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Development of Sustainable Supplier Selection Model using Dematel for Manufacturing Industry

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Abstract: A Sustainable Supplier Selection in supply chain becomes a key strategic evaluation to sustain in a competitive manufacturing environment. Thus, a careful consideration in supplier selection should be identified and prioritised. For this reason, the studies were carried out to determine and analyse the elements that contributes to the establishment of the sustainable supplier selection. To investigate the effectiveness of Sustainable Supplier Selection in the manufacturing Industry, a questionnaire was chosen to collect data from experts. Using a Decision Making Trial and Evaluation Laboratory (DEMATEL) method a Causal model was then established. These model shows that the priorities for Work System Performance (WSP) is WSP 4 (Manufacturing Cost Reduction). This finding is significant for manufacturing firm to establish a sustainable supplier in the supply chain management. Highly focuses on all these factors as a part of in their decision making stage for supplier selection will ensure their operation are in the sustainable manufacturing environment.

Keywords : Sustainable Supplier Selection, DEMATEL, Work System Performance, manufacturing environment.

I. INTRODUCTION

The development of manufacturing process has changed follow with the innovation of high technologies. Changes in this upheaval considered Supply Chain Management (SCM). SCM is the incorporation key business forms from end-client through unique providers that give items, administrations, and data that additional incentive for clients and different partners [1]. For this purposes, supplier selection will give an impact to the environment by the process Green Supply Chain Management (GSCM). [2] believes that the implementation of GSCM based on performance measures such as environmental performance or green [3], manufacturing performance or competence, and economic or financial performance. To develop the successful GSCM, there are requirement in selecting sustainable supplier.

During late years, the thought of deciding supportable providers in the inventory network has become a key vital thought. These is on the grounds that a viable and productive provider choice technique assumes a crucial job to the accomplishment of an association [4]. Using environmental criteria in supplier selection will improve the process of getting a better GSCM. In this paper, analysis of implementation of Sustainable Supplier Selection in manufacturing industry was divided into two that are Work System Performance (WSP) and Work Responsive Practice (WRP) WSP is the performance measured in the process of strategic decision making in the organization [5]. This examination centers around Work System Performance (WSP) comprising of a Lead time decrease, WSP 1, Through-put time decrease WSP2, Work in progress decrease WSP 3, Manufacturing cost decrease WSP 4, Product quality improvement WSP 5, Machine use improvement WSP 6, and adaptability improvement in process WSP 7.

The main goal of this paper is developing a framework which can help to select Sustainable Supplier for GSCM. To development of model, most review papers was using multi criteria decision making (MCDM) such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Linear Programming (LP) and Data Envelopment Analysis (DEA) [6]. The model introduced by these papers is using DEMATEL. The selection of this tool because of the specialist in suggestion in chooses the influential factors between the elements.

II. METHODOLOGY

The DEMATEL method has been identified as the best tool available to identify the cause and effect relationship among the criteria of evaluation. In order to identify the interrelationship between the factors, or to examine and create the cause and effect relationship among the criteria of evaluation [7]. Figure 1 shows the process of DEMATEL methods.

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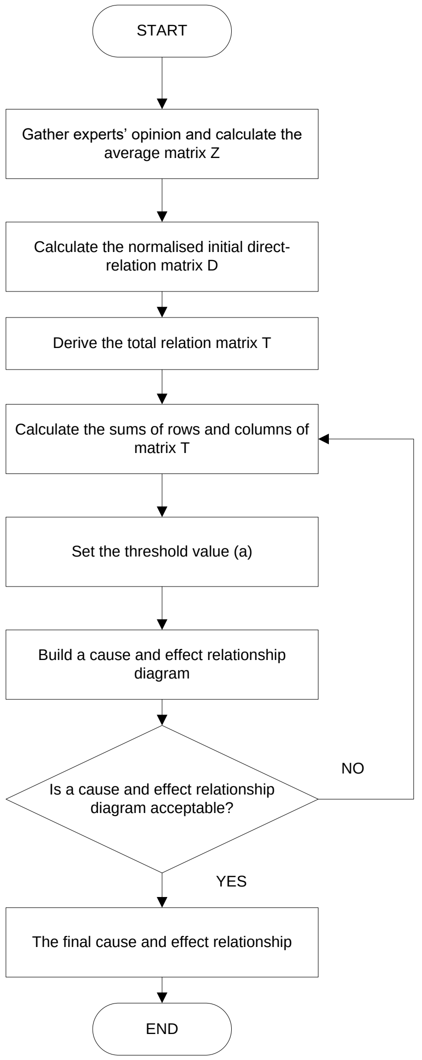

Fig. 1 DEMATEL Process

In gather experts' opinion, a comparison scale is selected in comparing the relative importance degrees of components. The comparison scale consists of the following levels in Table I.

