

Chapter 4

Performance Measurement Framework for Supply Chain Management

From related literature review that was provided in previous chapter, in this step research selects the criteria that suites for supply chain performance measurement of exported frozen foods. In selecting the related criteria, researcher focuses on the criteria from the ones that directly involved food, management of agricultural supply chain and other industries that have the same characteristics. After selecting criteria, researcher made primary framework as a guideline to develop the framework that is appropriate. The results are divided into 4 categories:

1. The exported frozen food supply chain and performance
2. Performance measurement framework
3. Determination of the criterion importance weight
4. The weight of balanced scorecard perspectives
5. The sensitivity analysis

4.1. The exported frozen food supply chain and performance

4.1.1. Characteristics and the general condition of the exported frozen foods supply chain

From the initial research of related studies on supply chain concept, frozen food supply chain could be drawn the figure 4.1.

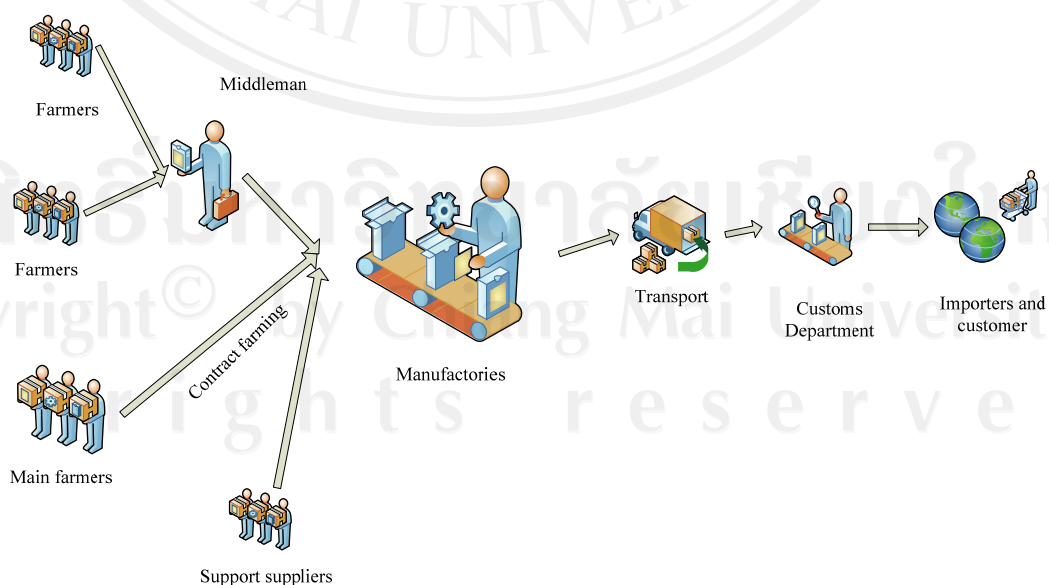


Figure 4.1 The exported frozen food supply chain

1. Farmers, main farmers

Farmers are the main suppliers of frozen food industry. The analyzing process will be categorized by the industry types which are frozen chicken, frozen seafood, frozen fruit and vegetable industry.

1.1.Chicken

There are 4 major groups of frozen chicken industry as follow;

1. Chicken farms of large company such as Charoen Pokphand Group (CP), Saha Farm Group, Lam Thong Sahakarn Group, Sri Thai Group and etc. These organizations fully operate from chicken gene Research and development, animal food, slaughterhouse and processed chicken to export frozen chicken and chicken products.

2. Chicken agriculturist in price guaranteed group – the contract will be taken place between agriculturist and animal food organization. The price of live chicken will be agreed in advance so agriculturists no need to shoulder about the risk of chicken price.

3. Hired agriculturist to feed chicken - animal food organization or its agency will invest on all expenses including financial help, management and feeding methods.

4. Independent chicken feeder – the feeder needs to be responsible for the total cost. Chicken can be sold in any markets and prices are depending on an alteration of environment. The feeder in this group will confront with the high risk from both cost and price.

1.2. Seafood

There are 2 groups of frozen seafood supplier as follow;

1. Material purchase from agriculturist provider

Seafood material from agriculturist provider that sign the contract farming with processed factory or cold storage provider is about the contract between processed factory or cold storage provider and agriculturist. Quantity and minimum price will be estimated for agriculturist. The processed factory and cold storage provider have the system to evaluate agriculturist including advice know how in order to increase material quality.

2. Material purchase from middleman provider

Another purchasing way is through the middleman provider who collects material from agriculturist. This system is the supplier source that very important to the processed factory because seafood material generally delivered to the processed factory through the middleman. The way to purchase from the middleman can be categorized into 2 types.

- Agriculturist contacts the middleman and considers the best price from each middleman. The middleman will inspect material randomly and estimate the suitable price again.

- Agriculturist opens the auction whether any middleman will be interested. The middleman will inspect material randomly and agriculturist will decide to sell to the middleman who gives the best price.

1.3. Vegetable and fruit

There are 2 types of agriculturist which are contracted system and non-contracted system. Both agriculturists operate similarly but the contracted system will be supported in terms of planting from the processed factory (such as seeds, planting preparation, fertilizer and herbicide), time specification and plant and harvest quantity factors. These factors will contribute to the conformation of factory's need and purchasing price. Sweet corn purchasing price will be indicated from the processed factory since it firstly planted. For non-contracted system, the product can be sold in the market and sell in the market price at the day sweet corn was sold.

2. Support suppliers

Apart from the main supplier, there is another supplier who supplies other materials related to the production such as package, plastic, breeders, animal food or any other product associated to the production.

3. Middleman

The middleman or broker responds to be an agent between the factory and agriculturist can be categorized into 2 types which are contracted middleman and non-contracted middleman.

Non-contract middleman normally acknowledge material demand of processed factory and responsible to contact with agriculturist. Before harvesting, the middleman will go to investigate the complement of material plant. If the material ready to harvest, the middleman will inform the factory and ask whether when the material can be delivered to the processed factory. After know an exactly date, the middleman will contact agriculturist again to make a confirmation of harvesting. Finally, material will be delivered to processed factory, weighted and receive money to pay to agriculturist. The material price is depending on the market price.

Contracted middleman will know the maximum quantity whether how much agriculturist can plant and how much they can supply per day. The following quantity is identified in the contract so the middleman can plan to distribute the planting for agriculturist. The harvest date can be indicated without asking the confirmation of demanding. However, the price will be indicated in advance at the day sweet corn is planted which is not the real market price at the day it sold.

4. Manufactories

Operation process of processed food factory begins with the material demand plan from the purchasing order. Then contact with the middleman or agency about the plan. When the middleman delivers material, the processed factory will weight and examine material quality, size and prosperity randomly. After that, the payment will be done as the price agreed with the middleman. Material will be put into the process depending on the food type and examine the product quality

randomly again. If there is nothing wrong about the product, it will be delivered to the transport organization in order to send it to the harbor. At the same time, the factory needs to contact with the shipping organization to receive the product and send to the harbor deliver internationally. The transportation provided by the transport organization deliver the product to the harbor can be divided into 2 types as follow;

1. Distribute to the customer directly is the way to distribute with general shops that order yearly.

2. Distribute to the agency of each country and the factory needs to pay an additional fee for the agency.

5. Transport

This process starts with the transport organization which contacted from the factory to receive the product at the harbor. Then the transport organization will plan and prepare the vehicles. When the product arrives, it will be delivered to the processed factory in order to put in the vehicle to transport. When everything is put in order and complete, it will be delivered to the harbor, the fees are informed and pay.

6. Customs Department

As this kind of product concern about sanitary, the export procedures need to be examined from the Customs Department. The processes are different depend on the type of product that are available in the website of Customs Department.

4.1.2. The activities in the exported frozen foods supply chain

After the study the exported frozen food supply chain, the activities that occur can be divided into four main activities all together. The details for each activity are as follows;

1. Planning

The uncertainty in the terms of quantity and quality of the activities in the areas of raw materials procurement is quite high if comparing with another type of industry. From this cause, the organizations have to plan the production planning as well in order to enable production to match the needs of most customers. Most of organizations in this industry have entered into agreements with customers in the long term contract so they can plan before production for a long time. However, due to the uncertainty of the raw material, the organizations are more prudent to planning production plan. The activities which related to planning have to be managed are show as follows.

1. The measurement the ability of the source material, the collection and prioritization of requirements specification, planning, inventory, distribution requirements, production, raw materials and the overall capacity of the product.

2. Management the basic plan and operational

3. The decision making to purchase or own production of raw material and products, the structure of the supply chain, the planning for resources and capacity in the long term, business planning, production scheduling for new product, the production line of various products.

