SUPPLIER RELATIONSHIP MANAGEMENT BASED ON PROCESS CAPABILITY INDEX FOR MULTIPLE CHARACTERISTICS

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Abstract

Quality of raw materials from suppliers is a very affect the product produced. A well managed supplier relationship management can improve the quality and better service of suppliers. From the selection criteria of existing suppliers, quality is one of the important criteria. Choosing a supplier based on the quality of its products will have a positive impact on the manufacturing company. There has been a lot of research on supplier selection using index capability process but it only ends in supplier selection only, no follow-up to selected supplier or not selected. In this research, the supplier is divided into two groups based on multiple characteristic capability index process with the aim to give development proposal for each supplier group. The number of suppliers in this study is nine, with the result of the division is, the first group consists of five suppliers. As for the second group consists of four suppliers. Characteristics of quality in group one is better than group two overall in both bursting, tear strength, tensile strength, and elongation. The development of this research is uninterrupted in the selection of suppliers only because there are not many skin suppliers available. From the supplier grouping based on the capability index, then develop the program for the supplier based on the group.

Keywords
Supplier relationship management, supplier grouping, capability index, multiple characteristic, supplier development

1. Introduction
Raw materials are a major requirement in the production process for manufacturing companies. In meeting the need for raw materials for the production process, most manufacturing firms depend on suppliers. The quality of raw materials supplied by suppliers is very affect both good and bad product that will be produced. The low quality of raw materials delivered can lead to a decrease in the quality of the resulting product. Non-compliance with raw material quality specifications may also result in additional work. This will lead to disruption of production processes in manufacturing companies. In that case the supplier plays a very important role to smooth the production process of manufacturing companies. From this case, the manufacturing company should be able to establish good relationships with suppliers, so that better support is given to manufacturing companies.
According to Roushdy et al. (2015) frequent interactions and close relationships with suppliers can have a positive effect on the exchange of information and knowledge flows, thereby improving process and

performance. Suppliers play an important role in business success. From a variety of supplier selection criteria, quality is considered the most important factor for supplier selection (Liao et al., 2013). Similarly, Weber et al., (1991). Therefore it is necessary to develop the supplier. According to Krause (1997) the understanding of supplier development is every business of a purchasing company with its suppliers to improve the performance and / or capability of suppliers and meet short-term and / or short-term supply needs of the purchasing company.

There has been much research on supplier selection with either single characteristic or with multiple characteristics. However, it only ends in the selection of suppliers only, no steps or follow-up on suppliers selected or not selected. In this research, grouping of suppliers based on process capability index for multiple characteristic has contribution to give development proposal according to the character of each supplier group. Supplier development program is part of Supplier Relationship Management (SRM). This is in line with the concept (SRM) that is the collaboration between suppliers and manufacturing companies together to improve quality, innovation and efficiency by improving cooperation, coordination and communication.

Examples of case studies presented are quality data of leather suppliers for shoe making at PT. Karyamitra Budisentosa. Characteristics of quality used include quantitative characteristics. All these characteristics are used for all types of women's shoe models. There are 4 (four) quantitative quality characteristics used in the company and also for this research. Characteristics of quality include Bursting, Tear Strength, Tensile Strength, Elongation. If the quality of the 4 (four) characteristics does not meet, it will affect the production process especially during the process of lasting (withdrawal) and application usage. The development of this research is uninterrupted in the selection of suppliers only because there are not many skin suppliers available. From supplier groupings based on capability index, then identification of program development for supplier based on group.

2. Literature Review

2.1 Supplier Relationship Management

According to Mettler & Rohner (2009) the definition of Supplier Relationship Management (SRM) is a comprehensive approach to enhance cooperation (business level level), coordination (process level), and communication (information systems level) between the company and its suppliers to continuously improve the efficiency and success of collaboration and while enhancing quality, security, and innovation. According to Roushdy et al. (2015) quality is a key factor whereby suppliers can improve and maintain quality assessment and delivery performance. Therefore, the practice of SRM introduced in its research shows its relevance to quality performance. It is very important for companies and suppliers that the quality and availability of products is always right. SRM activities include supplier selection, supplier evaluation, supplier segmentation, relationship development, performance measurement, risk management, supplier development and performance measurement of supplier relationship Tran (2015).

