

## **Chapter 2**

### **Principle and Literature Review**

In the study of supply chain management, there are many relevant activities for example, purchasing agricultural raw materials, processing activities, storage, transportation, distribution or other activities that also support. Hence for developing the performance of supply chain management, it is necessary to measure effectiveness, strengths, weakness or how organizations manage their supply chain. This research focuses on the performance measurement framework of supply chain management by applying the balanced scorecard principle. Because it is another principle that has been widely accepted and the concept of supply chain which does not consider the internal process as only consistent with the Balance Scorecard concepts but also consider both internal and external processes and the planning of the organization to focus on the long term and short term. Fuzzy set theory and the analytic hierarchy process method are applied to weight each criterion to convert to a score of performance measurement of supply chain management. The Quartile is used to divide the data from the measurement to the point range and the simple additive weighting (SAW) method is used to scoring the point of measurement to show the results more clearly. The Details for each principle is divided into the following topics.

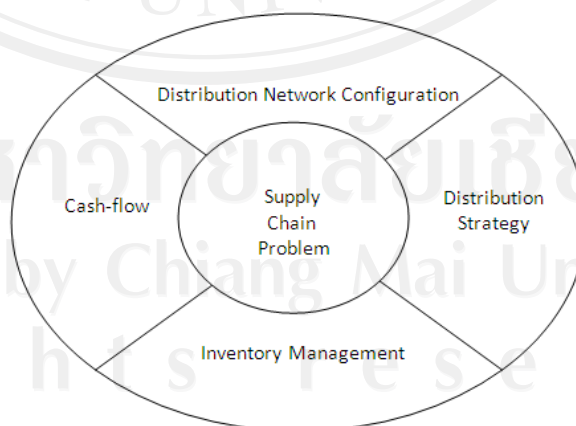
#### **2.1. The Supply Chain Management**

Supply chain management is an integration and management in organizations which are bringing supply chain relationships and collaboration activities to build value-added products and services which results in the competitiveness and sustainability (1). The supply chain consists of the activities which are related to the customer demands not only manufacturers and transporters but also distributors, middlemen and customers. Supply chain management is the oversight of materials, information, and finances as they move in a process from supplier to manufacturer to wholesaler to retailer to consumer.

The supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage, through to the end user as well as the associated information flows. Supply chain management is the integration of these activities through improved supply chain relationships, to achieve a competitive advantage. A supply chain extends from your customer's customer to your supplier's supplier and includes: developing, planning, sourcing, making and delivering (2). Supply chain management involves coordinating and integrating these flows both within and among companies. It is said that the ultimate goal of any effective supply chain management system is to reduce inventory.

There are many reasons for the popularity of the concept. Specific drivers may be traced to trends in global sourcing, an emphasis on time and quality-based competition, and their respective contributions to greater environmental uncertainty. Corporations have turned increasingly to global sources for their supplies. This globalization of supply has forced companies to look for more effective ways to coordinate the flow of materials into and out of the company. Key to such coordination is an orientation toward closer relationships with suppliers. Further, companies in particular and supply chains in general compete more today on the basis of time and quality. Getting a defect-free product to the customer faster and more reliably than the competition is no longer seen as a competitive advantage, but simply a requirement to be in the market. Customers are demanding products consistently delivered faster, exactly on time, and with no damage. Each of these necessitates closer coordination with suppliers and distributors. This global orientation and increased performance-based competition, combined with rapidly changing technology and economic conditions, all contribute to marketplace uncertainty. This uncertainty requires greater flexibility on the part of individual companies and supply chains, which in turn demands more flexibility in supply chain relationships (3).

The organizations should apply the supply chain management because it focuses on the fixing of the related problems with distribution network configuration for example, production facilities, distribution centers, warehouses and customers, distribution strategy which are the important part of the organization process for the flow of products and information, inventory management which show how the organizations manage their finished products to deliver to their customers and the cash-flow which can be the main problem between the supply chain members (4).