2. Sourcing

The quality of food industry depends on raw materials. The raw materials of this industry are agricultural products such as fruits, vegetables or meat. The characteristics of material are quantity and qualities which are very vary in each farmer. The organizations have to make a plan to provide sufficient of raw materials for manufacturing. In addition to the quantity, the organizations need to manage the quality of the material also because this type of industry focus on safety of foods as a main, for instance, terms of chemicals use and traceability the production process. Including the knowledge and technologies which used in the raw materials production of each farmer is not the same standard. Therefore, the raw material from different farmers is not the same quality. The organizations have to choose or grade raw materials. The natural disasters and epidemics are other reasons that the organizations have to take into consideration in production planning.

In addition the procurement of raw materials, management of suppliers is important for supply chain management. Each supplier is not equally important because the frequency of demand, quantity of demand, the value of the material, market conditions and the materials are different especially raw materials for food product which are unstable. The management for each supplier should be to maximize the delivery of products and services correctly as customer's required.

3. Manufacturing and quality control

Manufacturing is the process of processing inputs and raw materials to be produced which response the customer requirement. There are many processes, for instance, manufacturing, operation, storage, changing shape, size and weight. The packaging which includes the wrapper or container that used to transport from manufacturers to customers and suppliers is the one of important activities because for the food products, the primary purpose of packaging is preventing and treating products to maintain the quality. As above mentioned, the most important thing of food products is safety. Therefore, in the process of food freezing is necessary to have a quality control in terms of GMP, HACCP or other standards that are defined by the customers. The organizations need to be careful at all processes from receiving raw material from famers and suppliers until sending the finished products to customers.

The original concept of quality of products will focus on the satisfaction of customers but the present quality concept of food products conform to food safety with the standards of production simultaneously. Therefore the conclusion of "quality" refers to levels or properties of products which include the needs and preferences of customers. At the same time it is based on standard production that provides customers with the confidence in the products.

International quality systems in the food industry, including GMP and HACCP, which today is important and has to operate more in Thailand, especially large industries and export. Because of the food consumption and world trade that are higher competitive in quality and food safety. The process in the production and quality controls are divided into three stages,

1. The monitoring and quality controlling of raw materials to inspect the properties and features that used materials meet the standards of production or not by the sampling and analysis requirements

2. The quality control during manufacturing to maintain and control the ability of the process to stabilize by the random sampling, statistics, data analysis and interpretation

3. The quality control of the finished products to inspect the properties and features of the finished product that meets the required standard or not.

4. Transportation and storage

Transport and storage are also important to inspect the quality of the product. There are many activities that related in the transportation and storage, for instance, transport planning, selecting the type of shipment, inventory management and distribution management. Especially food products, frozen foods are required to maintain the temperature at the desired level. The transport plan is very necessary including the cost in shipping and storage are high.

Transport and storage which managed to response customers order and deliver products to customers include the following elements,

1. The order management consists of entering orders, preparation of bid documents, and the elements of related products, establish and maintain a customer database and products, accounting systems management, the customer credit, collection and issuance of invoices.

2. The transportation management, distribution channels, quality of delivery management

- 4.1.3. The performance of supply chain management of the exported frozen foods

From the study of supply chain and activities which occur in the exported frozen food, the researchers divided the view of the performance into three dimensions as follows;

1. Performance in the dimensions of the efficiency and process management in organization

We took the consideration to the ability of using resources for producing the benefit. How much benefit and value each organization can produce from their existing resources towards work to correcting the standard to be fast and easier.

2. Performance in the dimensions of quality

The quality performance for exported frozen food is divided into 2 parts. The two parts are about processes and products. In the process part, there are definite criteria, especially for exported food that organizations have to be qualified for export standards. So in this dimension is emphasized on the quality in production processes.

3. Performance in dimensions of collaboration between organizations

Because the main idea of supply chain management is management among the members in the supply chain. Therefore, the cooperation between the organizations should be attentive. Including the agricultural product which most of

quantity and quality of products depending on the suppliers thus the management among organizations should be given particular emphasis.

Therefore to measure the supply chain performance, the chosen criteria are based on performance in these three dimensions.

5.2. Performance measurement framework

To create the performance framework, the researcher has studied the research on the measurement of the supply chain in many types of industries. In the first step, the researcher chooses the framework from Aramyan who studied on the measurement of Dutch-tomato supply chain to be the first framework. This framework consists of the criteria as shown in the first part of figure 4.2.

From studying the general characteristics of Frozen food industry, it was found that these criteria should be modified to suit the type of frozen food industry. Because of this framework is used to assess the supply chain of fresh tomato which is quite different from the frozen food industry. Thus, the researcher modified some criteria as follows;

1. The mix flexibility criterion represents the ability to change the variety of products produced, which enables the firm to enhance customer satisfaction by providing the kinds of product that customers require, in a timely manner. From the studying about the character of frozen foods found that the organizations are planned in terms of type and quantity of products with customers clearly. Therefore, this criterion is not appropriate for this type of industry.

2. The appearance criterion represents the first sight of the products and combination of different attributes (color, size and form, firmness, lack of blemishes and damage). This criterion affects directly for the fresh food supply chain but not for the exported foods that have been processed already. Thus, the researcher dose not chooses this criterion.

3. Traceability is also a standard that focuses on the validation of the raw materials from suppliers, in the production process until delivering to customers to confirm the quality and safety of products. Including several countries, customers have highlighted this issue extremely

4. Production yield is regarded as one of another criterion that demonstrates the ability to produce, including the administration and management of raw materials as well.

From the analysis, the researcher modified the new performance framework which includes the criteria as shown in the second part in figure 4.2. The definitions of the criteria are also shown in the table 4.1 and table 4.2.

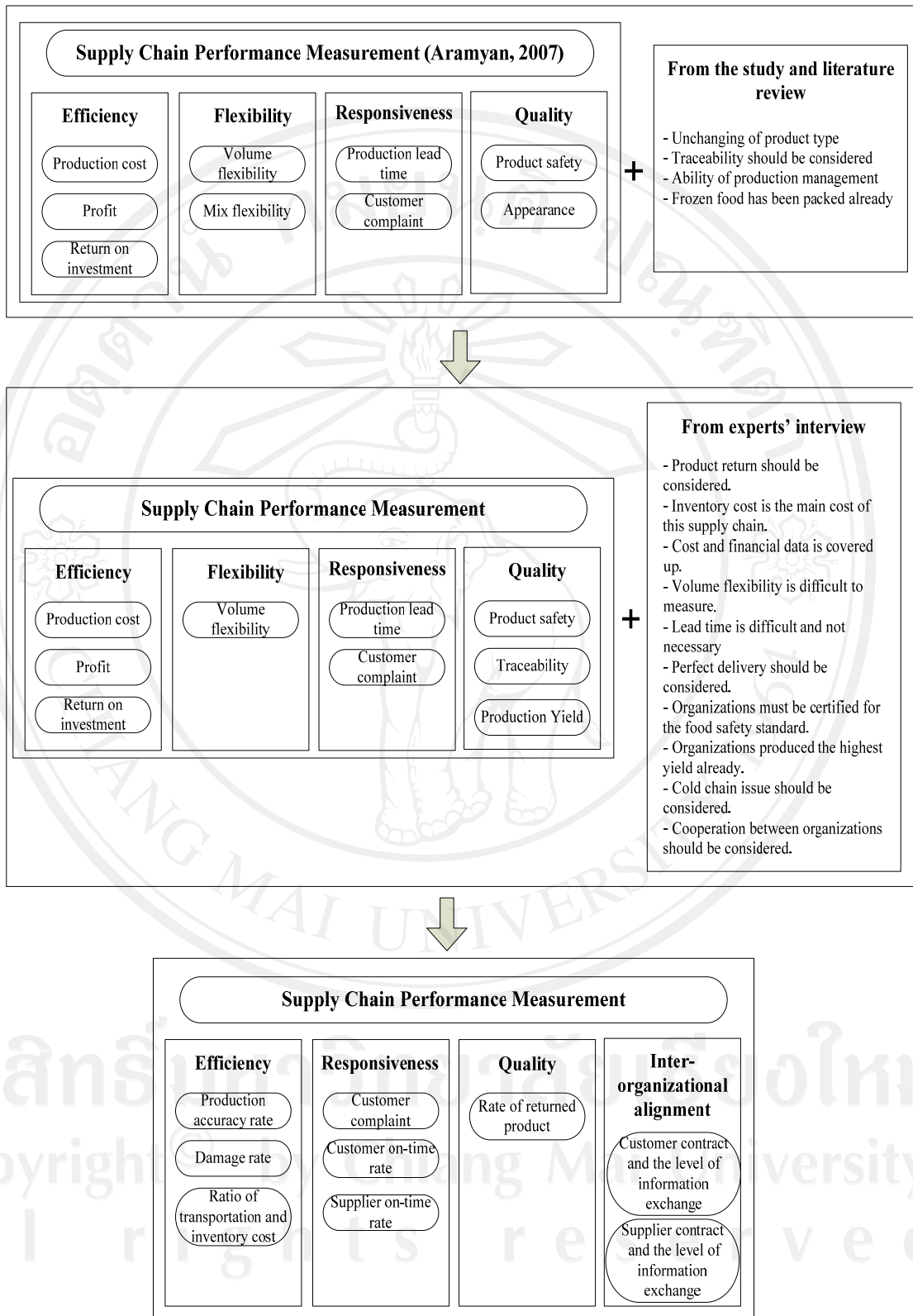


Figure 4.2 The step to create framework of performance measurement

Table 4.1 Definition of main criteria for Primary framework of performance measurement

