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Multi Criteria Decision Making Based Model For Supplier Selection

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Abstract –
Supplier selection and measurement of supplier performance are multiple criteria decision making (MCDM) problems and have a strategic importance for all industries. Supplier performance measures is a tool to determine whether suppliers are doing their job as expected. The importance of supplier performance measurement should not be underestimated. Supplier evaluation is a complex multiple criteria decision-making problem which is affected by several conflicting factors. Because of this, measurement of supplier performance is becoming increasingly important and critical. The purpose of this paper is investigate the MCDM methods in order to check how performance of suppliers are being measured with using MCDM methods. Evaluating supplier performance, derive the importance of the main criteria and sub-criteria applied in decision-matrix to sort the suppliers according to the measurement of supplier performance criteria.

Keywords – Supplier Selection, Multi, Decision Making, Supplier Evaluation , Analytical Hierarchy Process, Optimization

I. INTRODUCTION

Nowadays, the supply chain process has been made easier and traceable for companies to be carried out through enterprise resource planning systems such as processes logistics, inventory management, customer relationship management, supplier performance measurements. According to Chen, Simon, Reich-Weiser, & Woo (2013) as defined, supply chain is a global network covering the process from raw material to final product delivery in order to meet customer demand (as cited in N. Banaeian et al.,2015). The supply chain is a whole which covers almost all areas of a company such as purchasing, quality, finance, logistics and production. The supply chain is like the rings of the chain that interact. In the supply chain, each ring is the customer of the next ring. The problem in one of the rings affects all jobs that are connected. In this sense, accurate and proper reporting in the supply chain is very important. Reporting and analyzing processes, using forecasting methods are valuable tools and methods used to create strategies in the supply chain method. In this way, a more efficient production for companies will be realized and the costs will be reduced to a lesser extent.

The supplier evaluation systems are an evaluation system in which the companies have the opportunity to measure and monitor the performance of their suppliers according to the criteria which defined by companies. The measurement of Supplier performance is a measure of achieving results based on quality, on-time delivery accurate product or service at the right price. Companies are involved in the purchasing department to conduct transactions with suppliers. Purchasing specialists are interested in buying products, that is, the product is being valuable. Companies choose the most suitable suppliers with measurement of supplier performance.

The aim of this study is to perform measurement of supplier performance at Maquet Getinge Group which produces medical health products. In the study, the measurement of performance criterion for the company by using multi-criteria decision-making methods will be weighted by creating a decision matrix with Analytic Hierarchy Process (AHP). AHP method is used for determining the importance of the main criteria and sub-criteria, VIKOR and TOPSIS method are used to sort the suppliers according to the measurement of supplier performance criteria.

A variety of methodologies and studies have been suggested for the supplier selection problem in the literature. Shen et al., (2013) A case study is conducted in the automobile manufacturing company with the purpose of evaluating green suppliers' performance using with fuzzy multi criteria approach Shen et al., (2013). Govindan et al., (2013) examined the problem of identifying an effective model based on the Triple Bottom Line (TBL) approach for measuring sustainability performance of a supplier. Bruno et al.(2012) conducted a case study in railway company in order to cope with SSP (Supplier Selection Problem) by implementing AHP-based approaches for supplier evaluation. Azadnia et al., (2012) proposed an integrated approach in SSP to make clustering and multi-criteria decision-making methods. Gul and Guneri (2016) has used benefit of fuzzy logic with the application in Analytic Hierarchy Process to determine weights of criteria with the aim of prioritization of the alternative groups in manufacturing. On the other study Ebrahimnejad et al (2010) used multi criteria decision making methods to identificate risks with the help of fuzzy logic while Vahdani et al (2015) used parameters of FMEA to determine the preference of cause failures.

Multiple criteria decision making (MCDM) is a process evaluating the alternatives with respect to selected criteria. It is under operations research. There are two type of Multiple criteria decision making (MCDM) Multi-Attribute Decision Making, and Multiple-Objective Decision Making. Multi-

Attribute Decision Making is used when we are evaluating the criteria to select the best alternative, however Multiple-Objective Decision Making is used when you select the best alternative by evaluating the conflicted criteria. In this study, we will use the Multi-Criteria Decision Making, since we aimed to find weights of each criteria.

MCDM help the decision maker to give a rational decision and, select the best alternative with respect to criteria. Main purpose is from the view of all the criteria, determining the alternative that satisfies all of them. It is applicable in many topics, in our daily lives we evaluate the criteria, in order to make a decision.

