terms of the attribute $y_j$ can be formulated as in an equation (2.4). The MADM problem is then represented by *k* pairwise comparison matrices for the *k* attributes.

$$M = \{m_{il}\}_{m\times n} \begin{bmatrix} 1 & m_{12} \dots & m_{1n} \\ m_{21} & 1 \quad \dots & m_{2n} \\ \dots & \dots\dots & \dots \\ m_{n1} & m_{n2} \dots & 1 \end{bmatrix} \tag{2.4}$$

Where $m_{lh} = {}^{1}/_{m_{lh}}$ for all *l*, *h =1*, due to symmetry of comparison.

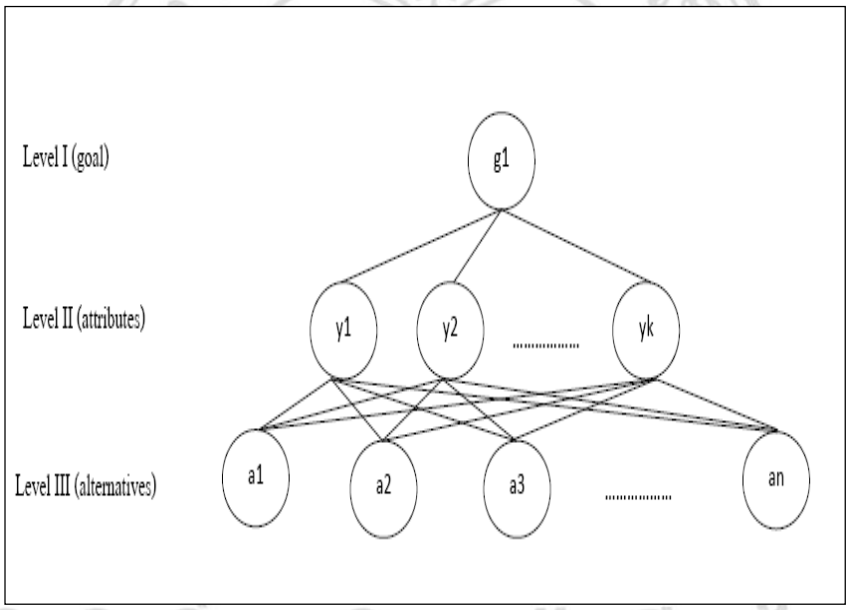


Figure 2.4 The hierarchy of the single – layer attribute structure and complete comparisons

*(Source: Sen & Yang, 1998)*

**2) The Analytic Hierarchy Process (AHP)**

Professor Saaty developed the Analytic Hierarchy Process (AHP) in 1980. The AHP is a multi-criteria decision-making tool used for prioritizing the alternatives in a group-decision environment. The AHP was firstly used to plan for working of the U.S. Department of Defense (DOD). Some of these earliest applications dealt with electricity rationing, transportation planning, and analysis of terrorism. In the

AHP method, the decision problem was deconstructed into a hierarchy of interrelated decision elements, in which elements at each level affected the elements in the level above it. Organizations can break a problem down by increasing the smaller constituent parts, and then guide decision makers through a series of pair-wise comparison judgments (which are documented and can re-examined later) to express the relative strength or intensity of impact of the elements in the hierarchy. These judgments are then translated into numbers. The AHP uses a pair-wise comparison of the same hierarchical elements, in each level (criteria or alternatives) using a scale indicating the importance of one element over another, with respect to higher-level elements (Bhagwat & Sharma, 2007a). The AHP is a popular method because it is easy to use and understand in a wide variety of cases. Therefore, much research has applied the AHP or has integrated the AHP in supply chain performance measurement (Bhagwat & Sharma, 2007a, 2010; Chan, 2003). The AHP method provides a simple way to formulate a MADM problem and to elicit preference information as it only requires comparisons between attributes or alternatives. The computation steps of AHP can be summarized as follow.

Step 1: Establish the hierarchy of MADM problem as shown in Figure 2.4.

Step 2: Formulate a pairwise comparison matrix for elements at a single level of the hierarchy with respect to each of the elements at a level immediately above.

Step 3: Define the weight and rank the element.

AHP is a well-known MADM method. However, it has several weak points. For example, it implicitly assumes that elements at any single level except for the bottom level are preferentially independent. If attributes in a MADM problem are not allowed to evaluate independently, it may be inadequate to use AHP to deal with the problem. Unfortunately, the evaluation of an attribute in a MADM problem may most probably depend upon the achievement levels of other attributes. Likewise, another weak point of AHP is that it requires each alternative be compared with all other alternatives while many of such comparisons are redundant. This often causes problems related to inconsistency. The method also suffers from the rank reversal of alternatives depending on the number of alternatives bring assessed, and this can be a disturbing factor in a normative decision-making tool. Not with standing these complaints, AHP

does clarify many decisions and can lead to acceptable answers if the technique is use caution.