| Main Criterion | Definition |
|----------------|--|
| Efficiency | In this criterion, we consider the ability on using resources for producing the benefit. How much the benefit and value that earn from existing resources. The main point of this criterion represents by quantitative criteria; for example, cost, benefit and return on investment. |
| Flexibility | Flexibility criterion provided the ability on improvement the process to response customer requirements or deal with the changing of environment. But for exported frozen food the customers and organizations usually make their contracts before production process. So, the production types are not much difference and the changing of product types is not considered. In this criterion, we consider only the number of products. |
| Responsiveness | In responsiveness criterion, we consider the sensitivity to response the incentives. In this research, we focus on the sensitivity to response customer requirements that how well and fast organizations can response to them. The mail points of this criterion represent in production lead timeand customer complaints |
| Quality | The quality criterion for exported frozen food is divided into 2 parts. First part is about processes and products. In the process part, there are definite criteria, especially for exported food that organizations have to be qualified for export standards. So in this criterion is emphasized the quality and safety in production processes that in whole processes have safety standards and can be checked back. |

Table 4.2 Definition of sub-criteria for Primary framework of performance measurement

| Main criterion | Sub-criterion | Definition | Measurement |
|----------------|-----------------|--|--|
| Efficiency | Production cost | All expense that incurred in production; for instance, raw material cost, labor cost, the storage cost and transportation cost | Percentage of all expense incurred in production or service per net cost |

Table 4.2 (continued)

| Main criterion | Sub-criterion | Definition | Measurement |
|----------------|----------------------|--|--|
| Efficiency | Profit | Primary profit incurred in production | Percentage of total sales per production cost |
| | Return on investment | The earning measure for all activities that occur in organizations. This represents the efficiency of resource using on the entire investment | Ratio of profit per investment |
| Flexibility | Volume flexibility | The organizations 'ability to change volume of production when customer requirements are changed | Maximum and minimum volume that can produce in the requirement changing period |
| Responsiveness | Production lead time | The time is taken for production or services | Production or service lead time |
| | Customer complaints | The customer complaints about the problem or dissatisfaction about products and services | Number of customer complaints |
| Quality | Product Safety | In production, the processes have to be controlled by safety standards; for example, chemicals using, storage period or another production standard. | Is each production process checked? |
| | Traceability | Recording at each process that where raw materials come from, how to produce or how long it takes in every step | The information record of every process or connection between each department |
| | Production yield | The resource using in production that can produce | Volume of products that are produced by production plan |

The primary performance measurement framework is made by literature reviews, study the general characteristics if export the frozen food. The primary criteria are chosen by the performance criteria that widely use for Agricultural supply chain then the questionnaires about criteria are created and sent to the experts. The exports of this research are separated into 3 groups;

1. Scholars who graduated in directly related disciplines or in supply chain management research for at least 5 years
2. A worker who has the management or operating decisions related to supply chain management in the frozen food manufactory with at least 5 years work experience
3. People who work on Planning Policy for exporting manufactory in the government

The interviews with the questionnaire are divided into two interviews. The first interview is open-ended questions about which criteria that the experts consider to approve for measuring the supply chain performance. From the first interview with the experts found;

1. The criterion about return of product should be considered.
2. The section of production cost, the main cost of the export frozen foods is the cost of storage therefore; another criterion that should be measured is inventory cost.
3. Information on costs and financial, company may not want to reveal specifically. If the organizations are not non-traded companies, may not have the data.
4. For the volume flexibility criterion, the raw material depends on the harvest season with features such as size and number to determine the performance. So the organizations must have a flexibility to increase production. But the food product, the different types of products is relatively small if compared with other industrial. The organizations have greater flexibility to adjust production and measurement issues are difficult. The percentage of production volume does not have the answer that shows the flexibility of the organizations.
5. For the production lead time criterion, there is no information which measured at the lead in producing each unit. It usually collects in the form of due date for each product. This criterion should be changed to fill customer orders completely would be better because sometime the production lead time goals do not show that the customer orders are perfect.
6. The percentage of perfect delivery should be considered because it affects to customer satisfaction.
7. The production safety criterion is not usually measured in this manner and each organization have different standard for production. Therefore, this criterion should not show anything. Especially, the organizations that export will be very strict because they must pass the FDA inspection of the destination country.
8. Traceability is the normal standard of frozen food manufactories which must be guaranteed that they can check back in any process of production. This criterion is not be helpful.

9. For the production yield criterion, every organization should produce the highest yield as much as they can already, so this criterion is not helpful. The criterion which should be considered is the accuracy of production.

10. Because of another criterion about quality of the food industry is “Cold chain” which is gaining attention. The cold chain is a direct impact on the quality of frozen foods. The principle of cold chain is to control the temperature of the food to be constant in both manufacturing, transporting and storing so in this section should be considered for performance measurement.

11. The main principle of supply chain management is co-operation between the members in supply chain so this issue should be considered.

After the first interview, the chosen criteria are collected and analyzed for choosing the criteria that used on the performance measurement and interview again to confirm the criteria are suitable and reasonable for measurement that shown in figure 4.3.

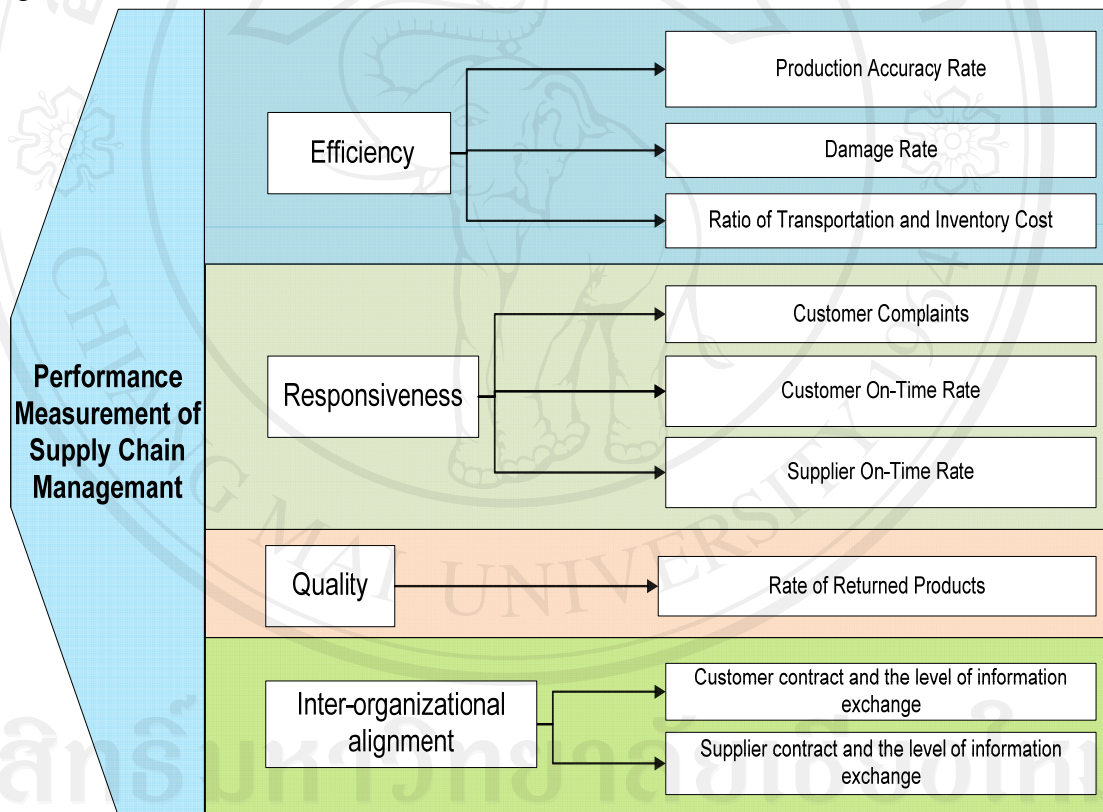


Figure 4.3 The performance measurement for export frozen food supply chain management

Each section of the measurement criteria is defined as follows;

1. Efficiency

In Efficiency criterion, we consider about the ability of using resources for producing the benefit, how much the benefit and value that the organizations produce and how well of management and production that the organizations do. In the

majority is expressed in the form of quantitative measurement. The efficiency criterion consists of sub-criteria as follows;

1.1. Production accuracy rate

Absolutely, the agricultural production has to be planned more carefully than another type. The main reason is the specific characteristics of raw materials that according to season, weather and time that have impact on quality of raw materials and products. Thereby planning has to be carefully and circumspect. Besides production has to follow the plan as much it can. The concerned activities are sourcing, production planning, manufacturing and quality controlling.