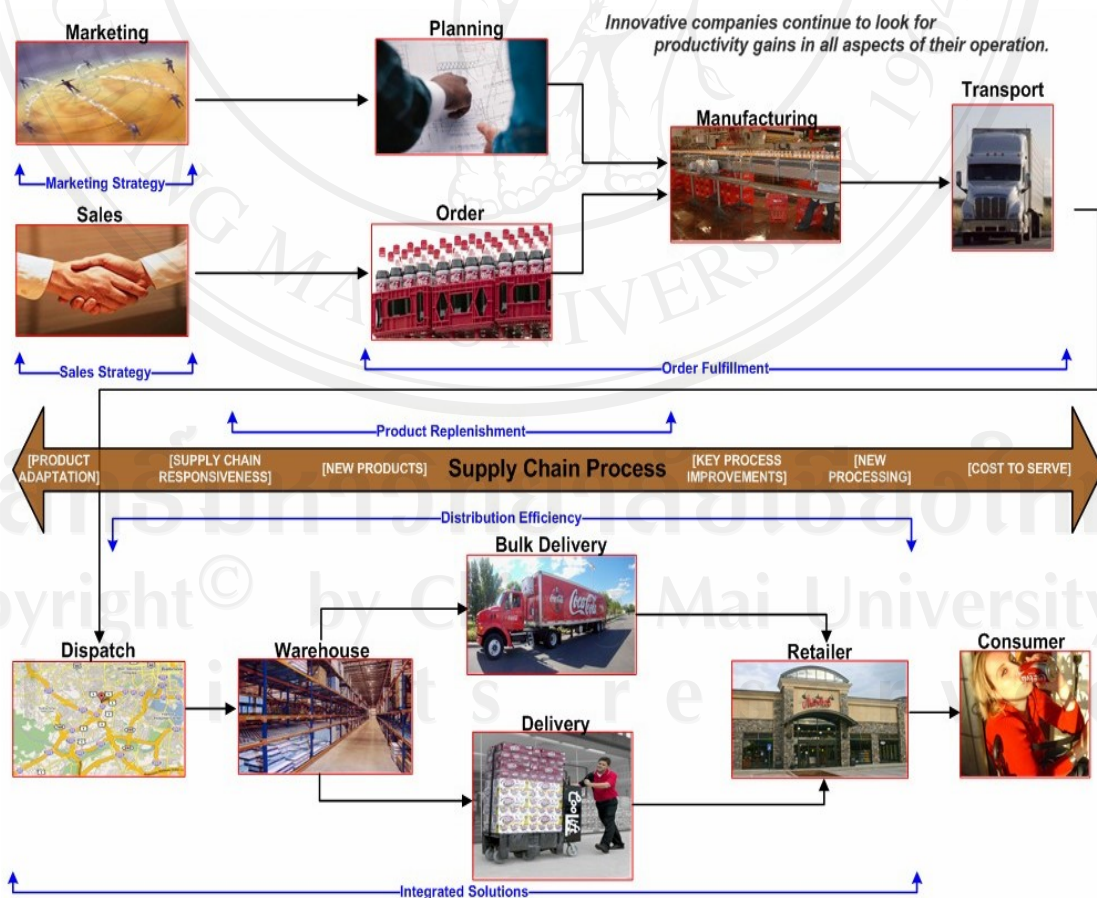


**Figure 2.1:** The reason for applied supply chain management

According to Jumadin (5), managing the chain of events in this process is what is known as supply chain management. Effective management must take into account coordinating all the different pieces of this chain as quickly as possible without losing any of the quality or customer satisfaction, while still keeping costs down. The first step is obtaining a customer order, followed by production, storage and distribution of products and supplies to the customer site. Customer satisfaction is paramount. Included in this supply chain process are customer orders, order processing, inventory, scheduling, transportation, storage, and customer service. A necessity in coordinating all these activities is the information service network.

In addition, key to the success of a supply chain is the speed in which these activities can be accomplished and the realization that customer needs and customer satisfaction are the very reasons for the network. Reduced inventories, lower operating costs, product availability and customer satisfaction are all benefits which grow out of effective supply chain management.

The decisions associated with supply chain management cover both the long-term and short-term. Strategic decisions deal with corporate policies, and look at overall design and supply chain structure. Operational decisions are those dealing with every day activities and problems of an organization. These decisions must take into account the strategic decisions already in place. Therefore, an organization must structure the supply chain through long-term analysis and at the same time focus on the day-to-day activities.



**Figure 2.2:** The structure of supply chain process

Furthermore, market demands, customer service, transport considerations, and pricing constraints all must be understood in order to structure the supply chain effectively. These are all factors, which change constantly and sometimes unexpectedly, and an organization must realize this fact and be prepared to structure the supply chain accordingly.

Structuring the supply chain requires an understanding of the demand patterns, service level requirements, distance considerations, cost elements and other related factors. It is easy to see that these factors are highly variable in nature and this variability needs to be considered during the supply chain analysis process. Moreover, the interplay of these complex considerations could have a significant bearing on the outcome of the supply chain analysis process. There are six key elements to a supply chain:

1. Production - Strategic decisions regarding production focus on what customers want and the market demands. This first stage in developing supply chain agility takes into consideration what and how many products to produce, and what, if any, parts or components should be produced at which plants or outsourced to capable suppliers. These strategic decisions regarding production must also focus on capacity, quality and volume of goods, keeping in mind that customer demand and satisfaction must be met. Operational decisions, on the other hand, focus on scheduling workloads, maintenance of equipment and meeting immediate client/market demands. Quality control and workload balancing are issues which need to be considered when making these decisions.

2. Supply - Next, an organization must determine what their facility or facilities are able to produce, both economically and efficiently, while keeping the quality high. But most companies cannot provide excellent performance with the manufacture of all components. Outsourcing is an excellent alternative to be considered for those products and components that cannot be produced effectively by an organization's facilities. Companies must carefully select suppliers for raw materials. When choosing a supplier, focus should be on developing velocity, quality and flexibility while at the same time reducing costs or maintaining low cost levels. In short, strategic decisions should be made to determine the core capabilities of a facility and outsourcing partnerships should grow from these decisions.

3. Inventory - Further strategic decisions focus on inventory and how much product should be in-house. A delicate balance exists between too much inventory, which can cost anywhere between 20 and 40 percent of their value, and not enough inventory to meet market demands. This is a critical issue in effective supply chain management. Operational inventory decisions revolved around optimal levels of stock at each location to ensure customer satisfaction as the market demands fluctuate. Control policies must be looked at to determine correct levels of supplies at order and reorder points. These levels are critical to the day to day operation of organizations and to keep customer satisfaction levels high.

4. Location - Location decisions depend on market demands and determination of customer satisfaction. Strategic decisions must focus on the placement of production plants, distribution and stocking facilities, and placing them in prime locations to the market served. Once customer markets are determined, long-term commitment must be made to locate production and stocking facilities as close to the consumer as is practical. In industries where components are light weight

and market driven, facilities should be located close to the end-user. In heavier industries, careful consideration must be made to determine where plants should be located so as to be close to the raw material source. Decisions concerning location should also take into consideration tax and tariff issues, especially in inter-state and worldwide distribution.

5. Transportation - Strategic transportation decisions are closely related to inventory decisions as well as meeting customer demands. Using air transport obviously gets the product out quicker and to the customer expediently, but the costs are high as opposed to shipping by boat or rail. Yet using sea or rail often time means having higher levels of inventory in-house to meet quick demands by the customer. It is wise to keep in mind that since 30% of the cost of a product is encompassed by transportation, using the correct transport mode is a critical strategic decision. Above all, customer service levels must be met, and this often times determines the mode of transport used. Often times this may be an operational decision, but strategically, an organization must have transport modes in place to ensure a smooth distribution of goods.

6. Information - Effective supply chain management requires obtaining information from the point of end-use, and linking information resources throughout the chain for speed of exchange. Overwhelming paper flow and disparate computer systems are unacceptable in today's competitive world. Fostering innovation requires good organization of information. Linking computers through networks and the internet, and streamlining the information flow, consolidates knowledge and facilitates velocity of products. Account management software, product configurations, enterprise resource planning systems, and global communications are key components of effective supply chain management strategy.

## **2.2. The Balanced Scorecard**

Traditional financial performance metrics provide information about a firm's past results, but are not well-suited for predicting future performance or for implementing and controlling the firm's strategic plan. By analyzing perspectives other than the financial one, managers can better translate the organization's strategy into actionable objectives and better measure how well the strategic plan is executing. The Balanced Scorecard is a management system that maps an organization's strategic objectives into performance metrics in four perspectives: financial, internal processes, customers, and learning and growth. These perspectives provide relevant feedback as to how well the strategic plan is executing so that adjustments can be made as necessary (6).

The Balanced Scorecard is a widely recognized tool to measure the operational and support decision making at the strategic management level which improves the satisfaction of the strategic objectives (7). It reflects the objectives of building the balance between financial and non-financial measures, lagging and leading indicators, short and long-term objectives and between internal and external performance perspectives" (8).

The concept of BSC was the beginning of many problems of the U.S. stock market in 1987 as most organizations in the United States used only the financial metric in measurement the organizations. It led to losing because the financial position of organizations in the glory was also very good but they were not aware that

the organizations were operating in the declining and did not improve and bring new technologies such as information systems. Moreover, financial indicators did not show the potential and future trends, so in 1990 Professor Robert Kaplan and Dr. David Norton of Harvard Business School discovered how to solve this problem by calling it "The BSC". It allows organizations to see the advantages and disadvantages of the management past clearly and helps in managing the corporate strategy to balance the interests of the organization in all areas to achieve sustainability.