## 2.4 The Case Study

In the case study, the data was collected based on survey questionnaires among 95 farmers, who breed shrimp larva and operate shrimp farms, 7 shrimp brokers, 18 factories and frozen food plants, as well as an interviewing with the big frozen seafood importer in Osaka, Kansai Region, Japan. It is found that the supply chain of frozen shrimps in Thailand is composed of three main groups; the up-stream including farmers and shrimp demands suppliers, the mid-stream including agents, seafood markets, frozen-food factories and seafood processing factories as well as the down-stream suppliers including conventional retailers, such as fresh-food markets, central markets for shrimps, restaurants in the country and modern retailers, such as big supermarkets in the country.

**The Up-stream**

This group is composed of 1) breeders, who breed and raise post larva, 2) farmers, who raise shrimp stock and 3) manufacturers and shrimp demand suppliers, who provide shrimp feed, shrimp medicine and other equipment for shrimp farms. The details of the up- stream group are explained as follows;

1. **Breeders**

In Thailand, there are more than 1,000 farmers to breed shrimps. Post larva is mainly bred in farms in Satun and Phuket provinces, most of which belong to the big water-animal agricultural company in the country.



2. **Minor Farms**

The farms, where baby shrimps are raised, are in the highest number of the group. Each of them has no more than ten ponds when the labors in the farms are people in the owner's family.

3. **Big Shrimp-Farms**

The farm owners in this group mostly are business people. Rather than using labors in the family, in this farm, labors and fishery experts are hired. The farms are in a

vast scale. There are more than ten hatcheries in each farm, and some farms include other small farms in their close areas. Therefore, the farms are well under a systematic process. There are fishery experts to operate the farms, and contracts to food processing factories and frozen food factories are made. In addition, the most of the farmers purchase of the inputs, such as post larva, shrimp feed, medicine and other equipment for the farm, from big companies that sell inputs, from the process of breeding to feeding. They also buy shrimp products back from farmers.

According to the survey, both minor farms and big farms buy inputs from agents. The agents help introduce experts to handle the farm, counsel the farmers, solve problems in the farm, provide important documents for shrimp farming and selling, inform larva and adult shrimp prices as well as find agents to buy adult shrimps.

**The Mid-stream**

This group is consisted of agents or seafood markets and food processing factories. The information of mid-stream has been explained under two headings;

1. **Agents and Frozen Food Factories**

Agents and frozen food factories are the middle persons who connect to the farmers of the food processing factories. Firstly, the agents sort the shrimps by their size and quality. Shrimps with high quality will be sent to frozen food plants, food processing factories, as well as supermarkets. Some of them will be sent to hotels and restaurants. Meanwhile, shrimps with flaws, which are caused from diseases, and under rating of six are delivered to retailers in local markets.



2. **Food Processing Factories**

At present, processed shrimps are instant foods that are more increasing the popularity. They have engrossing additional value and high sales rates in cities. From this information, the number of processing factories can also play the role of exporters. Some of them, for example, Charoen Pokphand Foods PCL (CPF) and The Union Frozen Products Co., Ltd. (UFP) are distributors in the country or have their affiliates play such a role.

**The Down-stream**

This category is divided into three groups and explained separately within two retailers and one buyer.

1. **Conventional Retailers**

They are retail shops in the fresh food market and restaurants. Basically, retailers in the local market buy shrimp directly from the farms. In this term, after shrimps are sold to agents, farmers sell the rest to the retailers to distribute the shrimps in local markets. Then, restaurants in the local corner the retailers for the shrimps.

2. **Modern Retailers**

They are supermarkets, hotels, and exporters. These sellers make future contracts to agents and frozen food factories with specific quality, size and quantity of the shrimps each round of orders. Then, the agents and the factories deliver the product to buyer's designated places.