1.2. Damage rate

Because of the time constrain and the difference of raw material characteristics, they have to make sure that their production plan can produce the products with the right volume and quality. The concerned activities are sourcing, production planning, manufacturing and quality control.

1.3. Ratio of transportation and inventory cost

Due to the fact that agricultural raw materials and products are rotten easily, therefore inventory and transport before and after production are the main variables that impact on product quality. The concerned activities are planning, transportation and storage.

2. Responsiveness

For responsiveness, we concentrate on the sensitivity to response to the incentive. In this research, to fulfill customer requirements and supplier are emphasized that the organizations can fulfill the customer requirements or not and how well they manage their suppliers. The issues that used to performance measurement are accuracy, precision and on-time delivery together with customer complaints. Wherewith the sub-criteria are presented as follows:

2.1. Customer complaints

The customers satisfy is the main result that represents the quality of business management that how well the organizations can fulfill and response customers. Hence customer complaints show the ability of organizations in customer require fulfillment. The concerned activities are manufacturing, quality control, transportation and storage.

2.2. Customer on-time rate

For customer require fulfillment, on-time delivery and product quality directly influence on customer satisfaction. Therefore, the organizations have to place importance on them. The concerned activities are production planning, manufacturing and quality control, transportation and storage.

2.3. Supplier on-time rate

Moreover, to fulfill customer requirement, the ability to manage the organizations' suppliers is another important issue for supply chain management. In addition, raw materials are very important in production line so that the product

quality is partly due to raw materials quality. The concerned activities are sourcing, transportation and storage.

Table 4.3 How to collect the data for each criteria

| Main criterion | Sub-criterion | Measurement |
|--------------------------------|---|--|
| Efficiency | Production accuracy rate | Percentage of number of the products that can produce per product that be planed |
| | Damage rate | Percentage of number of no quality product per all products |
| | Ratio of transportation and inventory cost | Percentage of inventory and transportation cost per all asset |
| Responsiveness | Customer complaints | Percentage of customer complaints that can be solved per all register complaints |
| | Customer on-time rate | Percentage of customer on-time order per all order |
| | Supplier on-time rate | Percentage of on-time purchase order per all purchase order |
| Quality | Rate of returned products | Percentage of number of retuned products per all products |
| Inter-organizational alignment | Customer contract and level of information exchange | Level of information exchange |
| | Supplier contract and level of information exchange | Level of information exchange |

3. Quality

The exported frozen food industry gives importance on products and all types of products to have their standard. The organizations must be certified the food standards; for example, HACCP, GMP and traceability. Since the criterion that used for measure product quality is the criterion that apart from general standards and the direct impact on product quality is presented. Rate of returned product is presented to be the criteria of quality section. Because the important issue is food safety in all of production processes from raw materials production until sending to customer. The products must be safe and in keeping with the production standard for export. If there are some mistakes, all products will be returned because it is not in the standard. The

concerned activities are production planning, manufacturing and quality controlling, transportation and storage.

4. Inter-organizational alignment

This section emphasized on the cooperation between organizations because the main idea of supply chain management is focused on the relationship between the members in chain wherever customers, partners or suppliers for the benefit that will occur. The sub-criteria of this sector are “customer contract and level of information exchange” and “supplier contract and level of information exchange”

4.1. Customer contract and level of information exchange

This criterion represents the relationship between organizations and customer that which level they are on information exchange for planning, production and business advantages. The concerned activities are production planning, transportation and storage.

4.2. Supplier contract and level of information exchange

This criterion is the same with customer contract and level of information exchange but measure by the suppliers and organizations. The concerned activities are production planning, transportation and storage.

For each criteria of measurement is used to collect the data has the method that shown in table 4.3

For “Inter-organizational alignment” criterion, researcher separates the level of information exchange into 4 levels because these criteria are qualitative data that cannot be measured in quantitative form that shown in table 4.4.

Table 4.4 Level of information exchange

| | | |
|-------------------------------|---------|---|
| Level of information exchange | Level 1 | The organizations have plans to make the official contracts or agreements but it's not practical reality |
| | Level 2 | There are official contracts or agreements with some main customers or main suppliers but they are not beneficial for both parties |
| | Level 3 | There are official contracts or agreements with most of main customers or main suppliers and the organizations are planning to make benefits and advantages of both parties but it depends on the cooperation and vision of main customers or main suppliers. |
| | Level 4 | There are official contracts or agreements with most of main customers or main suppliers. The suitable approaches are presented to produce the benefits and advantages for both parties by using their strategy and information exchange. |

4.3.Determination the criterion importance weight

The criterion important weight can be found by interviewing the expert in each field as mentioned in topic 4.2. The questionnaire consists of 2 sets asking about the expert's opinion and indicating the criterion important weight by using multi-comparative and needs to be only in the same level. When the expert gives the number to all criteria, the researcher needs to examine by calculating whether it conforms each other or not after the interview. If found that it is not conformed each other, interview and adjust the right number need to be reconsidered until it will conform each other.

The process to compare an important weight of each pair has some techniques which are quick process and makes it easier to avoid confusing. Firstly, the questionnaire asks about the step of important weight that which one is the most important to the less important. Then an arrangement of number 1-9 was used whether which one is more important. After that compare between the maximum criterion and the rest and asked like this until complete every pair.

After the expert indicates an important weight of each criterion, the consistency assessment needed to be done to prove the reasonability. It is considered from the Consistency Ratio (CR) and Consistency Index (CI) which derived from geometry mean as mentioned in chapter 3. For an initial measurement, the researcher chose Analytic Hierarchy Process (AHP) to measure by considering the point indicated by each expert of each criterion level. The example of the result and calculation were shown in table 4.5. Both of them derived from the interview result of the main determination of an important weight and the calculation of an important weight from the first expert.

Table 4.5 Comparison for the main criteria of the first expert

| <u>First Expert</u> | W_j | | | | W^T | AW^T | $AW^T W^T$ |
|-----------------------------------|---------------|-------------------|--------------|-----------------------------------|--------------|--------|------------|
| | 1. Efficiency | 2. Responsiveness | 3. Quality | 4. Inter-organizational alignment | | | |
| 1. Efficiency | 1 | 1/6 | 1/3 | 1/6 | 0.058 | 0.237 | 4.068 |
| 2. Responsiveness | 6 | 1 | 4 | 4 | 0.546 | 2.480 | 4.545 |
| 3. Quality | 3 | 1/4 | 1 | 1/3 | 0.130 | 0.529 | 4.087 |
| 4. Inter-organizational alignment | 6 | 1/4 | 3 | 1 | 0.267 | 1.141 | 4.278 |
| Vertical sum | 16.000 | 1.667 | 8.333 | 5.500 | 1.000 | | |

Considering consistency ratio (CR) from equation 3.1 By RI is random index which shown in table 3.2,

$$\begin{aligned} CR &= \frac{CI}{RI} \\ &= \frac{0.08}{0.09} = 0.091 \end{aligned}$$

The calculate consistency index (CI) by equation 3.2,

$$\begin{aligned} CI &= \frac{\lambda - n}{n - 1} \\ &= \frac{4.424 - 4}{3} = 0.082 \end{aligned}$$

And λ_{\max} from equation 2.4,

$$\begin{aligned} \lambda_{\max} &= \frac{\sum \left(\frac{AW^T}{W^T} \right)}{n} \\ &= \frac{4.068 + 4.545 + 4.087 + 4.278}{4} \\ &= 4.245 \end{aligned}$$

From the result, if CR is less than 0.10, it means that the data from the expert is consisting. The total point will be used to find an importance weight with the Fuzzy Analytic Hierarchy Process (Fuzzy AHP) in order to manage each expert's conflict. The result from comparing an important of each pair will be used to find the mean as shown in table 4.6. It indicates the main criterion of effective measurement of supply chain management.