The AHP method is a quantitative method for ordering and selecting alternatives based on multiple criteria according to the definition in Operations Management book by Russell and Taylor. With using hierarchy methodology percentage of each main and sub criteria are obtained with using pairwise comparisons. Superdecision, Microsotf Excel, Expertchoice are some tools to use AHP algorithm. In this study Superdecision program is selected to use it. AHP is based on pair-wise comparisons on a decision hierarchy, using 1-9 comparison scale.

In this study, multi criteria decision making based model has been proposed with the most important indicators to be considered in SSP. First of all, several alternatives of MCDM is analysed and three of them is selected in application.

Analytic hierarchy process (AHP) model can be used in the SSP with considering main objectives of supply chain process. Thomas L. Saaty developed AHP in 1980 as a measurement theory of intangible criteria (Aragon_es-Beltr_an et al. 2009). AHP exposes relevant priority vector when interpreting information preferred by decision makers based on a set of pairwise comparison values of objects. The AHP is based on the hierarchical structure and it is a kind of MCDM method. Goal , criteria and alternatives are 3 important elements of AHP. Goal shows the aim of the problem. Criteria is problem related elements that can be used for decision process. Saaty's scale of 1–9 has been used for each hierarchical level and pairwise comparisons are made with judgments using numerical values

AHP has a ability to evaluate hierarchical structure.as a whole of both quantitative and qualitative criteria. The pair wise comparisons are organized in a matrix and priorities are derived from the matrix as its principal eigenvector. Consistency of decision makers can be checked in AHP with the help of consistency ratio(CR). 0.1 value is the maximum limit to ensure that judgment is adequately done. Steps of AHP are shown below: (Guneri et al. 2015; Tzeng and Huang 2011):

Step 1: Definition of problem and identifying target of problem
Step 2: Criteria, sub-criteria and alternatives are determined by creating hierarchical structure.
Step 3: Pairwise comparison matrix is created with respect to experts
Step 4: Computation of λmax(average) of values from previous step.
Step 5: Computation of consistency index, CI = (λmax - n)/(n - 1) .
n : total number of items being compared.
Step 6: Estimation of CR and CI and obtaining random index (RI)

VIKOR (the VlseKriterijumska Optimizacija I Kompromisno Resenje) is one of the most common MCDM methods developed by Opricovic (1998) for multi-criteria optimization problems and compromise solutions. Ranking of alternatives and determination of compromise solution can be done with VIKOR. Solution shows the "ideal" which means closest to the optimal solution. This method focuses on selecting and sorting alternatives. The MCDM based on the basis of the proximity to the ideal solution "is also defined as the ranking index. VIKOR method steps are shown below:

Step 1: Creating alternatives and determining criteria

Step 2: Create a decision matrix: where $A_i$represents ith alternative, $i = 1,2,3, \dots m$; Cx_j represents the jth criterion, j =1, 2,..n; and x_{ij} separate performance of an alternative .

Step 3: The normalized decision matrix can be expressed as follows: $F = \left[f_{ij}\right]_{m\times n}$

Here, $f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$, $i = 1,2,3, \dots m$; x_{ij} is the performance of A_i alternative with respect to the jth criterion.

Step 4: Determination of the best and worst (f_j^* , f_j^-, respectively) values of all criterion functions $j = 1,2,, \dots n$. If the jth function represents a benefit then:

$$f_j^* = \max_i f_{ij} \ , \quad f_j^- = \min_i f_{ij}$$

Step 5 : Estimation of utility measure (S) and regret measure (R): S and R for each alternative are calculated as :

$$\boldsymbol{S_{ij}} = \boldsymbol{w_j}\frac{(\boldsymbol{f_j^*}-\boldsymbol{f_{ij}})}{(\boldsymbol{f_j^*}-\boldsymbol{f_j^-})} \quad , \quad \boldsymbol{S_i} = \sum_{\boldsymbol{j=1}}^{\boldsymbol{n}} \boldsymbol{w_j}\frac{(\boldsymbol{f_j^*}-\boldsymbol{f_{ij}})}{(\boldsymbol{f_j^*}-\boldsymbol{f_j^-})}$$

$$R_i = \max_j\left(S_{ij}\right) = \max_j\left(w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}\right)$$

where, S_i and R_i , represent the utility measure and the regret measure, respectively, and w_j is the weight of the jth criterion, expressing the relative importance of each criterion. w_j can be calculated by AHP or Entropy method.