The BSC allows organizers to look at the business from the four different perspectives (8, 9);

1. Financial Perspective: Timely and accurate funding data always is a priority and made sure to provide it.
2. Customer Perspective: This perspective focuses on an increasing realization of the importance of customer focus and customer satisfaction in the organization.
3. Internal Process Perspective: This perspective shows how well the organization is running and how our products and service conform to customer requirements.
4. Learning and Growth Perspective: In the organization, people are the main resources and it becomes necessary for the workers to learn continuously in the current high competition.

For each perspective of the BSC, four things are scored;

1. Objectives: the major objective of the organization to be achieved in long and short-term;
2. Measures (Key Performance Indicators): the tool used to measure the progress toward reaching the objective;
3. Target: the goal or target value which the organization measures;
4. Initiatives: project or program that the organization made to meet the objective but only a preliminary plan not the corporate plan.

Some of the benefits of the Balanced Scorecard system include (6):

1. Translation of strategy into measurable parameters.
2. Communication of the strategy to everybody in the firm.
3. Alignment of individual goals with the firm's strategic objectives - the BSC recognizes that the selected measures influence the behavior of employees.
4. Feedback of implementation results to the strategic planning process.

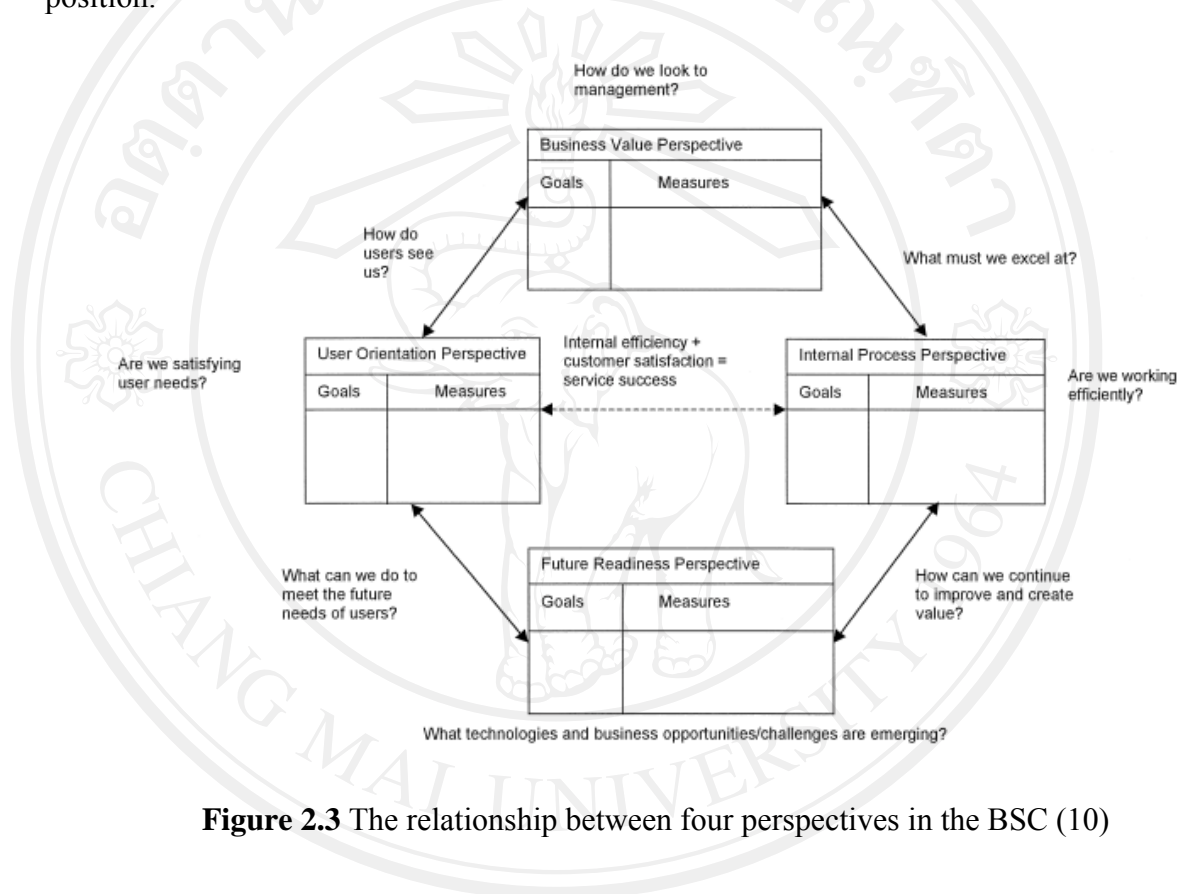
Since its beginnings as a performance measurement system, the Balanced Scorecard has evolved into a strategy implementation system that not only measures performance but also describes, communicates, and aligns the strategy throughout the organization.

The following are potential pitfalls that should be avoided when implementing the Balanced Scorecard:

1. Lack of a well-defined strategy: The Balanced Scorecard relies on a well-defined strategy and an understanding of the linkages between strategic objectives and the metrics. Without this foundation, the implementation of the Balanced Scorecard is unlikely to be successful.

2. Using only lagging measures: Many managers believe that they will reap the benefits of the Balanced Scorecard by using a wide range of non-financial measures. However, care should be taken to identify not only lagging measures that describe past performance, but also leading measures that can be used to plan for future performance.

3. Use of generic metrics: It usually is not sufficient simply to adopt the metrics used by other successful firms. Each firm should put forth the effort to identify the measures that are appropriate for its own strategy and competitive position.



**Figure 2.3** The relationship between four perspectives in the BSC (10)

### 2.3. Fuzzy set theory

The fuzzy set was introduced by Zadeh (11) to manipulate information possessing nonstatistical uncertainties. It was designed to mathematically represent vagueness and amphibole to provide formalized tools for dealing with the preciseness problem. It is a class of objects with a continuum of grades of membership function which assigns to each object a grade of membership ranging between zero and one (11).

