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Supply Chain Improvement with Design Structure Matrix Method and Clustering Analysis (A Case Study) 7

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Many strategic businesses attempt to achieve coordinating operations of company across departments using information and communication flow for their supply chain network. One of customer goods companies

in Surabaya attempts to improved their flow of information and communication using Design Structure Matrix (DSM). DSM is a method that could provide an alternative system grouping work activities. The activities of each department data and data interaction between the elements are needed to develop DSM. The research is done in the inter-department and intra department. The analysis technique used is the clustering analysis, which consists of hierarchical methods. The results show that for inter-department single linkage hierarchical clustering method with a number of groups of three is the best number of groups. For intra-planning department and intra-RMS department, the best number of groups is 14 and 8, respectively, using ward linkage method. Keywords supply chain, the design structure matrix, clustering analysis. 1. INTRODUCTION Nowadays, competitive pressures and changes in the economic conditions have forced companies to continuously improve their competitive advantage by creating new strategic business. Many strategic businesses attempt to achieve coordinating operations of company across departments using information and communication flow for their supply chain network. Simchi (2005) stated that

> **coordination of the supply chain has become strategically important as new forms of organization, such as virtual enterprises, global manufacturing and logistics networks, and other company- to-company alliances, evolve. The** customer goods industries **are** not an exception **for** developing and creating **the** new strategies. **They** 3

usually have a long supply chain and a complex network of

> **supply chain. The** multifaceted **of supply chain** 11

network may occur the ineffective of information flow, inefficient the use of information and communication. Ogulin (2003)

> **suggests three distinctive waves of supply chain management in the new economy: operational excellence, supply chain integration and collaboration, and virtual supply chains.** 5

Operation excellence refers to the degree of sharing within company, workflow activities across department within the company

> **in order to achieve efficiencies from increased order accuracy and timely shipments.** 8

Workflow activities and the interactions between elements can be depicted in a design structure matrix (DSM). A DSM can achieve an alternative system to perceive how strong the relationship between the elements effectively. After developing a DSM, the closeness relationship of activities in a DSM could be clustered using the use of information and communication. The clustering analysis is useful to classify the

groups with the similar characteristics (Barolomei, 2007). This research aims to propose an alternative system in a customer goods industry by applying DSM and clustering analysis. 2. LITERATURE REVIEW Design structure matrix is a matrix which aims to show all the interactions between elements (Chen & Huang, 2007). DSM has the advantage that they can improve the structure of the system by using matrix-based analysis techniques. Figure 1 presents the structure of the DSM. The input on a cell is the relationships between two elements.

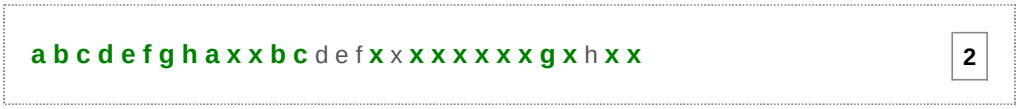

Figure 1. The example of DSM Type of interaction in DSM can be divided into two, namely numerica l binary DSM (Chen & Huang, 2007). The first type is the type of interactions that binary interactions, which interaction is only worth or not there is interaction. This type of interactions is able to show interaction between each element, but still have shortcomings. This type cannot describe how strong the interaction between one and another element. The second type of interaction in the DSM is the numerical which the value is worth its interaction with the figures. 2.1 Clustering Analysis Clustering analysis is a method of classifying an object into one or more than one group, so that each object is located in one group will have the same value of interaction. Clustering analysis aims to form groups with similar characteristics. Two kinds of methods in clustering analysis are hierarchical methods and non-hierarchical method (Sharma, 2006). Hierarchical method is a method that takes into account the distance between the two groups. Five-way hierarchical

Single linkage clustering Complete linkage clustering Centroid linkage clustering Average linkage clustering Ward linkage clustering In order to calculate the similarity value, the squared Euclidean distance can be applied. The squared Euclidean can be calculated in the formula 1. ……(1) j: is the element in column k: a number of variables of each of the elements 3. RESEARCH METHODOLOGY This research was designed and conducted using primary and secondary data. Primary data is applied by doing interview to the manager and his subordinates in the planning department and raw material store. The interviews used to obtain the workflow for each department. In addition, it also gives the information for determining the elements that are based on the activity manager and the subordinates. Secondary data used there are two that work instructions and past data on program systems and applications products in data processing in order to add elements that are not derived from the interviews and obtained the data flow. Data collection is designed in a Design Structure Matrix (DSM) and clustered using hierarchical methods and non-hierarchical method. Hierarchy has five different methods of linkage which often used for complete linkage, single linkage, average linkage, wards, and centroid. These five methods will be selected based on the highest similarity value. Clustering analysis aims to classify the activities contained in the DSM with a number of specific groups. Grouping is done based on distance data, which will make the flow of information between departments optimally. The method used to determine which group has a high value and the closeness low in the analysis of the distance is squared Euclidean distance. Finally, selection the best method of clustering analysis is done by considering the current conditions. 4. ANALYSIS After collecting data, design structure matrix (DSM) is built. The activities of two departments can be classified into 129 elements. The interaction values in each cell are obtained from number of transactions in raw material store department and number of daily activities in planning department. The