2.2 Process Capability Index Single Characteristic

Capability process index has been widely used in manufacturing companies to measure process capability and is essential for quality improvement activities. Several process capability indexes have been developed such as Kane (1986), Pearn et al. (1992).

$$C_p = \frac{USL - LSL}{6\sigma} \quad (1)$$

$$C_{pu} = \frac{USL - \mu}{3\sigma} \quad (2)$$

$$C_{pl} = \frac{\mu - LSL}{3\sigma} \tag{3}$$

$$C_{pk} = \min\left\{\frac{USL - \mu}{3\sigma^2}, \frac{\mu - LSL}{3\sigma^2}\right\} \tag{4}$$

where USL and LSL are the upper and lower specification limits, μ is the process mean, σ is the standard deviation of the process. The index measures only the distribution distribution (process precision), which only reflects the consistency of product quality characteristics. The index takes into account the magnitude of the process variance as well as the level of the average specification limits. and is used to measure the process with two specification sides namely Lower Specification Limit and Upper Specification Limit). Cpu and Cpl are specially designed for processes with one specification which requires only USL or LSL only. Cpu is an index that measures the ability of a smaller-the-better process to the upper specification limit (USL), whereas Cpl is an index that measures the ability of larger-the-better process with lower specification limits (LSL).

2.3 Multiple Characteristic Process Capability Indices for One Sided Specification

Wu & Pearn (2005) discusses multiple characteristic processes for one-sided specifications with upper specification limits and proposes a process capability index for smaller the better as,

$$C_{pu}^{T} = \frac{1}{3}\phi^{-1}\left\{\prod_{j=1}^{v}\phi\left(3C_{puj}\right)\right\} \tag{5}$$

which C_{puj} shows the value C_{pu} of the characteristic j_{th} for j = 1,2,. . , v and v are the number of characteristics. The relationship between C_{pu}^{T} index and overall yield yield P can be defined as,

$$P = \prod_{j=1}^{v} P_j = \prod_{j=1}^{v}\phi\left(3C_{puj}\right) = \phi\left(3C_{pu}^{T}\right) \tag{6}$$

For each single characteristic, the value C_{puj} can be estimated using a natural estimator,

$$\hat{C}_{puj} = \frac{\left(USL_j - \bar{x}_j\right)}{s_j},\ j = 1, 2, ..., v \tag{7}$$

where,

$\bar{x}_j$ = *mean* sample characteristic j_{th}

s_j = standard deviation sample characteristic j_{th}

and estimator from $\hat{C}_{pu}^{T}$ defined as,

$$\hat{C}_{pu}^{T} = \frac{1}{3}\phi^{-1}\left\{\prod_{j=1}^{v}\phi\left(3C_{puj}\right)\right\} \quad (8)$$

For larger the better characteristics C_{pl}^{T} can be done in the same way as the smaller the better.

2.4 Clustering Analysis

According to Santosa (2007) the main purpose of the cluster method is the grouping of data/objects into clusters (group) so that in each cluster will contain the data as closely as possible. In clustering we try to place similar objects (close distance) in one cluster and make the distance between clusters as far as possible. This means the objects in one cluster are very similar to each other and are different from the objects in the other clusters. In this technique we do not know beforehand how many clusters and how to group them. There are du approaches in clustering namely Clustering Hierarchy and K-means.

3. Research Methodology

Data collection of product quality characteristics from each supplier is done. In this research using quality characteristic data from 9 leather suppliers for shoe making. Characteristics used are bursting, tear strength, tensile strength and elongation. Then do the calculation of the capability index on each supplier. Supplier groupings are based on capability index. The supplier group is divided into 2 based on expert opinion to determine the team selected to develop each supplier group.

4. Result and Discussion

In the process of calculation of capability index, quality characteristic data is obtained from 9 (nine) skin suppliers. These data include the quality of bursting test results, tear strength, tensile strength, and elongation. Data quality characteristics are larger the better with the respective standards of bursting, tear strength, tensile strength, and elongation. The minimum specification limit of each quality characteristic for bursting = 20 kg / cm2, tear strength = 10 newton, tensile strength = 60 newton, and elongation = 70%. The requirements of these quality characteristics are very influential on the production process of shoes and at the time of application usage.

