

Determining Criteria for Food SME's Supplier Selection Using DEMATEL-Based ANP Method

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Abstract. SMEs' contribution to Indonesia's national GDP is quite high. However ineffective supply chain management causes the competitiveness of food SMEs company is low. The purpose of this research is to determine the appropriate criteria for supplier selection to improve the competitiveness of food SMEs company. This research method using a combination of DEMATEL and ANP called DEMATEL-Based ANP. This method is used to generate supplier selection criteria and their weight, which are obtained from the judgment of seven experts. This research resulted in the 20 criteria considered important from the results of the expert judgment. Criteria with the greatest weight is the communication openness with the weight value of 14%.

1 Introduction

SMEs' contribution to Indonesia Gross Domestic Product (GDP) in 2017 reached 61,41%. The non-oil and gas industry that gives the greatest role to the national GDP is the food and beverage industry which holds the largest percentage in the role of national GDP. Association of Indonesian Food and Beverage Entrepreneurs stated that Indonesia is the fifth most competitive food industry in ASEAN.

One of the most effective ways for a company to be competitive is implementing Supply Chain Management or SCM [1], [2]. Supplier selection is crucial and considered as a strategic way in the management of an adequate supply chain [3].

2 Literature Review

SCM is used to manage the supply chain to enhance the company's performance by making improvements in planning and management activities such as material planning, inventory management, capacity planning, and logistics with suppliers and customers [4]. Food supply chain management is created to explain the activities or operation of production, distribution and consumption to maintain the safety and quality of various food effectively and efficiently [5], [6].

Multi-Criteria Decision Making (MCDM) is one of the most commonly used methods to resolve the complex problem that exhibits high uncertainty, conflicting goals, different interests, and from multiple perspectives [7].

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The integration of Decision Making Trial and Evaluation (DEMATEL) method with Analytical Network Process (ANP) called DANP is an appropriate method to include interaction and interdependence which exists between dimension and criteria that appear in real life problems [8]. ANP is one of multiple criteria decision making, which most widely used because it allows more complex relationship between elements by changing hierarchy into networks [9]. The DANP method is used to overcome difficulties in giving evaluation for pairwise comparison performed by the expert by modifying the question in the pairwise comparison. DANP solves the problem of 9-scale questions for the usual pairwise comparison which confuses the expert in their judgment by using total influence matrix [10].

3 Research Methodology

3.1 Criteria Assessment

In this research, researcher collects data three times. Data processing begins with identifying criteria from the study of literature. Judgment of 7 experts will validate the criteria from the literature which are 35 criteria and seven dimensions through the first questionnaire. The results will be processed using the geometric mean to eliminate the valuation criteria. The results which are 20 criteria and seven dimensions will be used for the next data collection to find the linkage between relationships judgment criteria to the expert. The final data collection will be processed by DEMATEL-Based ANP method to find the global weight of the criteria.

The results of dimensions and criteria that have been eliminated are seven dimensions and 20 criteria. The first dimension (D1) is economic, consist of price (C1), the speed of delivery (C2), and quality (C3). The second dimension (D2) is the response speed, consist of quick response time (C4), communication skills (C5), and service performance (C6). The third dimension is capability (D3), consist of problem-solving (C7), capacity (C8), and correct quantity (C9). The fourth dimension is customer relations (D4), consist of mutual trust (C10), honesty and truth (C11). The fifth dimension is supplier strategic (D5), consist of certificates (C12), guarantee (C13), and sales and marketing ability (C14), after sales service (C15), and support service (C16). The sixth dimension is flexibility (D6), consist of flexibility to respond to unexpected demand changes (C17), availability of resources (C18), and willingness to improve the product and process continuously (C19). The seventh dimension is social (D7) with the criteria of communication openness (C20).