Table 4.6 The average from comparison of main criteria from 9 experts.

| Criteria | W _j | | | |
|-----------------------------------|--------------------------|--------------------------|--------------------------|-----------------------------------|
| | 1. Efficiency | 2. Responsiveness | 3. Quality | 4. Inter-organizational alignment |
| 1. Efficiency | 1.000,1.000,1.000 | 1.111,1.000,0.900 | 0.900,0.692,0.563 | 2.667,2.778,2.889 |
| 2. Responsiveness | 0.900,1.000,1.111 | 1.000,1.000,1.000 | 0.818,0.643,0.529 | 2.333,2.444,2.565 |
| 3. Quality | 1.111,1.444,1.778 | 1.222,1.565,1.889 | 1.000,1.000,1.000 | 2.667,2.778,2.889 |
| 4. Inter-organizational alignment | 0.375,0.360,0.346 | 0.429,0.409,0.391 | 0.375,0.360,0.346 | 1.000,1.000,1.000 |
| Vertical sum | 3.386,3.804,4.235 | 3.762,3.965,4.180 | 3.093,2.265,2.438 | 8.667,9.000,9.333 |

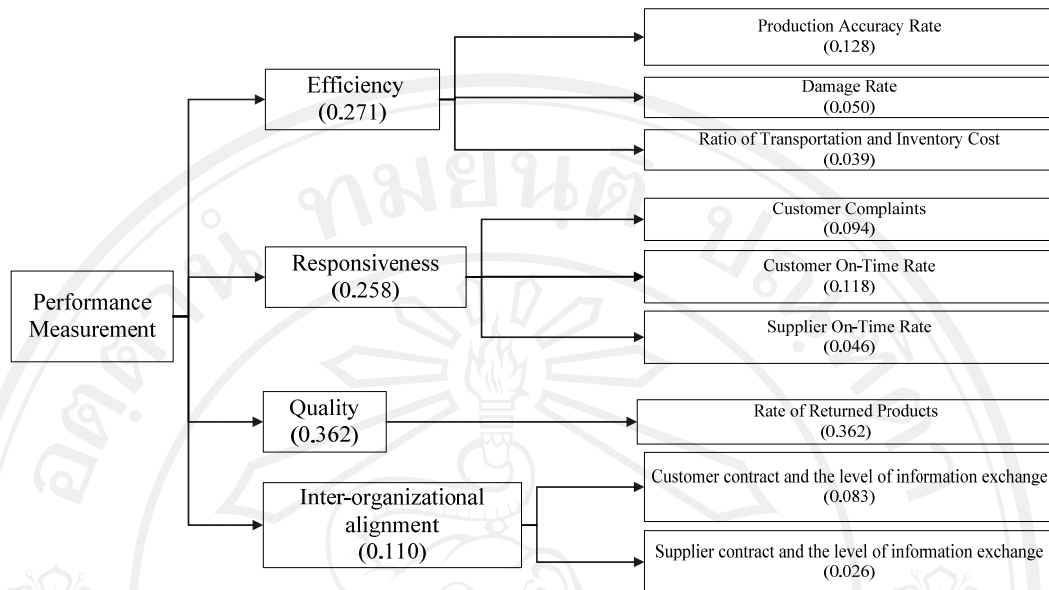
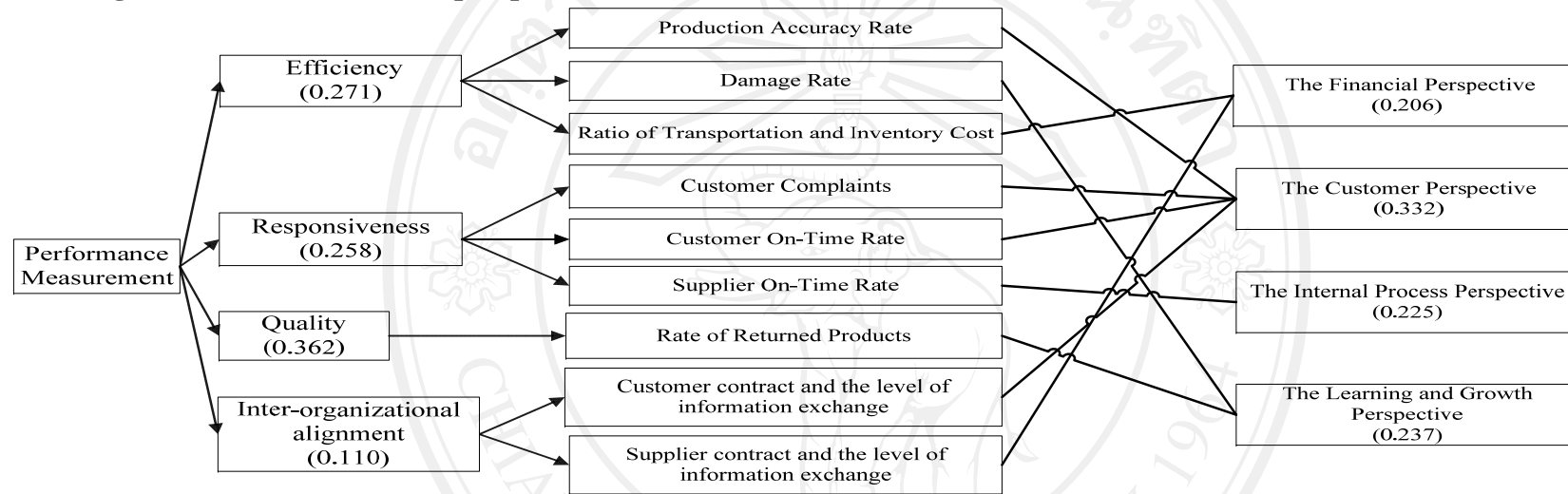


Figure 4.4 The structure of measurement framework

According to figure 4.4, the highest weight of main criterion is ‘Quality’ at 0.362. It shows that the exported frozen foods industry is focused on the quality of product than others. The management in the organizations and between customers or suppliers needs to be aware of the quality as the first priority. The ‘Efficiency’ main criterion achieves the second rank of weight as 0.271. This main criterion demonstrates the ability to manage in-house production that shows how well they can meet the customers’ expectation. The sub-criterion which got the highest weight in this part is ‘Production accuracy rate’. It has got the weight more than ‘damage rate’ and ‘ratio of transportation and inventory’ which their weight is very clearly similar. This means that the organization should be focused to produce as planned to reduce the waste that will occur subsequently. The main criterion which is the third rank is on the part of responsiveness as 0.258. This main criterion indicates the ability of organizations to respond to events that affect the activities in the supply chain. The highest weight in this part is ‘customer on-time rate’ and the second is ‘customer complaints’ which both criteria is about customer. If compared with the weight of ‘supplier on-time rate’, it is found that there is a very different weight. This indicates that the exported frozen foods industry is still focused on the customer more than supplier. The main criterion which is the lowest weight and much less than other criteria is ‘Inter-organizational alignment’ as 0.110. Besides the weight of its sub-criteria shows that ‘customer contract and the level of information exchange’ criterion’s weight is very higher than supplier’s as 0.083 and 0.026. This result demonstrates the exported frozen foods industry is focused on the exchange of information with relatively low if compared with other criteria as well as to provide priority on customers’ side-more than suppliers’ as well.