3. **Frozen Shrimps Buyers in Foreign Countries**

According to an interview with a big company in Osaka, Kansai Region, Japan, who imports and distributes frozen products in the region, the company imports as well as owns and provides warehouses to store frozen products for other importers. It also transports and distributes frozen products throughout the country. The company has 81 warehouses around the country for distributing the goods, which are carried in refrigerated trucks. The imported goods are frozen fresh meat, frozen fresh seafood, vegetables, fruits and ice cream, for example. Most of the frozen shrimps imported by this company are from Thailand. Thai's shrimps are in middle and small sizes, which the brokers of the company's affiliates in Thailand buy directly from frozen, and seafood processing industrials. Then, the goods are delivered to Japan by its affiliate shipping company, before storing in each warehouse throughout the country. The shrimps are distributed to food companies, supermarkets, sushi restaurants and other restaurants around the country. The information is briefly illustrated in the following chart;

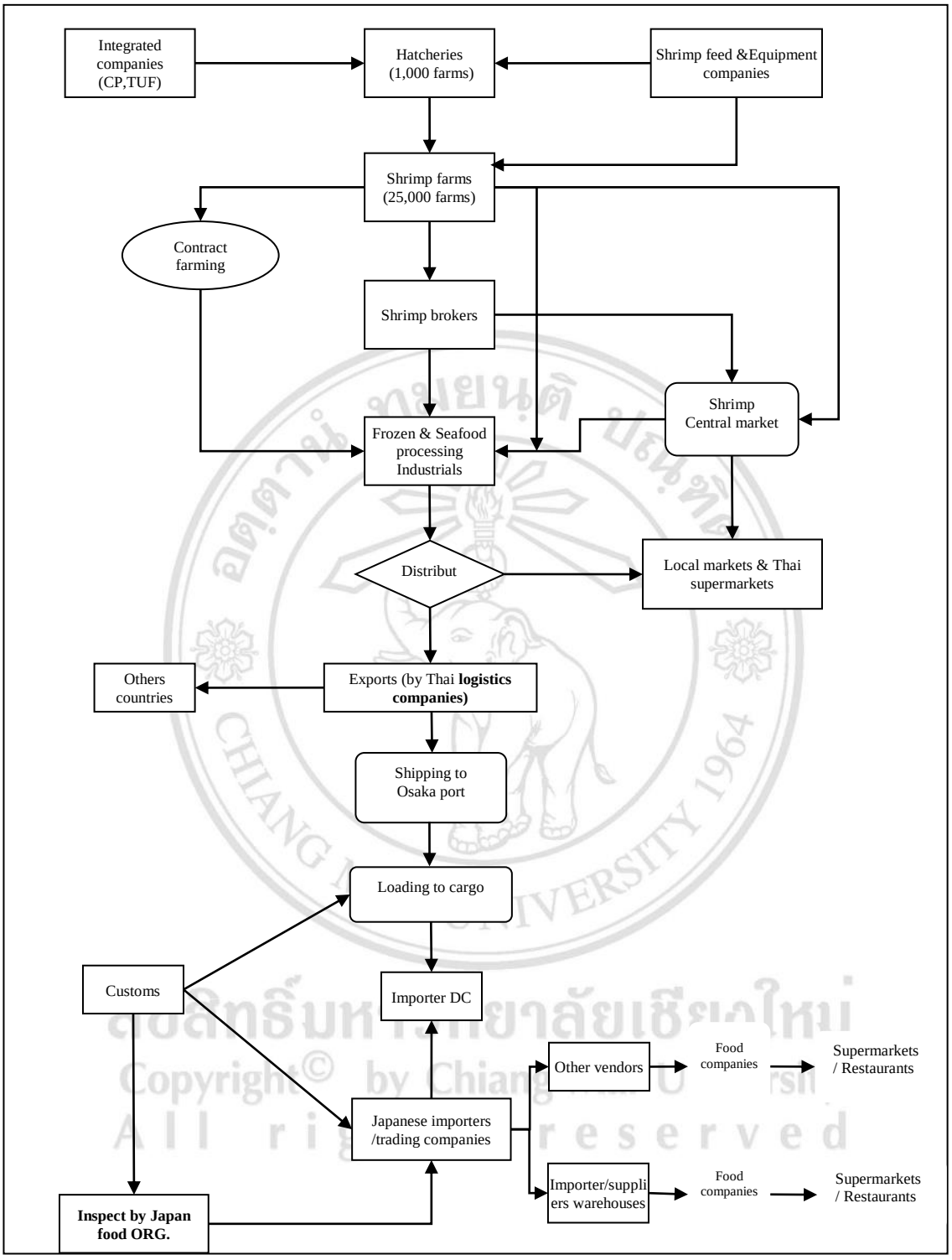


Figure 2.5 The Thai frozen shrimp supply chain and shrimp logistics from Thailand to Japan

According to Figure 2.5 above, the supply chain of Thai frozen shrimps and shrimp logistics from Thailand to Kansai Area, Japan begins from the up-stream breeders and ends at the down-stream customers in restaurants and supermarkets in Japan. Moreover, there is some additional information about the logistics from the survey that there are mainly 4 steps of shrimp farming business in Thailand; 1) post larva procurement, 2) shrimp raising, 3) shrimp harvesting and 4) logistic processes. The logistics process can be divided into two sections; the larva delivery to the farm and the adult shrimp delivery from farms to central markets as well as frozen food and food processing industries.