The fuzzy set is a simulation method like the human mentation because many problems are not clear and direct such as, when someone comes up with the limitations of our need "The young". The young cannot be indicated exactly how much that is old. If there are 2 candidates aged 35 and 25 years old, we may be able to tell that people aged less than becoming young. But when there are many candidates

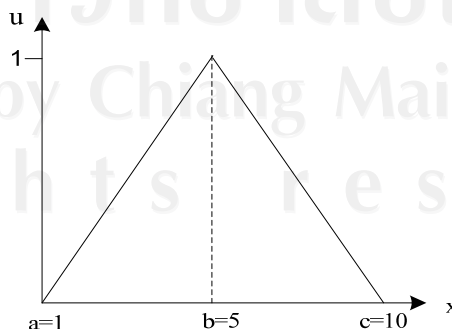
coming up with different ages as 42 years to 23 years, we cannot say clearly that anyone qualified as the young. If we apply fuzzy set, every candidate will see that every member of the young with each member representing a difference. Candidate as the 23-year-old may have a 0.75 ratio and candidate aged 35 years may have accounted for only 0.25.

The characteristic function of a crisp set assigns a value of either 1 or 0 to each individual in the universal set, thereby discriminating members and nonmembers of the crisp set under consideration (12). This function can be generalized such that the value assigned to the elements of the universal set fall within a specific range and indicate the membership grade of these elements in the set in question. Larger values denote higher degrees of set membership. Such a function is called a membership function and the set defined by it a fuzzy set. The range of values of membership functions is the unit interval (0, 1). Here each membership function maps elements of a given universal set  $X$ , which is always a crisp set, into real numbers in (0, 1). The membership function of a fuzzy set  $A$  is defined by

$$\mu_A : X \rightarrow (0, 1). \quad (2.1)$$

There are many types of membership function, for example; Trapezoidal, Gaussian, Bell, S-shaped and Z-shaped, but for this research has chosen Triangular Membership Function because, this function is easy and gives the priority is not different from the other function. The Triangular membership function with straight lines can formally be defined by parameters  $\{a, b, c\}$  as follows;

$$\text{Triangular}(x : a, b, c) = \begin{cases} 0 & x < a \\ \frac{(x-a)}{(b-a)} & a \leq x \leq b \\ \frac{(c-x)}{(c-b)} & b \leq x \leq c \\ 0 & x > c \end{cases} \quad (2.2)$$



**Figure 2.4** Triangular membership function



## 2.4. The Analytic Hierarchy Process (AHP)

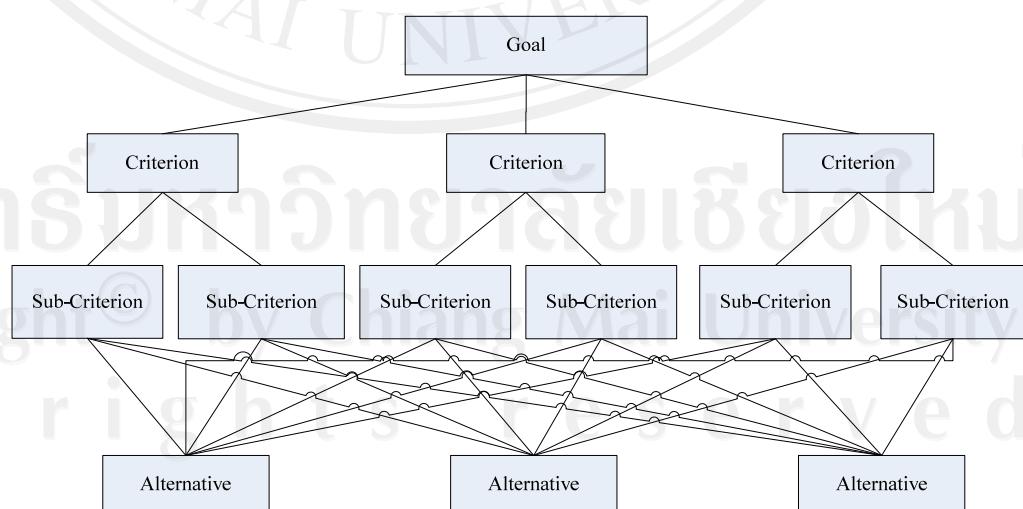
The Analytic Hierarchy Process (AHP) which developed by Professor Thomas Saaty in 1970 is a theory of measurement through pairwise comparison and relies on the judgments of experts to derive priority scales (13) and always use as multi - criteria decision making method that is the problem of deciding to have the priority of options when multiple criteria are considered. The advantages of AHP are that it is effective and easy to prioritize and make effective decisions that meet the goal of accurate decision which can be used to decide a complex because AHP will be able to show clearly the reason why the selection of the most important thing is made.

There are three basic principles in the AHP:

1. The Hierarchy Construction Principles: The AHP principle makes the complex systems easy to understand by decomposing into essential elements and hierarchically structured into several levels according to the relative importance of each element. The lowest level is the alternatives and the highest one is the main objectives.

2. The Priority setting principle: According to the human thinking which is able to intuitively perceive relationships between elements and represent it numerically and the weight or fixed priority must be independent form other elements. This method will derive the priority scale between all the considered elements.

3. The logical consistency principle: For weight the priority for each element, the consistency must be considered. For example, there are three elements A, B and C, if A is better than B and B is better than C. So A must be better than C. Nevertheless, perfect consistency cannot be expected because of the subjective character of the comparisons and of the changing circumstances.



**Figure 2.5:** The hierarchy of the hierarchical analysis process.

To make a decision by using AHP, Saaty (13) decomposed the decision into the following steps: determine the problem and the kind of knowledge sought, structure the decision hierarchy from the top with the goal of decision, then the objectives through the intermediate levels to the lowest level which always is a set of alternatives, build the pairwise comparison metrics (Fig. 2.5). The element in the upper level is used to compare the elements in the respect level below and use the priorities obtained from the comparisons to weight the priorities in the level below and do this for every element. For each element in the level below, add its weight and obtain its overall. Continue this process until the final priorities of the alternatives in the lowest level are obtained.

For making the comparison, a scale of numbers that represent how each element is more important than another element with points to compare is needed. The scale which used to judgment is shown as table 2.1.

The calculations to determine the weight of each criteria is according to the theory AHP method and then calculate the corresponding of data by calculate the max of Eigen Values ( $\lambda_{max}$ ), consistency Index(CI) and consistency Ratio(CR).