4.4. The weight of balanced scorecard perspectives



| | Efficiency | | | Responsiveness | | | Quality | Inter-organizational alignment | |
|------------------------------|---------------------|-------------|---------------------------------------|--------------------|-----------------------|-----------------------|--------------------------|--------------------------------|-------------------------|
| | Production accuracy | Damage rate | Ratio of transport and inventory cost | Customer complaint | Customer on time rate | Supplier on time rate | Rate of returned product | Customer contract level | Supplier contract level |
| Financial | 0.317 | 0.083 | 0.584 | 0.082 | 0.084 | 0.150 | 0.209 | 0.198 | 0.271 |
| Customer | 0.431 | 0.240 | 0.124 | 0.541 | 0.399 | 0.124 | 0.241 | 0.478 | 0.216 |
| Internal process | 0.171 | 0.201 | 0.157 | 0.231 | 0.237 | 0.393 | 0.242 | 0.177 | 0.258 |
| Learning & growth | 0.081 | 0.476 | 0.135 | 0.145 | 0.281 | 0.332 | 0.308 | 0.148 | 0.255 |

Figure 4.5 The relationship between the performance criteria and balanced scorecard perspective

In this research, the weights for each perspective of the balance scorecard are collected by the second questionnaire. Each criterion has weight which shows the relationship with the balance scorecard perspective. In the figure 4.5, the relationship between each criterion is shown by connecting the line of criteria with their highest relationship perspective. From the figure 4.5, the highest weight perspective is “the customer perspective” which strongly relate to four criteria which are “production accuracy rate”, “customer complaint”, “customer on-time rate” and “customer contract and the level of information exchange”. The second rank of perspective is “the learning and growth perspective” with the weight 0.237. This weight is compound by all of criteria weight but the highest weight of criteria which are related are “damage rate” and “rate of returned product”. The internal process perspective is the third rank with weight 0.225. This perspective represents how the organizations manage themselves so the criteria which relate are “supplier on-time rate” and “rate of returned product”. For the last perspective, the financial perspective has strong relationship with two criteria which are “ratio of transportation and inventory cost” and “supplier contract and the level of information exchange”. Besides this, the weights of each perspective of each criterion are analyzed and shown as below.

4.4.1. Product accuracy rate

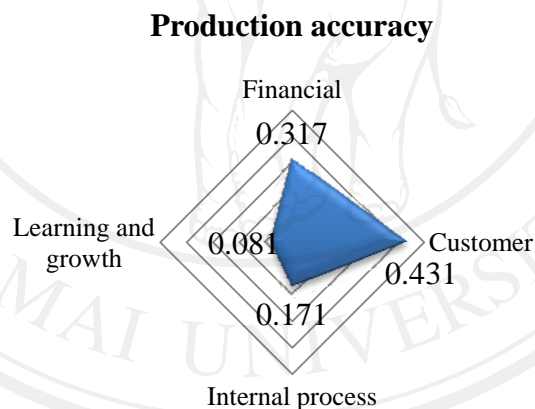


Figure 4.6 The balanced scorecard perspectives' weight of product accuracy rate

From the 'Production accuracy rate' chapter (figure 4.6), customer perspective has got the maximum weight with 0.431 followed by 'Finance perspective' with 0.317, 'internal process perspective' with 0.171 and the last one is 'Learning and growth perspective' with 0.081.

The weight indicated by each specialist for 'Production accuracy rate' found that the customer perspective's weight got the maximum weight because frozen food industry, production plan depend on the customers' need. The following reason happens since the organization sets the contract in advance about the product quantity and establishes the production plan to meet the customers' need. The second one is the financial perspective's weight and this one affected directly to the organization

that never followed the plan. The following effect contributes to the financial risk both production cost and unexpected expense in case of late delivery. In the internal process perspective's weight, it is also very important because in order to produce product as plan or not also needs to have a good plan in the organization.

4.4.2. Damage rate

In the chapter of Damage Rate (figure 4.7), the 'Learning and growth perspective' weight has got the maximum weight with 0.476 followed by 'customer perspective' with 0.240. There is 0.201 for 'Internal process perspective' and 0.083 for 'finance perspective'.

From the following weight, the 'damage rate' criterion in the Learning and growth perspective's weight has got the maximum weight, this may be because the experts focus on the damage of product may affect the learning improvement and development within the organization. The damage rate forced the organization to find out the source of problem and then solve and develop the product for the better quality. The second weight is 'customer perspective' described that if there is any waste of product in the production line and delivered to the customer, it will affect the reliability of the organization especially the food product that focus on the quality. 'Internal process perspective' is also very important for the waste product issue because the product quality is depending on the production process. If the production has a good quality and effectiveness, the quality of product will increase accordingly.

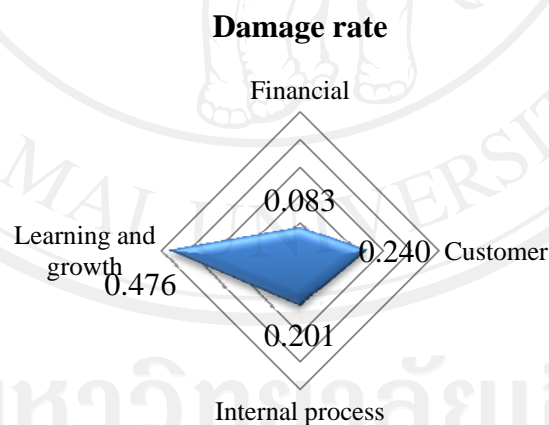


Figure 4.7 The balanced scorecard perspectives' weight of damage rate

4.4.3. Ratio of transportation and inventory cost

Each weight of balanced scorecard perspectives' weight in 'ratio transport and inventory cost' chapter illustrates the financial perspective's weight as the maximum weight with 0.584 and very obvious when compare with other perspective. The second one is internal process perspective with 0.157 followed by learning and growth perspective with 0.135 and the last one is customer perspective with 0.124 and can see in figure 4.8.

According to the previous data, 'ratio of transport and inventory' criterion and financial perspective's weight has got the maximum weight because the cost issue is relevant to financial by the way. Specially, there is the high expense about this criterion in food industry because transportation and inventory need to control the temperature to keep the product quality which is depending on temperature and period inventory. The management organization is also important such as, whether the organization plan for the maximum worthwhile or not. In addition, for transportation, whether the organization plan for the logistic or transportation route or not and this issue affect the organization's expense as well.

Ratio of transport and inventory cost

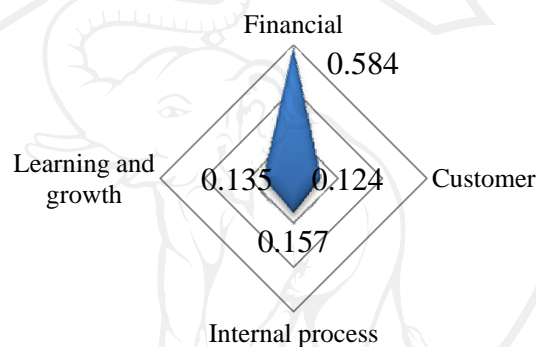


Figure 4.8 The balanced scorecard perspectives' weight of ratio of transport and inventory cost

4.4.4. Customer complaints

Regarding to the customer complaints criterion (figure 4.9), the customer perspective has got an obviously maximum weight with 0.54 followed by internal process perspective with 0.23. Learning and growth perspective got the 3rd rank with 0.15 and the last one is finance perspective with 0.08.

Customer complaint

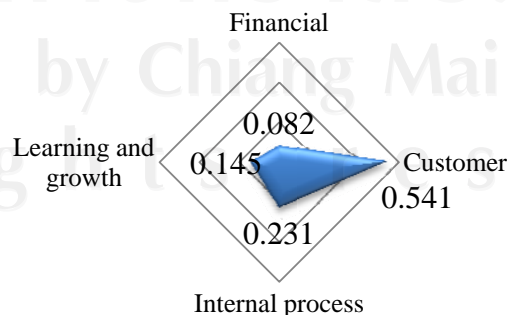


Figure 4.9 The balanced scorecard perspectives' weight of customer complaints

It can be seen that 'customer complaints are affected the most by the customer perspective because the customer complaints reflect the problem occurred within the organization that not respond the customer's need. In the food industry, some mistakes may occur in the food quality issue or the spec the organization cannot produce follow by the order or insufficient product quantity. Management within organization may contribute to the customer complaint because if the management within organization is good such as the good production, transportation plan or production plan, the organization can respond the customer need and no customer complaint.

4.4.5. Customer on-time rate

From the customer on-time rate criterion (figure 4.10), it can be found that the customer perspective got the maximum weight with 0.399 and followed by learning and growth perspective with 0.281. The 3rd one is internal process perspective with 0.237 and financial perspective's weight is the last one with 0.084.

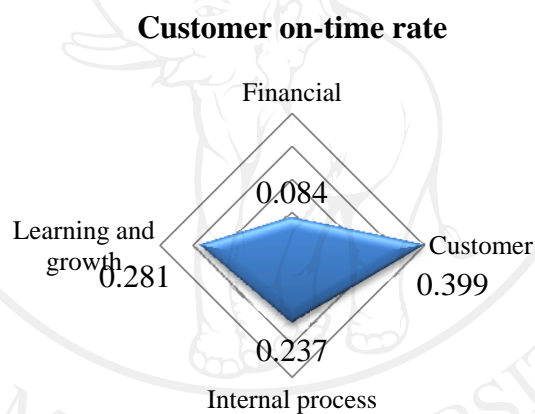


Figure 4.10 The balanced scorecard perspectives' weight of customer on-time rate

From the following weight, it can be found that customer on-time rate has got the maximum weight in the customer perspective because the following criterion refers to association with customer. This criterion shows the organization's capability in case of delivery on-time and correct. Furthermore, the internal process necessary to manage appropriately and effectively in order to deliver on-time and correctly. Apart from the effective process, the organization needs to improve the management process or operation in order to enhance its capability to respond the customer need.