### 2.4.1 The Shrimp Logistics from Thailand to Kansai Area in Japan

1) The logistics in the Thai shrimp chain starts from hatcheries and finishes at the shipping process to the customer. Ordinarily, the logistics system has three fundamental flows that have detailed as follows;

2) Material flows shrimp feed, equipment, shrimp drug, chemical, Post larva (age 10-15 days), shrimp (3-4 months).

3) Cash Flows: Credit and cash.

Information flows shrimp market price, Post larva price, Post larva reservation, and shrimp auction information.

The transportation in the up-stream usually uses a pick-up car to move post larva, and shrimp feeds to the shrimp pound. While trucks use in mid-stream and downstream for moving shrimp from a pound and to the frozen industries, and the shrimp markets. The ship transportation uses for exporting of the frozen shrimp products from the frozen industries to foreign customers. Moreover, management of the exportation from producers of frozen shrimp products to Japan is one week for ship transportation. By the way, the business and logistics details were explained as follows;

**Post Larva Procurement**

The process of the post larva procurement takes approximately 20-22 days to contact to authorities and complete the documents and costs $1,800 per one round. The time to raise the shrimp is about 90-120 days depending on the size of the shrimp.

In addition, the capital for one kilogram of the shrimps is $2and the highest cost of shrimp aquaculture is in post larva & shrimp feed procurement.

**Shrimp Harvest**

In harvesting shrimps, adult shrimps in each hatchery are auctioned before the harvest, which takes approximately 4-6 hours. The price of the shrimps at the auction belongs to the decision of the bidders while the actual price at a certain time depends on the cost estimate in the market. In addition, the cost of a shrimp harvest process includes in shrimp prices on a shrimp auction process, for example, when farmer and a shrimp broker have a contract to buy shrimp in 100 baht / kg. The harvest cost is added into 100 bahts. The longest time is in an aquaculture process, the document processes for exporting, and the shipping process, respectively.

**Logistics process**

The transportation of shrimp's logistic process takes no longer than two hours to transport larva, which costs $34 each round. Moreover, to deliver adult shrimps from farms to central markets or factories takes from two hours to two days and costs $400 each time. In this term, the cost of production in producing frozen shrimps is also in the account. It includes production cost and inventory cost which is estimated by each kilogram of the shrimps. In addition, the shrimps are exported by shipping. Exporting operation takes 30 days, which costs approximately $68-150. The cost includes shipping cost, freight charge, loading cost and inventory cost. To ship goods to Osaka Port, Japan, takes about one week. After that, Japanese importers take between 5 and seven days to declare the goods to the customs and no more than five days for inspection for the goods by Japan Food Organization. Regularly, Thai frozen shrimps, which are contained in 40 containers each round, are imported into Japan 7-10 times a month via Osaka Port. However, the goods are returned within 2-3 times every year. Finally, five percentage of the shrimp's selling price is transportation and distribution cost.

## 2.5 Conclusion

This literature review chapter provides the analytical evidence in the contexts of the performance measurement system (PMS) in the supply chain. The principle of the performance measurement (PM) is systematically reviewed and explored including

KPIs. The result of the reviews proved that the performance measurement is the crucial element and will provide the most effectiveness when it is integrated with other confirming factors and evaluation methods including the supply chain operation reference (SCOR) model, balance scorecard (BSC) and a multiple criteria decision making (MCDM), the multiple methods, data envelopment analysis (DEA), structure equation model (SEM) and confirmatory factor analysis (CFA). Furthermore, the case study and the data from the shrimp logistics from Thailand and Kansai area in Japan are critically evaluated and added for the strongest of reviews. The limitation of literature shows that there is a lack of the evidence about the integrating performance measurement model in the supply chain. The new research study on the developing of the integrating performance measurement model for using to evaluate specifically with the Thai's frozen shrimp supply chain is therefore significantly needed to conduct. Then, the result of this new research will provide the potential benefit to such people who are working in the Thai' frozen shrimp supply chain business and those researchers who are trying to integrate evaluation methods to develop the performance measurement model in the area of supply chains.