Table I : Scale of relative influence used in the pairwise comparison matrix

Scale	Linguistic variable
0	No influence
1	Low influence
2	Medium influence
3	High influence
4	Very High influence

The average matrix *Z = [Zij]* are the matrices from *m* experts to aggregate all judgements from *m* experts is shown below.

$$Z\ ij = \frac{1}{m} \sum\nolimits_{i=1} m\ x_{ij}^{i} \quad (1)$$

The worth of each element in matrix *D* is placed between [0,1] and the normalized initial direct-relation matrix *D* is denoted as d_{ij} .

$$D = \lambda \text{ x } \mathrm{Z} \quad (2)$$

$$[d_{ij}\ ] \ = \lambda\ [Z_{ij}] \quad (3)$$

Where ,

$$\lambda = Min\left(\frac{1}{\max 1 < i < n\ \sum_{j=1}[z_{ij}]} + \frac{1}{\max 1 < i < n\ \sum_{i=1}[z_{ij}]}\right) \quad (4)$$

Equation 5 is used for the calculation and identification of the total impact matrix (*T*).

$$T\ = \lim_{m \to \infty} (D + D^2 + \ldots . + D^m) \quad (5)$$

$$T = D\ (1 - D)^{-1} \quad (6)$$

Vector *r* and *c* are used in order to depict the sum of rows and columns in the total impact matrix (*T*)

$$r = [r_i] \quad _{nxi} = (\sum\nolimits_{j=1}^{n} \quad t_{ij}\ ) \quad _{nx1} \quad (7)$$

$$c = [c_j] \quad _{1xn} = (\sum\nolimits_{j=1}^{n} \quad t_{ij}\ ) \quad _{1x\,n} \quad (8)$$

The calculation of elemental average was done in matrix T to derive the threshold value of ∝.

$$\propto = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}\ ]}{N} \quad (9)$$

III. RESULT AND DISCUSSION

The normalized initial direct relation matrix *D* was calculated that present in Table 3 from the value of normalized initial direct relation matrix z based on tens expert perspective represent in Table 2. The total relation matrix T was calculated using Eq. 5 and Eq. 6 as shown in Table 4 (*I*), Table 5 (*I-D*), Table 6 (Inverse of I-D) and Table 7 (T).

TABLE II. The Normalised Initial Direct – Relation Matrix, z

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
WSP 1	0	2.6	2.9	3	2.2	2.3	2.9
WSP 2	2.7	0	2.9	3.2	2.5	2.3	2.8
WSP 3	2.9	3.1	0	2.9	2.3	2.1	2.6
WSP 4	3.1	3.4	3.1	0	2.4	2.7	2.8
WSP 5	2.4	2.8	2.7	2.8	0	1.7	2.5
WSP 6	2.4	2.4	2.3	2.7	2.1	0	2.8
WSP 7	2.8	2.7	2.7	3	2.7	2.6	0

TABLE III. The Normalised Initial Direct- Relation Matrix D

WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
0	0.147727	0.164773	0.170455	0.125	0.130682	0.164773
0.153409	0	0.164773	0.181818	0.142045	0.130682	0.159091
0.164773	0.176136	0	0.164773	0.130682	0.119318	0.147727
0.176136	0.193182	0.176136	0	0.136364	0.153409	0.159091
0.136364	0.159091	0.153409	0.159091	0	0.096591	0.142045
0.136364	0.136364	0.130682	0.153409	0.119318	0	0.159091
0.159091	0.153409	0.153409	0.170455	0.153409	0.147727	0

TABLE IV. Total Relation Matrix T (I)

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
WSP 1	1	0	0	0	0	0	0
WSP 2	0	1	0	0	0	0	0
WSP 3	0	0	1	0	0	0	0
WSP 4	0	0	0	1	0	0	0
WSP 5	0	0	0	0	1	0	0
WSP 6	0	0	0	0	0	1	0
WSP 7	0	0	0	0	0	0	1

TABLE V. Total Relation Matrix T (I-D)

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
WSP 1	1.00000	-0.14773	-0.16477	-0.17045	-0.12500	-0.13068	-0.16477
WSP 2	-0.15341	1.00000	-0.16477	-0.18182	-0.14205	-0.13068	-0.15909
WSP 3	-0.16477	-0.17614	1.00000	-0.16477	-0.13068	-0.11932	-0.14773
WSP 4	-0.17614	-0.19318	-0.17614	1.00000	-0.13636	-0.15341	-0.15909
WSP 5	-0.13636	-0.15909	-0.15341	-0.15909	1.00000	-0.09659	-0.14205
WSP 6	-0.13636	-0.13636	-0.13068	-0.15341	-0.11932	1.00000	-0.15909
WSP 7	-0.15909	-0.15341	-0.15341	-0.17045	-0.15341	-0.14773	1.00000

TABLE VII. Total Relation Matrix T (inverse of I-D)

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
WSP 1	2.3669	1.5456	1.5291	1.6013	1.3190	1.2897	1.5091
WSP 2	1.5368	2.4554	1.5668	1.6491	1.3647	1.3212	1.5417
WSP 3	1.5086	1.5670	2.3883	1.5978	1.3236	1.2810	1.4967
WSP 4	1.6317	1.6982	1.6544	2.5787	1.4293	1.4056	1.6203
WSP 5	1.4123	1.4772	1.4453	1.5136	2.1420	1.1985	1.4170
WSP 6	1.3940	1.4404	1.4090	1.4899	1.2328	2.0948	1.4124
WSP 7	1.5445	1.5918	1.5619	1.6447	1.3766	1.3373	2.4084