Because data obtained by this interview may not always be correct. Therefore, it must be validated by consistency check. The CR must be less than 0.1 to show that the consistency of the results in measurement. The CR values can be obtained from the equation as follows;

$$CR = \frac{CI}{RI} \tag{2.3}$$

By

CR	=	Consistency Ratio
CI	=	Consistency Index
RI	=	Random Index

And Consistency Index (CI) is equal to

$$CI = \frac{\lambda - n}{n - 1} \tag{2.4}$$

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

$$\lambda_{max} = \frac{\sum \left( \frac{AW^T}{W^T} \right)}{n} \tag{2.5}$$

**Table 2.1** The level of importance for AHP

Preference Level	Numerical Value
Equally Preferred	1
Equally to Moderately Preferred	2
Moderately Preferred	3
Moderately to Strongly Preferred	4
Strongly Preferred	5
Strongly to Very Strongly Preferred	6
Very Strongly Preferred	7
Very Strongly to Extremely Preferred	8
Extremely Preferred	9

**Table 2.2** Random Index (RI)

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

If  $CR \leq 0.10$  is considered acceptable but if  $CR$  is more than 0.10 is considered unacceptable and the decision maker have to review the scale of comparison again until the  $CR$  is lower

## 2.5. Quartiles

A quartile is any of the three values that divide an ordered data set into four approximately equal parts. Quartiles are a particular type of quantiles, which divide the data into some given number of equal parts. Quartiles are one of the most common types of quantiles, although deciles (10 parts) and percentiles (100 parts) are used frequently as well. It is important to note that there is no specific rule for choosing the quartile values, although several techniques are common.(14)

Define quartiles more formally. The lower quartile ( $Q_1$ ) separates the bottom fourth of the data from the upper three-fourths of the data, the middle quartile ( $Q_2$ ) separates the bottom half from the top half, and the upper quartile ( $Q_3$ ) separates the bottom three-fourths of the data from the upper fourth of the data

If a data set of values is arranged in ascending order of magnitude, then:

- The median is the middle value of the data set.  
: **Median** =  $\frac{1}{2}(n+1)$ th value where  $n$  is the number of data values in the data set.
- The lower quartile ( $Q_1$ ) is the median of the lower half of the data set.  
:  **$Q_1$**  =  $\frac{1}{4}(n+1)$ th value where  $n$  is the number of data values in the data set.
- The upper quartile ( $Q_3$ ) is the median of the upper half of the data set.  
:  **$Q_3$**  =  $\frac{3}{4}(n+1)$ th value where  $n$  is the number of data values in the data set.

- The interquartile range (*IQR*) is the spread of the middle 50% of the data values.

So

**Interquartile range = Upper quartile - Lower quartile**

$$\text{I.e. } IQR = Q_3 - Q_1$$

## 2.6. The simple additive weighting (SAW) method

The SAW method is probably the best known and most widely used. A score in the SAW method is obtained by adding contributions from each attribute. Since two items with different measurement units cannot be added, a common numerical scaling system such as normalization is required to permit addition among attribute values. The total score for each attribute by importance weight assigned to the attribute and then summing these products over all the attributes (6).

Formally the value of an alternative in the SAW method can be expressed as

$$V(A_i) = V_i = \sum_{j=1}^n w_j(x_{ij}), \quad i = 1, \dots, m$$

Where  $x_{ij}$  is the score of the  $i_{th}$  alternative with respect to the  $j_{th}$  criteria,  $w_j$  is the weighted criteria

## 2.7. Review of Literature

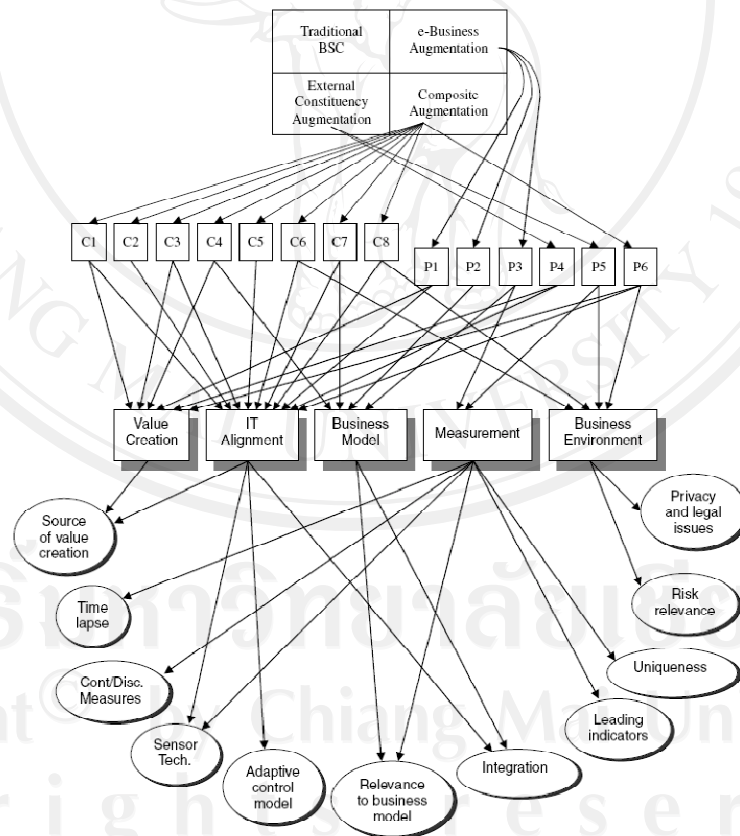
Supply chain performance is an overall performance measure that depends on the performance of the stages in supply chain (15). The performance of supply chain can be defined by the information or feedback on activities with respect to meeting customer expectations and strategic objectives(16), or the degree to how well the supply chain can fulfill end user requirement (17). According to Neely(18), performance measurement is defined as the process of quantifying the effectiveness and efficiency of actions.

With the fast change happening in the world, performance measurement plays an important role in SCM initiative and improvement (7) because it plays in setting objectives, goals, evaluating performance and determining future courses of actions. In recent years, performance measurement and indicators have acquired much attention from many researchers.

Gunasekaran (19) summarized why we need to study the measures and indicators in two reasons: lack of a balance approach and lack of clear distinction between metrics at strategic, tactical and operational levels. The metrics and measures in this literature are discussed following the activities in supply chains: metrics of plans for measuring the performance of the order-related activities, metrics of sources for assessing the degree of coordination among supply chain members, metrics of production/assemble which consist of activities with major impacts on the product

cost, quality, delivery and flexibility and metrics of delivery which is a primary determinant of customer satisfaction. The results of this research show that the improvement of the performance measurement program should be involved and committed to common goals and tailored to varying needs of members in chain.

Brenser (20) presented a framework of developing performance measurement metrics in e-business environment by incorporating the BSC methodology with existing taxonomies of e-business model and theories behind them. This research presents eight issues for C-suite executives (top-level manager), seven issues for P-suite executives (primarily process manager) and eleven key implementation issues for plan metrics. (Fig. 2.6) He suggested that the using this framework should be helpful to firms in designing and using a lens to provide a perspective of performance for e-business. Maksound (21) reported a large-scale investigation of development and application of non-financial measures of performance in UK manufacturers. This research aims to explore possible relationships between performance measures and other organizational characteristics.