Step 6: Computation of VIKOR index (Q_i) for ith alternative by the following relation:

$$Q_i = \frac{v(S_i - S^-)}{(S^* - S^-)} + \frac{(1-v)(R_i - R^*)}{(R^* - R^-)}$$

where: Q_i represents the ith alternative VIKOR value, $i = 1,2,3, \dots m$;

$$S^* = \max_i S_i \ , \ S^- = \min_i S_i$$

$$R^* = \max_i R_i \ , \ R^- = \min_i R_i$$

where "v" denotes: weight of the maximum group utility. It ranges between 0 and 1, and is based on the level of compromise among decision makers. The higher the term v,

the compromise is greater. In most cases, it is to be set to 0.5 (v =0.50).

Step 7: Rank the alternatives, sorting by the values S, R and Q, from the minimum value to the maximum. The results are three ranking lists.

Step 8: The alternative A_1 and A_2 are, respectively, the alternative with first (minimum) and second positions in the ranking list by the measure Q (Minimum) if the following two conditions are satisfied:

C1) Alternative A_1 must also be the best ranked by S or/and R

C2) Acceptable advantage: $Q(A_2) - Q(A_1) \geq DQ$; where DQ=1/(m-1); m is the number of alternatives.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is another MCDM method which is used for The proximity of the decision points to the ideal solution is based on the main principle. TOPSIS aims to find the best selection among the criteria.

Step 1: Creation of Decision Matrix

$$A=\begin{bmatrix} a_{11} & a_{12} & .. & a_{1n} \\ a_{21} & a_{22} & ... & a_{2n} \\ ... & ... & ... & ... \\ a_{m1} & a_{m2} & a_{m3} & a_{mn} \end{bmatrix}$$

m is an integer from decision in the decision matrix,

n gives the number of evaluation factors

Step 2: Creating of Standard Decision Matrix(R)

The Standard Decision Matrix is calculated using the elements of matrix A.

$$r_{ij}=\frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

R decision matrix is obtained as a result of the calculation above.

$$R=\begin{bmatrix} r_{11} & r_{12} & .. & r_{1n} \\ r_{21} & r_{22} & ... & r_{2n} \\ ... & ... & ... & ... \\ r_{m1} & r_{m2} & r_{m3} & r_{mn} \end{bmatrix}$$

Step-3: Formation of Weighted(V) Standard Decision Matrix

After calculating the wi values, multiplied by the value of rij, V decision matrix is created.

$$R=\begin{bmatrix} w_1 r_{11} & w_2 r_{12} & .. & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & ... & w_n r_{2n} \\ ... & ... & ... & ... \\ w_1 r_{m1} & w_2 r_{m2} & w_3 r_{m3} & w_n r_{mn} \end{bmatrix}$$

Step-4: Determine the ideal and negative ideal solutions.

The TOPSIS method assumes that each evaluation factor has a monotonous increasing or decreasing tendency

A* stands for ideal solution and A- stands for negative ideal solution

$$A^* = \left\{ \left(\max_i vij \;\middle|\; j \in J \right), \left(\min_i vij \;|\; j \in J' \right) \right\}$$

$$A^- = \left\{ \left(\min_i vij \;\middle|\; j \in J \right), \left(\max_i vij \;|\; j \in J' \right) \right\}$$

Step-5: Calculation of Discrimination Measures

The deviation values for the decision points obtained from the following equations are called the Ideal Separation (S_i^*) and Negative Ideal Discrimination (S_i^-).

$$S_i^* = \sqrt{\sum_{j=1}^{n} (vij - v_j^*)2} \qquad \text{Positive Ideal Separation}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (vij - v_j^-)2} \qquad \text{Negative Ideal Separation}$$

Step-6: Calculation of Relative Proximity to Ideal Solution

The ideal and negative ideal separation measures are used to calculate the relative proximity of each decision point to the ideal solution.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}$$

It takes the value C_i^* in the range of values 0<=C_i^*<=1 and shows the absolute closeness of the relevant decision point C_i^*=1 to the ideal solution, the corresponding decision point C_i^*=0 to the negative ideal solution.

II. RESULTS

AHP, VIKOR and TOPSIS are three important MCDM methods in order to find each SSP criteria to increase productivity. Criteria set is defined and determined with the help of 6 experts who have an experience in supply chain process.
Main and subcriteria of them can be seen in Table 1.

Table 1. Main and Sub Critreia Set of SSP.

Management Capabilities-MC1	Management and Organization (S1), Financial position(S2), Customer relation(S3), Reputation(S4)
Production Capabilities MC2	Production capacity(S5), Product diversity(S6), Quality(S7), R&D(S8)
Collaboration Capabilities MC3	Deliver reliability(S9), Warranties and claim policies(S10), Collaboration with partners(S11)
Cost MC4	Discount(S12), Terms of Payment(S13), Transportation cost(S14), Unit Product Cost(S15)
Agility MC5	Delivery flexibility(S16), Delivery speed(S17), Make Flexibility(S18), Source flexibility(S19)

MC: Main criteria
S: Sub criteria

In this study each of criteria weights have been found with using AHP ,ranking and prioritization of alternatives have been done with the help of VIKOR and TOPSIS method.