4.4.6. Supplier on-time rate

For the supplier on-time rate criterion as can see in figure 4.11, the maximum weight is internal process perspective with 0.393 which is similar to learning and growth perspective's weight with 0.332. There is 0.150 for financial perspective's weight and 0.124 for customer perspective.

Supplier on-time rate

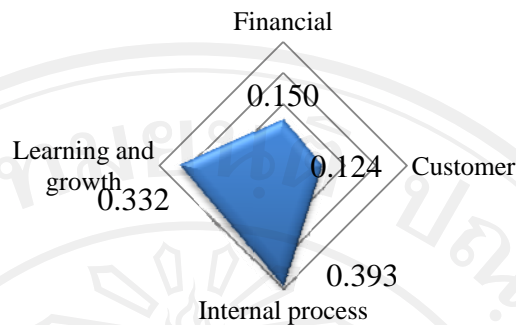


Figure 4.11 The balanced scorecard perspectives' weight of supplier on-time rate

From the following weight, the maximum weight for supplier on-time rate is internal process perspective. It indicates that the management with supplier is relevant to the internal management within organization. Also, whether how good it is because the supplier influence directly to the production especially in food industry. As the product quality depends on the material quality, it is not only the management of supplier but it also necessary to improve the relationship for further benefits of both organization and supplier.

4.4.7. Rate of returned product

The maximum weight for rate of returned product criterion is learning and growth perspective with 0.308. The internal process and customer perspectives have got the weight with 0.242 and 0.241. And the last one is financial perspective with 0.209 as can see in figure 4.12.

Rate of returned product

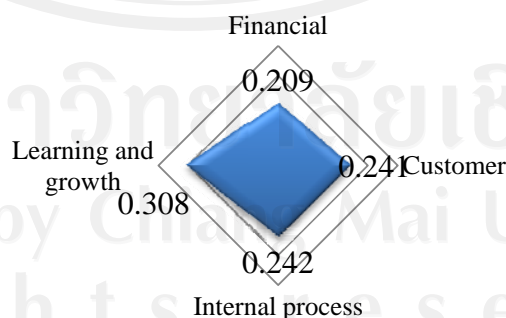


Figure 4.12 The balanced scorecard perspectives' weight of returned product rate

From the following data, learning and growth perspective influence rate of returned product criterion the most. This means that organization needs to improve its

management in order to decrease the mentioned issue. It may be because there is the regulation or limitation of exporting food in the present. Therefore, the organization needs to produce and develop its product by following that regulation. The following development will also affect the management within the organization, process improvement and management and the customer directly.

4.4.8. Customer contract and level of information exchange

Customer contract and level of information exchange

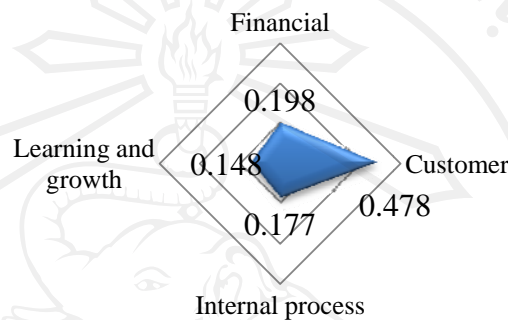


Figure 4.13 The balanced scorecard perspectives' weight of customer contract and level of information exchange

According to figure 4.13, the customer perspective has got the maximum weight with 0.478 in the customer contract level customer contract and level of information exchange criterion. The finance, internal process and learning and growth perspectives' weights are 0.198, 0.177 and 0.148 subsequently.

From the following data, it can be seen that the customer contract and level of information exchange criterion has got the customer perspective with the maximum weight because this criterion shows the relationship between organization and customer. The information exchange provides benefits to each other not only respond the customer need but also for the production plan. For the other perspective, the weights are similar because all of them related to the relationship between organization and customer.

4.4.9. Supplier contract and level of information exchange

For the supplier contract and level of information exchange criterion from the figure 4.14, all 4 perspectives are similar. The first one is the financial perspective has got 0.271 followed by internal process and learning and growth perspective with 0.258 and 0.255. The last one is customer perspective got 0.216.

From the following data, the supplier contract and level of information exchange criterion has got the similar weight for all 4 weights of perspective because food industry generally depending on the supplier. The financial weight of perspective has got the maximum weight because the main suppliers of food industry are agriculturists. Moreover, in order to manage with the supplier may contribute to high cost because their technology is totally not in the same level as organization

has. For example, organization use computer to keep database so that there is a high expense and for the farming contract, the organization also needs to pay in advance. Moreover, other perspectives are also important such as learning and growth perspective which is the direct way to develop organization especially the customer relationship management. If there is a good management, the planning, production and product quality will be better as well.

Supplier contract and level of information exchange

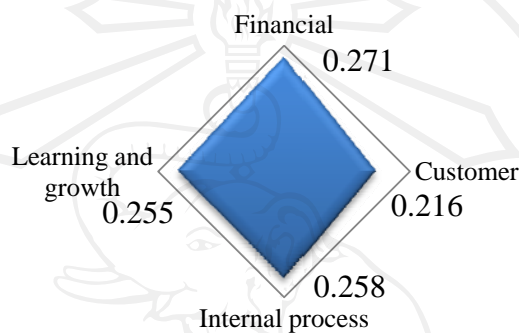


Figure 4.14 The balanced scorecard perspectives' weight of supplier contract and level of information exchange

4.4.10. The overall measurement

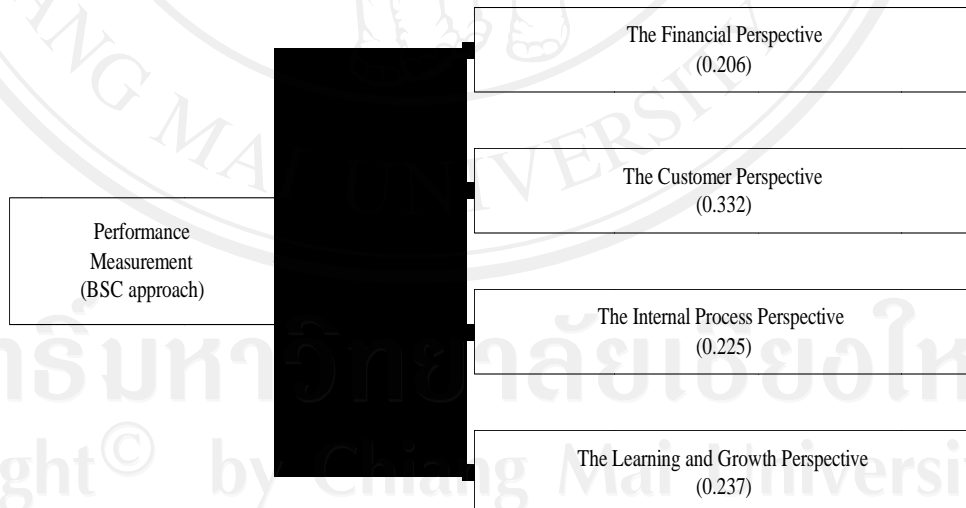


Figure 4.15 The balanced scorecard perspectives' weight of the overall measurement

From the figure 4.15, it shows the measurement of supply chain management. The 'customer perspective' weight is the maximum with 0.332 and followed by the weight of 'learning and growth perspective' with 0.237. The 'internal process

perspective' has got 0.224 point and the minimum weight is 'finance perspective' with 0.206 point.

For the measurement of the performance supply chain management of frozen food for exporting purpose, the financial perspective's weight is not that important rather than any other perspective weight. As can see that the customer perspective's weight gets the maximum weight, this means that the customer is the most important for these four perspectives because they are the main mechanism to operate business. Specially, the product for this industry is depending on customers. They will indicate their demands on the products including the contract before the purchasing occur. Apart from the customer perspective, the learning and growth perspective also important as well because food industry needs advanced technology to increase the product quality or effective production including the product improvement to meet the customers' need. The internal process is also important to indicate the product quality. The organization needs to handle about this point in order to keep the product quality. Another important point is financial perspective because finance is the basement of profitable business.