**Figure 2.6:** Mapping of C-suite and P-suite issues for integrated framework (20)

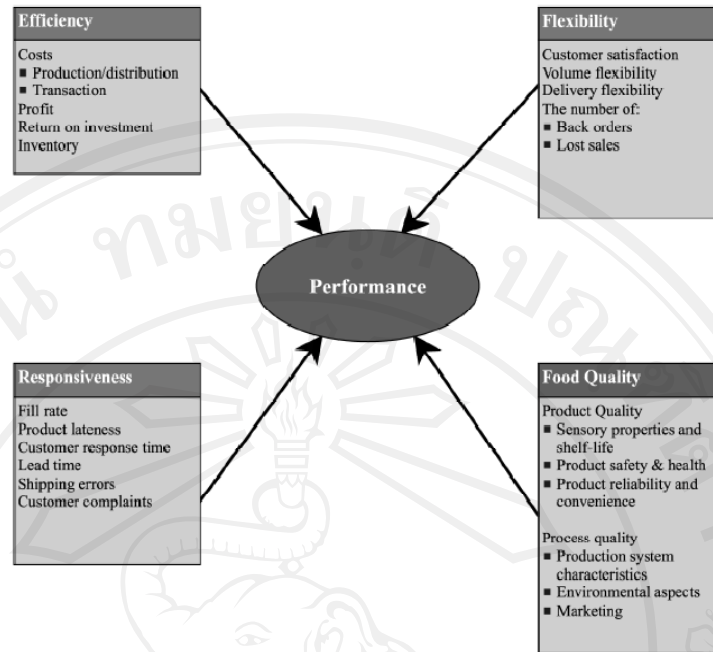
Theeranuphattana (22) has combined the Chan and Qi’s model and SCOR model to demonstrate the applicability of the combination by creating a more practical and efficient model. The structure of this performance measurement is comprised

three hierarchical; level, top, configuration and process level. Each level is combined from five measurement metrics; reliability, responsiveness, flexibility, cost and assets. From the improvement with case study, this method help the SC manage to understand and benchmark the whole picture of SC performance and show that reliability metric has got the highest score. That means this case study can deliver the correct product in the correct condition to the correct customer.

Charan (23) determine the key supply chain performance measurement system (SCPMS) implementation variable on which the top management should focus by using interpretative structural modeling (ISM) for identify relationships among specific variables. From the ISM model, awareness about SCPMS is a very significant enabler, so top management should focus on developing strategies to create awareness about the use of SCPMS for reap the benefit. In 2007, Matopoulos (24) analyze the concept of supply chain collaboration and provide an overall framework of agri-food industry by conducting in depth interviews and applied in SMEs. The conceptual framework is developed based on the overall framework suggested earlier by divide into 4 propositions. This result of this study identified the importance of the elements of trust, power, dependence and risk/reward sharing in establishing and maintaining supply chain relationships.

In 2006 Aramyan (25) provided a literature review on existing performance indicators and models for agri-food production chains. Many methods widely used to measure supply chain performance in this research present advantages and disadvantages of them. That can help us choose the methods to use in performance measurement or combine two methods or more for their advantages. In agri-food supply chains, there are two types: fresh products and processed food products which have different characteristics. This research is focused on fresh agricultural products and conceptual framework of performance measurement is divided into four groups: efficiency, flexibility, responsiveness and food quality (Fig. 2.7).

Then in 2007, Aramyan (26) used the framework in a Dutch-German tomato supply chain for evaluating the usefulness of novel conceptual model which contained financial as well as non financial indicators combined with the specific characteristics of this supply chain. In order to evaluate the conceptual framework in this case study, the source of information is interviews with members in supply chain. In those interviews, interviewees were asked for weight and rank indicators of performance according to the importance of their firms by a 5-point Likert scale. The conditions for chosen indicators are the high importance score, measurability and applicability to the entire chain. The most relevant indicators appeared to be costs, profit, customer satisfaction, lead time and all quality indicators.



**Figure 2.7:** Conceptual framework of agri-food supply chain performance indicators. (25)

For measurement the performance of SCM needs suitable indicators and metrics which include related activities. According to R.Bhagwat (27), the metrics in performance measurement in SCM are divided into 4 perspectives of BSC for solving the problem of the lack of a balanced approach and discussing the various measures and metrics of SCM. The perspectives in BSC for performance measurement for SCM are briefly described as follow;

Customer perspective (value-adding view): the objective of the BSC is to transform the strategy in the customer service into the standard which can be identified as a related factor with customers. To respond to the customer satisfaction, lead-time, quality, service performance or high competitive are taken into account.

Financial perspective (shareholder's view): financial indications show how effective a company's strategy, implementation and execution to the bottom line are. The financial objectives include achieving profitability, maintaining liquidity and solvency in the short and long terms, maximizing wealth of shareholders and growth in sales turnover.

Internal perspective (process-based view): the internal perspective mission is to promote efficiency and effectiveness in the organization's business process and the greatest impact on customer's satisfaction factors such as lead-time, skill of workers and productivity.

Learning and growth perspective (future view): this perspective is all about how the organizations can continue to improve and create value to achieve their

vision. Innovation and a continuous learning process can ensure cost reduction and product differentiation to meet the varied requirements of customers.

Putting the four perspectives together helps the managers understand the relationship among the organization and manage barriers in the same way. This leads to decision making and solving any problems. The interesting thing of BSC is it can show results which occur in the organization to the managers and workers. Moreover it helps in planning in a very timely manner.

Xiaoping (28) presented the characteristics of supply chain performance evaluation by following the benchmark balance scorecard approach. In this research, supply chain performance evaluation system was established by BSC as a framework and benchmark enterprise as a reference. It was divided into 5 areas (four from the BSC and one from characteristics of supply chain environment) including management performance, customer satisfaction, business process, future development and flexibility. This will make the index system reflect the ability condition of supply chain adapting to the market environment. Referring to Hung-Yi Wa (29), the BSC has been used to select an evaluation index for banking performance. He suggested that BSC is a useful and effective assessment tool for banks. There are many benefits that can be used as a framework to assess and develop a strategy, provides a way to measure and monitor the performance of key performance driver. It is an effective tool to ensure that banks continuously improve its systems and process. Furthermore, Ton Ren (30) used BSC to propose an approach of supply chain performance measurement in the manufacturing industry to translate the organization's vision into a set of performance indicators and recommended that performance measurement must be accompanied by BSC strategic planning.

The BSC is a popular tool that is applied by many businesses to assess their performance. It provides insights into corporate performance not only managers seeking the way to improve performance but also investors wanting to gauge the organization's outgoing health (29). Although BSC is widely used, the measurement of the performance of SCM for each organization has focuses on different factors. The BSC also has restrictions on this point so there are many studies to develop methods to solve this problem.