TABLE VIII. The Relation Matrix T

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7
WSP 1	1.36692	1.545562	1.529114	1.601327	1.318992	1.289734	1.509079
WSP 2	1.53685	1.455386	1.566812	1.649143	1.364687	1.321227	1.541729
WSP 3	1.508606	1.567038	1.388257	1.597765	1.323592	1.280956	1.496682
WSP 4	1.63167	1.698228	1.6544	1.578686	1.429304	1.405576	1.620315
WSP 5	1.412308	1.477196	1.445316	1.513614	1.142026	1.198486	1.416972
WSP 6	1.394004	1.440378	1.408995	1.489887	1.232773	1.094808	1.412395
WSP 7	1.544473	1.59183	1.561883	1.644705	1.376598	1.33729	1.408416

The factor was found to be cause when ri – cj was positive. Furthermore, when ri – cj was negative the factor is effect [8]. As table 8, WSP 1, WSP 2, WSP 3 and WSP 4 are factors of effect. Meanwhile, WSP 5, WSP 6 and WSP 7 is cause factors. The importance of the evaluation perspective was determined by the ri+cj values. Based on Table 8, WSP 4 was the most significant evaluation perspective with the largest ri +cj value = 22.0933, whereas WSP 6 is the least significant perspective with the smallest ri+cj value = 18.4013. With regards to the r + c values, the prioritised of the importance of the seven evaluation perspectives seem s to be WSP 4 > WSP 2 > WSP 7 > WSP 3,> WSP 1 > WSP 5 > WSP 6.

TABLE IX. The average elements in matrix T

	WSP 1	WSP 2	WSP 3	WSP 4	WSP 5	WSP 6	WSP 7	ri
WSP 1	1.3669	1.5456	1.5291	1.6013	1.3190	1.2897	1.5091	10.1607
WSP 2	1.5368	1.4554	1.5668	1.6491	1.3647	1.3212	1.5417	10.4358
WSP 3	1.5086	1.5670	1.3883	1.5978	1.3236	1.2810	1.4967	10.1629
WSP 4	1.6317	1.6982	1.6544	1.5787	1.4293	1.4056	1.6203	11.0182
WSP 5	1.4123	1.4772	1.4453	1.5136	1.1420	1.1985	1.4170	9.6059
WSP 6	1.3940	1.4404	1.4090	1.4899	1.2328	1.0948	1.4124	9.4732
WSP 7	1.5445	1.5918	1.5619	1.6447	1.3766	1.3373	1.4084	10.4652
71.3220	10.3948	10.7756	10.5548	11.0751	9.1880	8.9281	10.4056	**cj**
	20.5556	21.2115	20.7177	22.0933	18.7939	18.4013	20.8708	**ri +cj**
	-0.2341	-0.3398	-0.3919	-0.0569	0.4179	0.5452	0.0596	**ri - cj**
∝	**effect**	**effect**	**effect**	**effect**	**cause**	**cause**	**cause**	
1.4556	**P 5**	**P 2**	**P 4**	**P 1**	**P 6**	**P 7**	**P 3**	

In terms of the threshold value (∝) that represents the interactions between perspectives, e.g. the values of WSP 2(1.5456) > ∝ (1.4556) hence the arrow in the cause and effect diagrams is drawn from WSP 2 to WSP 1 . The cause and effect diagrams of all sevens perspective is presented visually in Figure 2.

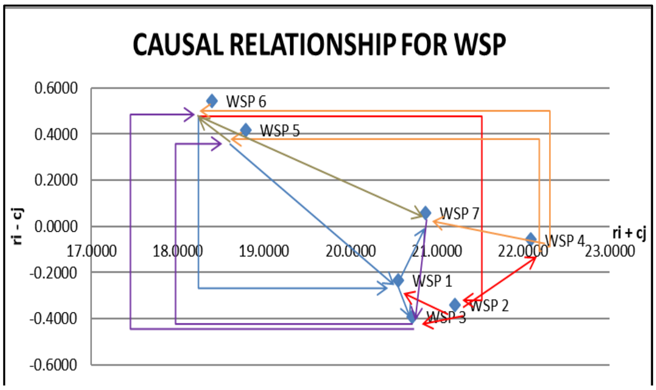

FIGURE 2. A causal relationship for WSP

IV. CONCLUSION

WSP activities are the performance that influences the Sustainable Supplier. This paper used DEMATEL method of analyse the WSP activities. The results were depending on data from threshold value, vector r and c. It is possible to conclude that there are two factors in WSP which is causes and effect. For the cause activities that are Product quality improvement WSP 5, Machine utilization improvement WSP 6, and flexibility improvement in process WSP 7. These three elements were classified in the cause group as directly affecting the others. From the prioritised element, the highest element is WSP 4 which is manufacturing cost reduction. However, this study is relevant to the Malaysia scope as it was collected in Malaysia only.

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