Table 1. Capability Index Calculation Data

Supplier	*Bursting*	*Tear Strength*	*Tensile Strength*	*Elongation*	C_{pl}^{T}
A	1,0979	0,9030	0,9678	1,0346	0,8251
B	1,1250	0,7038	0,6406	1,4304	0,5666
C	0,9088	1,1289	0,6214	1,4812	0,6057
D	1,1393	0,9090	1,0631	1,0752	0,8621
E	0,7674	0,6489	0,7407	0,7521	0,5175
F	0,4608	0,2414	0,3913	0,3425	0,0196
G	0,5014	0,4025	0,4099	0,7786	0,2041
H	0,4039	0,3868	0,3185	0,4886	0,0844
I	1,2476	0,9038	0,8979	1,2467	0,8181

From the calculation of capability index data then conducted the simulation of supplier grouping using minitab software. Minitab output data for cluster observation are as follows,

Cluster Centroids

Variable	Cluster1	Cluster2	Grand centroid
Bursting	1,10371	0,533377	0,850227
Tear	0,90969	0,419913	0,692009
Tensile	0,83816	0,465076	0,672347
Elongation	1,25360	0,590459	0,958871

Figure 1. Minitab output data for cluster observation

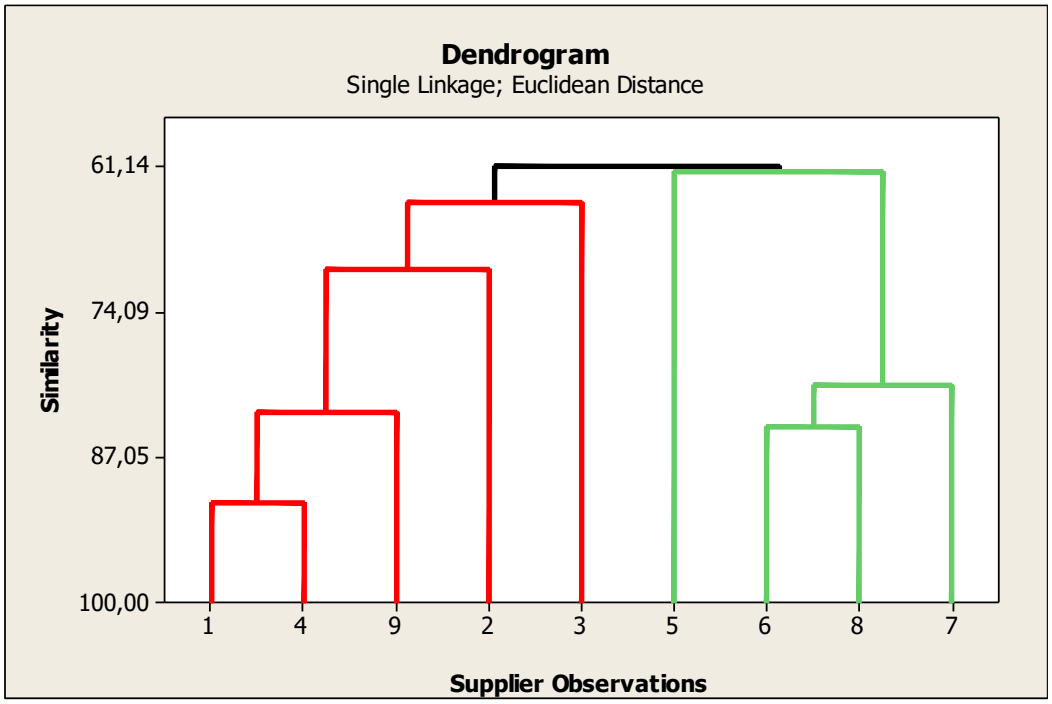

Figure 2. Supplier grouping dendogram

In the simulation of supplier grouping using minitab software, the supplier is divided into 2 (two) groups. Supplier group is divided into two because according to the consideration of the company's management representative. These considerations are based on the appointment of a development team for each supplier group based on the costs incurred by the company. The result of the division is, the first group consists of supplier A, supplier D, supplier I, supplier B, and supplier C. While for the second group consists of supplier E, supplier F, supplier H, and supplier G.

From Figure 1 it can be seen that the quality characteristics in the 1 (one) group are better than the 2 (two) groups overall in both bursting, tear strength, tensile strength, and elongation. After grouping into 2 (two) groups, then proposed for SRM activity with reference to research (Tran, 2015).

Table 2. Proposed activities of each supplier group based on SRM

Activity	**Group 1**	**Group 2**	**Tool/Document/ Data**
Supplier Grouping			Index Process Capability
Supplier Relationship Plan	Time Duration	Time Duration	SRM Program Templates (Determining the meeting plan and

Activity	Group 1	Group 2	Tool/Document/ Data
			determining who should be involved in the meeting)
Meeting with Supplier	Time Duration	Time Duration	Meeting report
Financial Analysis	Once a year	Once a year	Annual financial statements and financial analysis tools
Price Negotiation	Time Duration (refers to the price of leather on the market)	Time Duration (refers to the price of leather on the market)	Letter of Agreement, leather price list
Sustainability Management	Time Duration	Time Duration	Questionnaire
Capability Measurement	Time Duration	Time Duration	Historical data of skin quality
Risk Management	Based on the indication and risk assessment, adjust the risk as needed		Risk Assesment Tool
Supplier Development	Based on historical data of skin quality		Framework of Supplier Development Program
Internal Communication			Meeting, transfer of information between sections

The importance of the supplier relationship plan used in the SRM process will govern how the company and its suppliers maintain ways of communicating and arranging their meetings further. Then risk management is also very influential to understand the ability of suppliers that cause the highest risk in the company's operations. In this case, especially those that affect the quality of the preparation of raw skin and skin tanning process.