3.2 Global Weight Calculation

The first step in data processing with DANP method is to create the direct-influence matrix (G) in the form of a 20x20 matrix because the number of criteria is 20, from the expert judgment. The results of the calculation of the direct-influence matrix (G) will be proceed with the calculation of Equation (1) to obtain the normalized direct-influence matrix from the direct or indirect effect, i.e., matrix X .

$$X = vG \quad (1)$$

The value of v is obtained based on Equation (2) where the maximum value of the row sums and the maximum value of the column sums of the matrix components.

$$v = \min_{ij} \left\{ \frac{1}{\max_i \sum_{j=1}^n g_c^{ij}}, \frac{1}{\max_j \sum_{i=1}^n g_c^{ij}} \right\}, \quad i, j \in \{1, 2, \dots, n\} \tag{2}$$

The next step after obtained the Matrix X is to get the total-influential matrix T_c from Equation (3) below

$$T_c = X(I - X)^{-1} \tag{3}$$

where I is the identity matrix. The next step after getting Matrix I is to calculate matrix $(I - X)$. Matrix $(I - X)$ will be inverted to obtain matrix $(I - X)^{-1}$. The next step after getting the inversed matrix $(I - X)$ is to multiply the Matrix X with the result of the Matrix $(I - X)^{-1}$ to obtain the total-influential matrix T_c . After calculating the total-influential T_c is calculating the total-influential matrix T_D . Matrix T_D is obtained from the sum of the total-influential matrix T_c based on each dimension.

The next step after getting the total-influential matrix for the dimension is creating Influential Network Relation Map (INRM). INRM is obtained from the sum and reduction of r and s value. The value of r and s will be compared with the threshold value to get the relationship between dimensions. Fig 1 shows the relationship between each dimension.

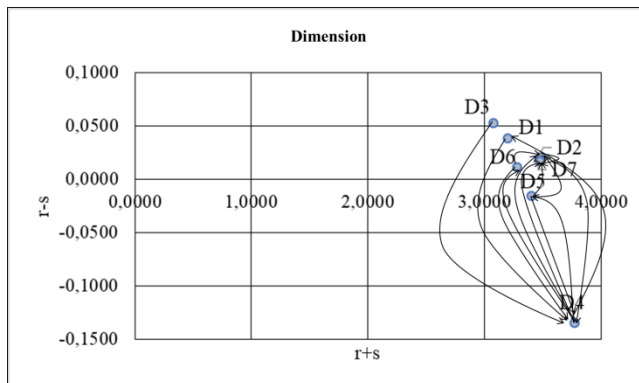


Fig. 1. Influential Network Relation Map of Dimensions

To make unweighted supermatrix for the dimensions, Equation (4) is used

$$W_c = (T_c^{nor})' \tag{4}$$

where to get matrix T_c^{nor} , the first step is doing normalization for matrix T_c . Normalization is calculated by dividing each element of the row with an average of each element in the criteria row of the same dimension in the matrix of criteria. To make the weighted supermatrix W_c^* through Equation (5) by doing the multiplication of each element T_D^{nor} with each division matrix W_c . The normalized matrix T_D in the form of T_D^{nor} is calculated by dividing each element of the row into the matrix dimensions.

$$W_c^* = T_D^{nor} W_c \tag{5}$$

The final step is to form the limit weighted supermatrix to obtained stable supermatrix through Equation (6). Limit supermatrix shows global weight for criteria that may indicate the importance of each criterion in the selection of suppliers.