example of DSM is shown in figure 2. 2

Element

T-1 T-2 T-3 T-4 WOP **-1** WOP **-2 T-** 9

1 - 756 0 0 0 0 T-2 4190 - 112 0 0 0 T-3 0 112 - 0 0 0 T-4 3895 756 108 - 105 0 WOP-1 0 0 0 0 - 0 WOP-2 0 0 0 0 0 - Figure 2. The example of DSM where: Improving supply chain in this research is done by classifying the activities that have the same number of interactions (in one group). Dij: distance between elements i and j A group is expected to enlarge the company performance since they can communicate and inform the information effectively. X: the different data elements on Clustering analysis is accomplished using Minitab software. Clustering methods used there are two, namely, hierarchical i: an element which was in line methods and non-hierarchical method. Hierarchy has five different methods of linkage which often used for complete linkage, single linkage, average linkage, wards, and centroid. These five methods will be selected based on the highest similarity value. The similarity level of each method and each clustering

can be seen in table 1. **The result shows that** 6

single linkage method gives the highest similarity value. After calculating single linkage, the best clustering is determined through a combination of the computation RMSSTD with the company's current condition. Similarity Hierarchical method is an appropriate method because all elements have relationships with one another. Value of RMSSTD for each number of groups

can be seen in table **2.** The **result shows that** 6

10 groups give the smallest RMSSTD. But, this classification does not fit with the company's condition and consideration. After discussing and interviewing the company's expert about the classification each number of groups, we can get the result that the best number of cluster is three groups. In this research, clustering analysis is also applied to group the activities in Planning Department and Raw Material Store Department. The number of the selected group in Planning Department is 14. The result shows the single linkage clustering method is the highest in term of similarity value. Unfortunately, it is not suitable for company's current condition. Wards linkage clustering method gives an appropriate number of groups in term of company's current condition (figure 3). Group activity was initially assessed based on the type of product, whereas proposed group is classified based on the closeness activities of the group. Table 1. Similarity Level using Hierarchical Methods Cluste Ring Single linkage Centro id Complete Averag e Ward 1 80.673 58.28 0 40.067 -285.258 2 86.798 76.163 52.809 73.596 27.457 3 86.798 79.829 58.985 78.388 35.904 4 86.798 83.247 60.394 79.178 51.162 5 86.798 83.497 62.63 82.346 60.114 6 86.798 86.798 73.538 86.546 60.394 7 90.827 86.798 81.513 86.798 77.566 8 90.899 86.852 86.798 86.798 82.105 9 92.919 88.221 86.798 86.798 86.646 10 93.166 90.911 86.798 90.337 86.798 Table 2 Value of RMSSTD from 1 to 10 groups Number of groups RMSSTD 1 451.1007 2 440.1591 3 394.4475 4 350.8927 5 310.8812 6 276.2852

7 250.2835 8 232.0255 9 216.6936 10 208.5315 For Raw Material Store Department, the single linkage clustering method gives the highest similarity value. Indeed, it is not appropriate with the company's condition. Therefore, wards linkage clustering with number of groups is eight can be applied in term of company's condition. Currently, the group activity is classified based on the early function of each part (receiving, storing, shipping, etc.). The proposed group attempts to combine the administration activities on any part of the RMS. 5. CONCLUSION The result of clustering analysis interdepartmental planning and RMS differs from the grouping prior to the DSM. Total group originally owned by the company prior to using the DSM is the eight groups, after performing clustering analysis with the DSM has been reduced to three groups. The closeness relationship between the planning department and department RMS makes both departments need to be placed together or into one large department. Clustering analysis of intra-departmental planning has brought changes in the group activities held by the department. The first group owned by the department is planning three groups, after performing clustering analysis of these groups has increased to fourteen groups. Analysis of intra-departmental grouping of RMS has brought changes in the group activities held by the department. Total group originally owned by the department RMS are five groups, after analyzing the grouping of these groups has been increased to eight groups. Dendrogram with Ward Linkage and Squared Euclidean Distance -245.23 -130.16 -15.08 100.00 Observations Figure 3. The Example of Dendogram with Ward Linkage method and Squared Euclidean Distance. 6. REFERENCES [1] Bartolomei, Jason E. (2007, June). Qualitative Knowledge Construction for engineering systems: Extending the design structure matrix methodology in scope and procedure. "Massachusetts Institute of Technology, 1-191 [2] Chen, Gary. & Huang, Enzhen. (2007, April). A systematical approach for supply chain design using matrix structure. Montana State University, 285-299 [3] Ogulin R. Emerging requirements for networked supply chains (2003). In: Gattorna JL, Ogulin R, Reynolds MW, editors. Gower handbook of supply chain management. Burlington, VT: Gower Publishing; 2003. p. 486–500. [4] Simchi-Levi, D., & Kelompoknsky, P. (2008). Designing and managing the supply chain: concepts, strategies and case studies. New York: McGraw-Hill. [5] Sharma, Subhash. (2006). Applied multivariate techniques. Canada: John Wiley and Sons, Inc.

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