Supplier development is a business of the company and its suppliers together to improve the performance and capability of its suppliers in the field of quality, cost, delivery, technology, managerial skills, etc. Internal communication should also be considered because misunderstandings can occur in every part. Therefore, good internal communication can lead to increased efficiency in SRM activities. All documents and tools, measurement and analysis metrics are recommended to be systematically arranged. This will make it easier for everyone to follow the use of the same tools and templates in handling SRM activities. If the frequency of activity with suppliers in different groups is done well, then it can reduce quality errors and build relationships better than ever.

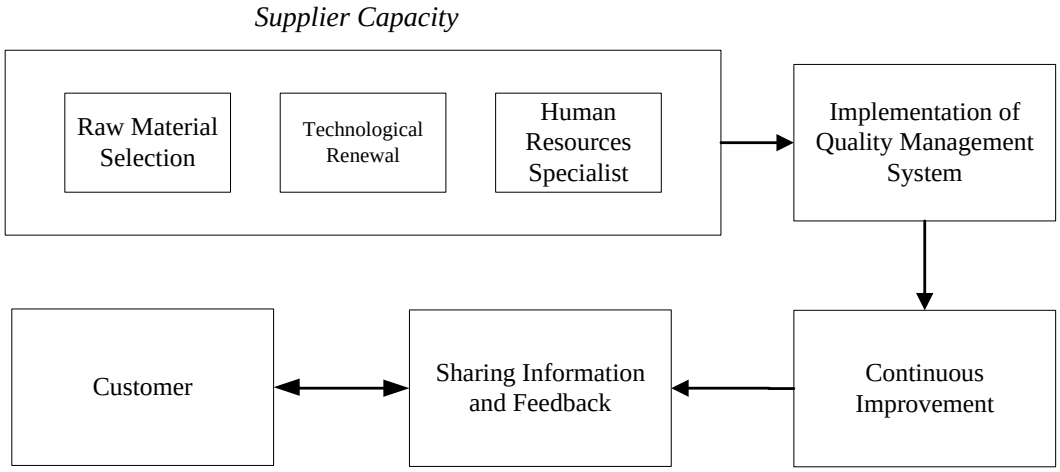

Figure 3. Framework of Group Supplier Development 1

Figure 3 shows the framework for the development of cluster suppliers. In Group 1, the capacity of suppliers is higher than that of suppliers in cluster 2, that is, in the process of searching for raw materials, the selection for technological reform related to the processing of raw materials of leather has been done. Then on Human Resources (HR) has been done specialties such as specialty for tannery and specialty for sheepskin tanning. Of the three categories related to raw materials, technology renewal and HR specialization, will have a positive impact on the quality of the products produced. Implementation of a quality management system such as ISO or standard of addidas has also been done on group 1 suppliers. To improve the quality of the resulting product, continuous improvement of the tannery / tanning process is made. Then share information and provide feedback has been done, this is to provide quick steps on management of both parties to immediately take decisions.