$$\lim_{\varphi \rightarrow \infty} (W_c^*)^\varphi \tag{6}$$

Table 1. Limit Super-matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
C1	0,044	0,044	0,044	0,049	0,049	0,049	0,042	0,042	0,042	0,055	0,055	0,048	0,048	0,048	0,048	0,048	0,046	0,046	0,046	0,049
C2	0,042	0,042	0,042	0,046	0,046	0,046	0,040	0,040	0,040	0,052	0,052	0,045	0,045	0,045	0,045	0,045	0,043	0,043	0,043	0,046
C3	0,047	0,047	0,047	0,052	0,052	0,052	0,045	0,045	0,045	0,058	0,058	0,051	0,051	0,051	0,051	0,051	0,049	0,049	0,049	0,051
C4	0,045	0,045	0,045	0,049	0,049	0,049	0,043	0,043	0,043	0,055	0,055	0,049	0,049	0,049	0,049	0,049	0,046	0,046	0,046	0,049
C5	0,045	0,045	0,045	0,049	0,049	0,049	0,043	0,043	0,043	0,055	0,055	0,048	0,048	0,048	0,048	0,048	0,046	0,046	0,046	0,049
C6	0,044	0,044	0,044	0,048	0,048	0,048	0,042	0,042	0,042	0,054	0,054	0,047	0,047	0,047	0,047	0,047	0,045	0,045	0,045	0,048
C7	0,049	0,049	0,049	0,054	0,054	0,054	0,047	0,047	0,047	0,061	0,061	0,053	0,053	0,053	0,053	0,053	0,051	0,051	0,051	0,054
C8	0,040	0,040	0,040	0,044	0,044	0,044	0,038	0,038	0,038	0,050	0,050	0,043	0,043	0,043	0,043	0,043	0,042	0,042	0,042	0,044
C9	0,044	0,044	0,044	0,048	0,048	0,048	0,042	0,042	0,042	0,054	0,054	0,047	0,047	0,047	0,047	0,047	0,045	0,045	0,045	0,048
C10	0,069	0,069	0,069	0,075	0,075	0,075	0,066	0,066	0,066	0,085	0,085	0,074	0,074	0,074	0,074	0,074	0,071	0,071	0,071	0,075
C11	0,065	0,065	0,065	0,071	0,071	0,071	0,062	0,062	0,062	0,080	0,080	0,070	0,070	0,070	0,070	0,070	0,067	0,067	0,067	0,071
C12	0,026	0,026	0,026	0,028	0,028	0,028	0,025	0,025	0,025	0,032	0,032	0,028	0,028	0,028	0,028	0,028	0,027	0,027	0,027	0,028
C13	0,023	0,023	0,023	0,026	0,026	0,026	0,022	0,022	0,022	0,029	0,029	0,025	0,025	0,025	0,025	0,025	0,024	0,024	0,024	0,026
C14	0,029	0,029	0,029	0,031	0,031	0,031	0,027	0,027	0,027	0,035	0,035	0,031	0,031	0,031	0,031	0,031	0,030	0,030	0,030	0,031
C15	0,027	0,027	0,027	0,029	0,029	0,029	0,026	0,026	0,026	0,033	0,033	0,029	0,029	0,029	0,029	0,029	0,028	0,028	0,028	0,029
C16	0,029	0,029	0,029	0,031	0,031	0,031	0,027	0,027	0,027	0,035	0,035	0,031	0,031	0,031	0,031	0,031	0,030	0,030	0,030	0,031
C17	0,046	0,046	0,046	0,051	0,051	0,051	0,044	0,044	0,044	0,057	0,057	0,050	0,050	0,050	0,050	0,050	0,048	0,048	0,048	0,051
C18	0,042	0,042	0,042	0,046	0,046	0,046	0,040	0,040	0,040	0,052	0,052	0,045	0,045	0,045	0,045	0,045	0,043	0,043	0,043	0,046
C19	0,045	0,045	0,045	0,050	0,050	0,050	0,043	0,043	0,043	0,056	0,056	0,049	0,049	0,049	0,049	0,049	0,047	0,047	0,047	0,049
C20	0,133	0,133	0,133	0,146	0,146	0,146	0,128	0,128	0,128	0,165	0,165	0,144	0,144	0,144	0,144	0,144	0,138	0,138	0,138	0,146

4 Results and Discussion

The result of DANP method is global weighting to criteria as seen in Table 2. The global weighting for each supplier criterion is obtained from the diagonal value of limit super-matrix from Table 1.

Table 2. Dimension and Criteria Weights

Dimension	Criteria	Global Weight
D1	C1	0,04437
	C2	0,04202
	C3	0,04703
D2	C4	0,04922
	C5	0,04902
	C6	0,04788
D3	C7	0,04718
	C8	0,03845
	C9	0,04204
D4	C10	0,08493
D4	C11	0,07979
	C12	0,02800
	C13	0,02537
D5	C14	0,03086
	C15	0,02905
	C16	0,03094
D6	C17	0,04796
	C18	0,04317
	C19	0,04675
D7	C20	0,14592

The global weight is defined the importance weight of criteria. The highest weight criteria is communication openness, and the lowest weight is the guarantee (C13). The importance weight of criteria can be considered to select the right supplier.

The data are validated using geometric mean. The results of judgement 7 experts value will be processed using the geometric mean to eliminate the valuation criteria less than 3,4375. The results are 20 criteria and seven dimensions.

5 Conclusion

This research resulted in the 20 criteria considered important for supplier selection in food SMEs from the results of the seven experts judgment. The results are calculated using geometric mean to eliminate the criteria according experts' judgment. Criterion with the

greatest weight is the communication openness with the weight value of 14% from DANP method calculation. Criterion with the lowest weight is the guarantee with the weight value of 3%. The communication openness is considered important and the guarantee is considered less important for supplier selection in food SMEs company. The company can consider the criteria for selecting the right supplier.

This research funded by Universitas Indonesia – PITTA 2018

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