4.5. The sensitivity analysis

The sensitivity analysis in the one of importance process in multiple criteria decision making (MCDM) because weight of each criteria affect to the weight of balanced scorecard. For sensitivity analysis, researcher changed the criteria weight by starting at 0.0 until 1.0 and observed sensitiveness by focus on changing of the balanced scored card weight. In this research, the level of sensitiveness is divided into 3 levels which are high, medium and low sensitiveness. The definition of each level is described below.

1. For the criteria with high sensitiveness, the graph is steep slope, the curves intersect and the sequence of balanced scored card perspective is changed obviously.
2. For the criteria with medium sensitiveness, the slope of graph is steep but the curves do not intersect or slightly intersect. The sequence of of balanced scored card perspective is changed slightly.
3. For the criteria with low sensitiveness, the graph is a little steep. The curves do not intersect.

The sensitivity analysis of this research was analyzed from weight of criteria which affect to the balanced scored card criteria. The result of this show as the table 4.7

Table 4.7 The sensitivity analysis for main criteria

| Sensitivity level of criteria | | |
|-------------------------------|--|-------------------|
| High sensitiveness | Medium sensitiveness | Low sensitiveness |
| - Efficiency - Quality | - Responsiveness - Inter-organizational alignment | |

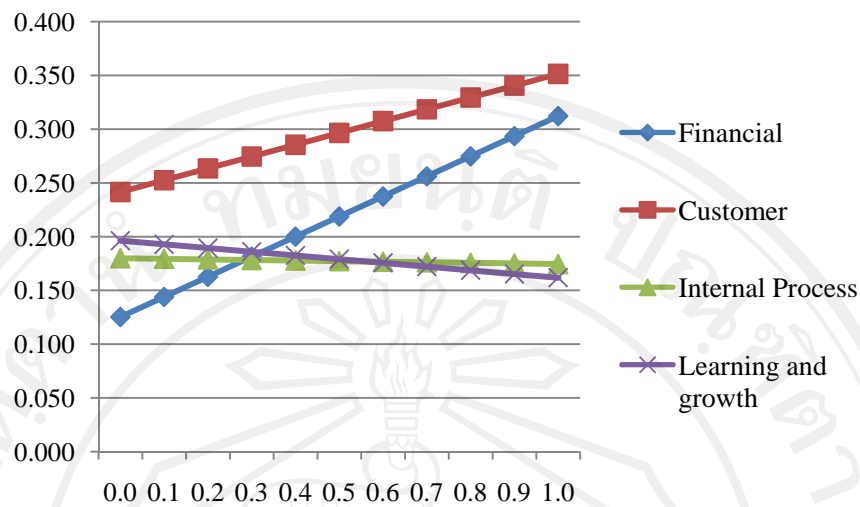


Figure 4.16 Sensitivity analysis of the weight of efficiency criterion.

The sensitivity analysis of efficiency criterion is shown in figure 4.16. The result shows that this criterion has high sensitiveness. The highest sensitivity perspective is financial perspective because its graph bristles and intersects with other graph. But for the customer one, graph also bristles quite same as financial one but its rank didn't changed even the weight was changed. Both criteria show that if efficiency weight increase, their weight also increase and are opposite with the internal process and learning & growth perspectives.

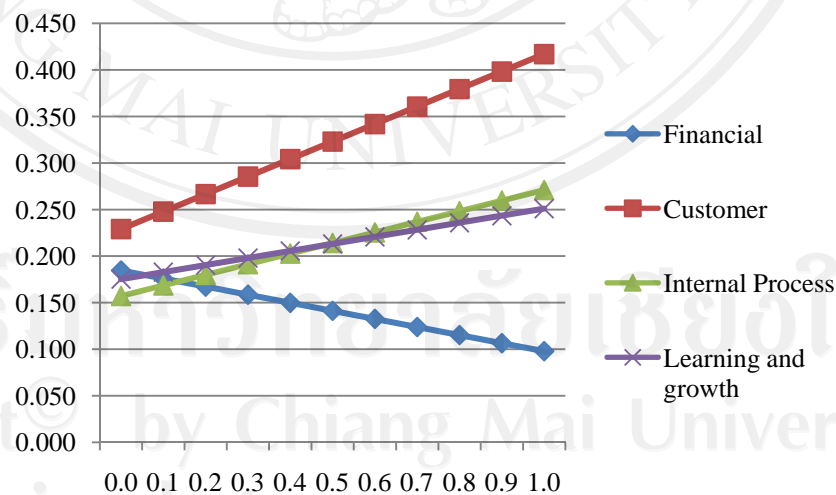


Figure 4.17 Sensitivity analysis of the weight of responsiveness criterion.

The sensitivity analysis of responsiveness criterion is shown in figure 4.17. The result shows that this criterion has medium sensitiveness. The highest sensitivity perspective is customer perspective but it does not intersect with other graph. The financial one also bristles quite same as customer one but its trend is opposite. The

internal process and learning & growth perspectives are quite same curves but interact each other when the weight is increased. The rank of them is alternating.

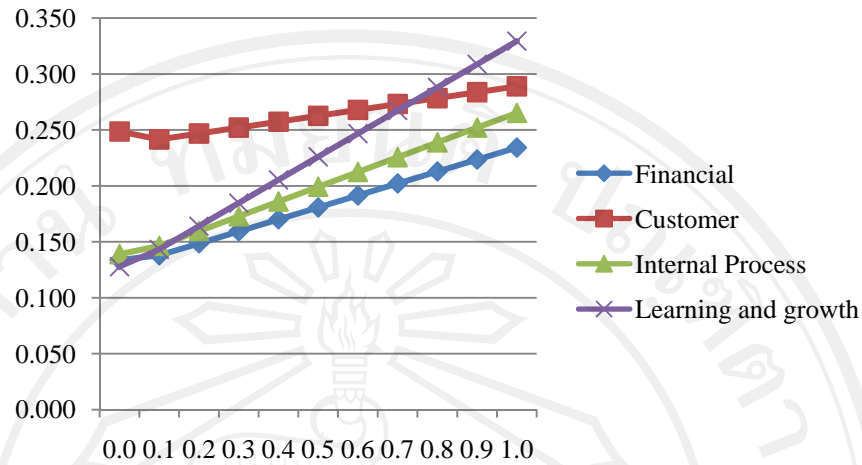


Figure 4.18 Sensitivity analysis of the weight of quality criterion

In accordance with the variations of quality weight, all four of the perspectives shown in the figure 4.18, the result shows that this criterion has high sensitiveness. However, as being shown in the graph above, the learning and growth perspective dominates and interact with the customer perspective when weight of quality is increased. But for other perspective, the slopes of their graph are quite steep but do not interact with others.

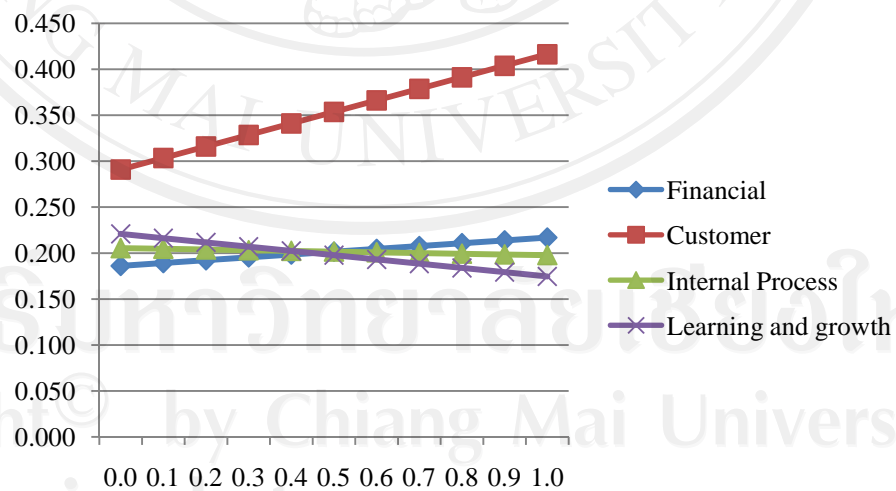


Figure 4.19 Sensitivity analysis of the weight of inter-organizational alignment criterion

As the figures 4.19 shown in the graph above, some inflate and some decline. The “Customer” and the “Financial” inflate and the “Learning growth” and the “Internal Process” decline at only small rate. But, the infatuation of the “Customer” is outstandingly progressive. However, three of the four factors which are the “Internal

process”, “Financial” and “Learning and growth” interact with each other. If considering only the slopes of all perspectives, the slopes are not steep as much as when changing weight of other criteria.

The results show that the criteria which are very sensitive are “Efficiency” and “Quality”. From this result, it will cause uncertainty in the reliability and accuracy of the results obtained earlier. For the result of the measurement by using this performance framework will be shown in the next chapter.



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