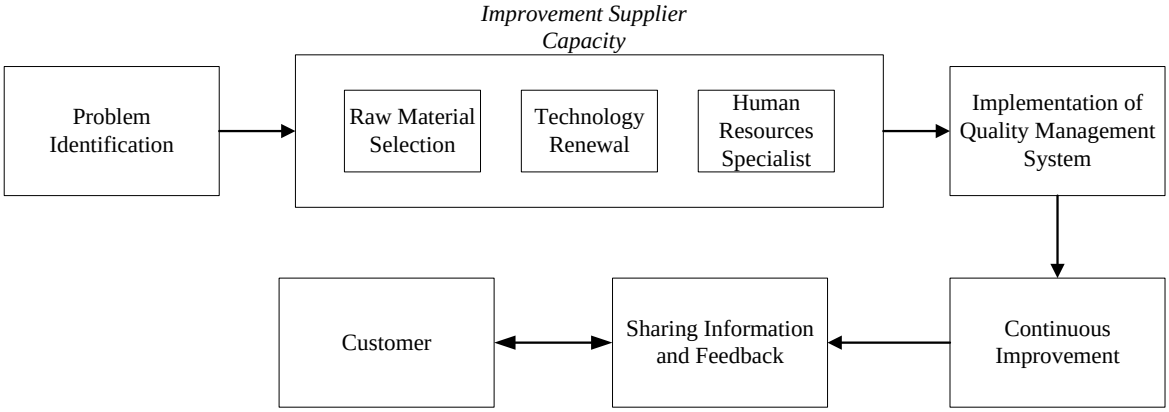

Figure 4. Framework of Group Supplier Development 2

Figure 4 shows the framework for the development of cluster suppliers. In group 2 with a lower capability index of group 1, what needs to be done is to identify the problems occurring in the tannery / tanning process. From the identification of problems that existed in group 2 suppliers with problems on raw materials, technological reforms and HR specialization that are under-scrutiny then required improvements to these three categories. Then the implementation of a quality management system such as ISO or standard of addidas should also be done on group 2 suppliers that will have a positive impact on product quality improvement. To improve the quality of the resulting product, continuous improvement in the tannery / tanning process should be carried out. Sharing of information and providing feedback has been made, this is to provide quick action on the management of both parties to take immediate decision. Improvements to group 2 suppliers refer to what has been done with group 1 suppliers.

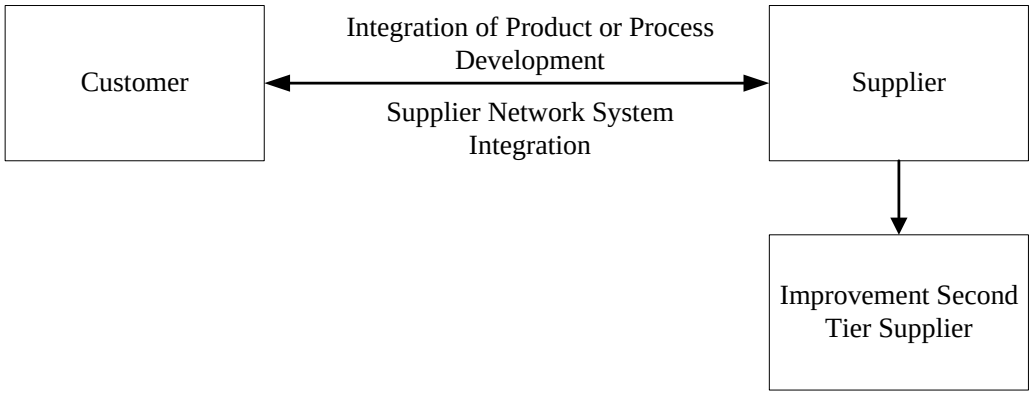

Figure 5. Future Supplier Development Framework

For the development of suppliers in the next stage is presented in Figure 5. In the development of this stage is done integration of product / process development. This is done so that between customers and suppliers can share information about new products they can do or the effective and efficient process they get to improve the quality of the products produced between the two. Supplier network system integration is built, so that between customers and suppliers can share information quickly, so it can be easy to make decisions. Improvement on second level supplier is also done, in this case second level supplier can provide raw material of leather with good quality. Steps in making improvements to second-tier suppliers are initial supplier capacity evaluation, production process evaluation, performance evaluation, supplier qualification, and implementation of quality management system.

5. Conclusion

Frequent interactions and close relationships with suppliers can have a positive effect on the exchange of information and knowledge flow, thereby improving process and performance. Suppliers play an important role in business success. A well managed supplier relationship results in increased customer satisfaction, reduced costs, better quality and better service from suppliers. As a result, supplier management processes are an important factor to maintain competitive advantage and quality improvement through continuous improvement and supplier development.

Process capability index has been widely used in manufacturing companies. The method is used to measure supplier capability process. The process capability index provides a numerical measure for the ability of a process to produce goods that meet specified quality requirements. The advantage of using process capability index is more accurate and reliable.

After the calculation of the capabiitas index on each supplier, then done grouping suppliers using minitab software, suppliers are divided into 2 (two) groups. The results of the division are:

1. The first group consists of supplier A, supplier D, supplier I, supplier B, and supplier C.
2. The second group consists of supplier E, supplier F, supplier H, and supplier G.

The quality characteristics in the 1 (one) group were better than the 2 (two) groups overall in both bursting, tear strength, tensile strength, and elongation. After grouping into 2 (two) groups, then proposed for SRM activity.

Supplier development framework identified into 3 phases include:

1. Framework of Group Supplier Development 1
2. Framework of Group Supplier Development 2
3. Framework of Supplier Development in the future

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