Determination of important of performance measures is a challenge of decision-making because there are two difficult issues while implementing a performance measurement system (31). First, the common measurement system is static that lags behind the varying change in supply chain (the environment in supply chain is dynamics). Second, few measurement systems have a systematic method for prioritizing the measures (32). To solve the problems of metric's trade-off, some decision making tools have been used by prioritization of different indicators (33).

Xia (34) study about supply chain performance measurement system to help the company to understand which measurement metrics really matter to the their business strategy by using AHP to find the priority of each supply chain attributes and



fuzzy logic to integrate both quantitative and qualitative metrics. Supply chain strategies are transformed into supply chain attributes; reliability, responsiveness, flexibility, re-configurability and cost. For determine weight of attributes with AHP, she used the questionnaire for manager or decision maker. The result of this study shows that cost is the highest weight of all attributes that means the cost problem is very critical.

In accordance with Chan (35), the hierarchy has been used to group the process and sub-process in performance measurement and building a process and performance measurement hierarchy. According to the changing supply chain objectives among high competition, the priorities of performance indicators should differ from each other in measuring the whole performance. The AHP has been used to set different weight for each indicator by the pairwise comparison method. Moreover, the AHP is used to analyze the relative important weight of performance evaluation index for banking performance measurement (29) and is used as the method to solve complex decision problems. Sharma (36) proposes that the AHP is the best tool for prioritizing and choosing the best BSC perspective for SCM operations and in this study the overall PMS of all SCM has been defined by three performance criteria in the hierarchy. The results of AHP help in prioritizing the most critical perspective. The AHP method has the following advantages (37);

1. A subjective decision process can be formalized owing to the hierarchy structure and leads to precise decisions.
2. Certifying consistency of the decision judgment.
3. Clearer understanding of the problems by dividing them into sub-problems.
4. The comparison may be made by term or an initiative process until an agreement is reached by the team members.
5. Sensitive analysis may be performed by the results using computers before final judgment is rendered.

Although the BSC and AHP are popular and widely used, the supply chain has several related activities and indicators which are used to measure and need to be considered from the related operator. This leads to the problem about different attitudes and translation of qualitative into quantitative attitudes. Therefore, there are many researches to try to solve this problem and the method that is widely used is the Fuzzy Set theory. Zadeh introduced fuzzy set theory to solve problems involving the absence of sharply defined criteria in 1965 (11). If uncertainty of human decision-making isn't taken in to account, the results can be misleading (38).

Yu (39) suggested that a good decision-making model needs to tolerate vagueness because fuzziness and vagueness are common characteristics in many decision-making problems. Conventional AHP may not be enough for the selection of arbitrary values in pairwise comparison and uncertainty should be considered in all or some pairwise comparison values (39). By using fuzzy set theory, the rating opinions of decision makers were considered and translated into the fuzzy number used in the conventional numerical equivalence method.

The application of fuzzy AHP has been used by many researchers. Lee presented a fuzzy AHP and BSC to evaluate performance of IT department in the manufacturing industry. The fuzzy AHP was used to tolerate vagueness and ambiguity of the relative importance between performance indicators to propose a systematic performance evaluation model to allow IT department managers to improve the department performance. Ong S.K. (40) proposed a fuzzy set to generate relative manufacturability indices to prepare product designers with the better understanding of relative ease of machining the features in their designs and AHP to assign weight for factors and features to reflect their functional importance. By using fuzzy AHP, it helps product designers in making designs easier to manufacture while not compromising the functional requirements of their designs.

The FAHP can not only capture the thinking logic of human beings but also focus on the relative importance of the evaluation criteria. Hung-Yi Wu (29) offered a fuzzy AHP for analysis of importance weights of banking performance evaluation indexes and the result of the FAHP analysis display the customer satisfaction is the most important evaluation index. For maintaining a high performance, banks must ensure that their customers remain loyal to them and try to attract new customers. For determining the evaluation weights the step of FAHP are construct fuzzy pairwise comparison metrics, examine the consistency of the fuzzy pairwise comparison metrics ,compute the fuzzy geometric mean for each criterion and compute the fuzzy weights by normalizations.

**Table 2.3** Literature reviews of performance measurement

	Type of Business	Tools	Suitable for characteristics of	Relate with financial and non- financial	Relate with qualitative and	Assessing weight	Actual measurement
Gulledge T.(43)	E-Business	SCOR model	/	/	/	/	/
Wu H.(29)	Bank	Fuzzy-AHP, BSC	/	/		/	/
Ertugrul I.(41)	Cement firm	Fuzzy-AHP, TOPSIS	/	/		/	/
Monitto M.(42)	Automotive industry	Fuzzy AHP	/			/	/
Chan F.T.S.(16)	Electronic industry	AHP	/	/		/	/
Bremser W.G.(20)	E-business	BSC	/	/	/		

**Table 2.3** (continued)

	Type of Business	Tools	Suitable for characteristics of	Relate with financial and non- financial	Relate with qualitative and quantitative	Assessing weight	Actual measurement
Bhagwat R.(27)	Day-to-Day business	BSC	/	/	/		/
Lee A.(38)	Manufacturing industry (IT department)	Fuzzy-AHP, BSC	/	/		/	/
Gunasekarn A.(19)	-	-		/	/		
Cai J.(31)	-	-		/		/	
Matopoulos (24)	Food Industry	-	/				/
Tong R. (30)	-	SCOR model, BSC		/			/
Charan P.(23)	-	ISM		/			
Theeranuphattana A.(22)	-	SCOR model, Fuzzy logic		/		/	/
Sharma M.(36)	-	AHP,BSC		/	/	/	
Aramyan L.(44)	Food Industry	Statistics	/	/		/	/
Xia L.X.X.(34)	-	Fuzzy AHP		/		/	

Ertugral (41) developed a fuzzy model to evaluate the performance by using financial ratios and at the same time, taking subjective judgments of decision makers into consideration based on FAHP and TOPSIS methods. In this literature, FAHP method have been used in determining the weights of the criteria by decision makers. He suggested that AHP was developed for solving the hierarchical problems with more confidence to give interval judgments than fixed value judgments.

Monitto (42) presented the FAHP to select Automated Manufacturing System(AMS) to produce a new part in a complex and turbulent environment. From the results, uncertainty due to the unpredictable environment has been managed by relationship among parameters in uncertain events and performance measures of

alternative solutions. The development of decision support system by using FAHP allows firm management to define the best AMS.

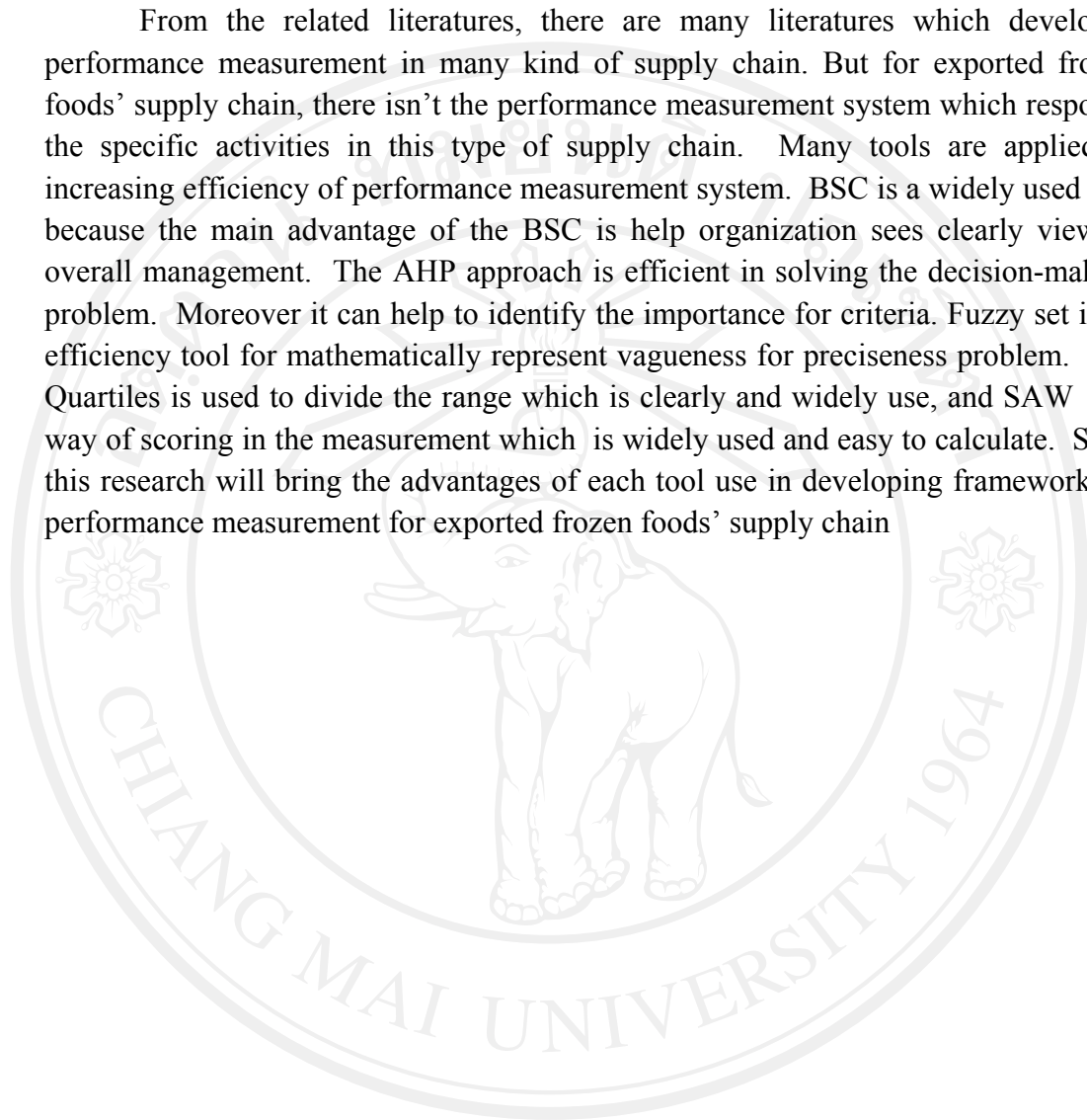
For the dividing the level of the data, there are many method. In the 2003, Muttluk (45) used the quartile for ranking set the sample of estimating population mean. This research studied the results of ranking by quartile method comparing with mean's and discovered that the quartile's is more efficient. Also in the 2011, Tsarouhas and Arvanitoyannis (46) used the quartile and other statistical analysis of studying the peach production line. This study aimed to analysis reliability and maintainability. The analysis result of this study was divided the level of results by quartile to compare the result more clearly. Ang and Smedema (47) studied about the financial flexibility and analyzed how the organizations manage its conditional. In the part of analysis the result, they used the statistical analysis such as mean and quartile to report the summary statistics of their variables.

In accordance with Gracia et al. (48), the quartile analysis was used in ranking the Spanish saving to propose a multicriteria methodology on goal programming in bank saving performance. The result shown that the credit risk, profitability and productivity are the first three important performances of Spanish saving bank's financial institutions. Wen et al. (49) presented a knowledge-based decision support system for measuring enterprise performance. They used the quartile in knowledge reasoning for comparing performance and compared the results of the sample electronics industry.

For scoring the point of measurement, Chou et al. (50) presented a new fuzzy multiple attributes decision-making (FMADM) approach by integrated fuzzy set theory with simple additive weighting (SAW) to evaluate facility locations alternative. In this paper suggested that the SAW is intuitive, user friendly, effective and applicable to other management decision problem such as supplier evaluation, personal selection and project management. From this research found that the fuzzy simple additive weighting (FSAW) process considers both the importance of each-decision makers and total scores for alternative that derived by homo/heterogeneous group of decision-makers. In the 2001, Chang and Yeh (51) used the three widely used decision making method that include the SAW, the weighted product (WP) method and the technique for order preference by similarity to ideal solution (TOPSIS) to evaluate airline competitiveness. The competitiveness dimensions of this research were divided into 5 dimensions; costs, productivity, service quality, price and management. For weighting the competitiveness attributes, they used SEW, WP and TOPSIS to calculated and compared the result. It found that the SAW is the most appropriate for the evaluation problem formulated as its evaluation outcome will have a minimum expected value loss when using equal weights. Lo et al. (52) studied about the important attributes to operating an efficient wafer foundry fabrication and empirically tests the attributes with a selected case. In this study, the SAW was applied with fuzzy to assign weight of attributes of the semiconductor companies'

performance evaluation. The weight of each attributes in this framework came from the 20 experts of the related field.

From the related literatures, there are many literatures which developed performance measurement in many kind of supply chain. But for exported frozen foods' supply chain, there isn't the performance measurement system which responds the specific activities in this type of supply chain. Many tools are applied to increasing efficiency of performance measurement system. BSC is a widely used tool because the main advantage of the BSC is help organization sees clearly view of overall management. The AHP approach is efficient in solving the decision-making problem. Moreover it can help to identify the importance for criteria. Fuzzy set is an efficiency tool for mathematically represent vagueness for preciseness problem. The Quartiles is used to divide the range which is clearly and widely use, and SAW is a way of scoring in the measurement which is widely used and easy to calculate. So in this research will bring the advantages of each tool use in developing framework for performance measurement for exported frozen foods' supply chain



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

Copyright© by Chiang Mai University

All rights reserved