Subjective weights of Main Criteria set can be seen in Table-2

Table 2. Subjective weights of Criterias

Main Criteria	Weight
MC1	0.25
MC2	0.23
MC3	0.2
MC4	0.13
MC5	0.19

According to the AHP application, evaluations of the 6 experts in 9 scale matrixes are used to evaluate the relative weights of each group by pairwise comparisons. Table 2 shows the obtained results.

After determining the weights of five SSP parameters by AHP, the evaluations of each subcriteria is done for each sub criteria. Obtained results are showing in Figure 1-5.

Figure 1. Weights of Management Capabilities.

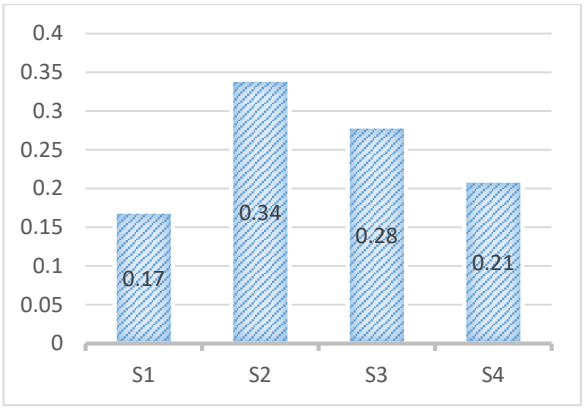


Figure 2. Weights of Production Capabilities.

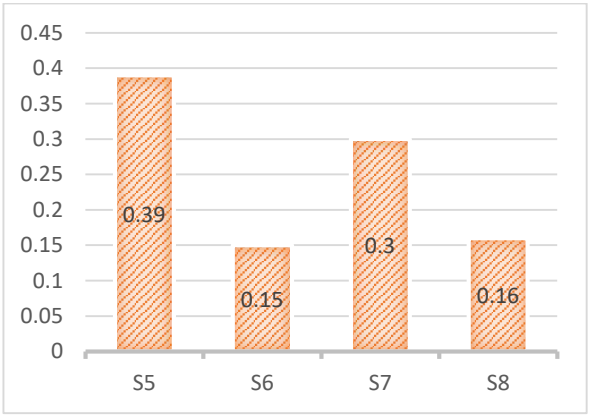


Figure 3. Weights of Collaboration Capabilities.

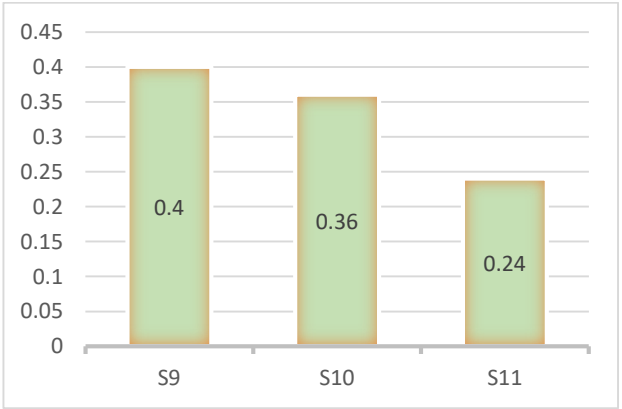


Figure 4. Weights of Main Crtirea: Cost.

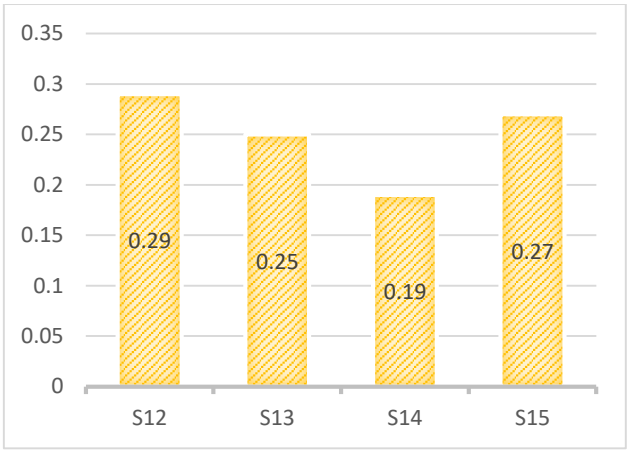
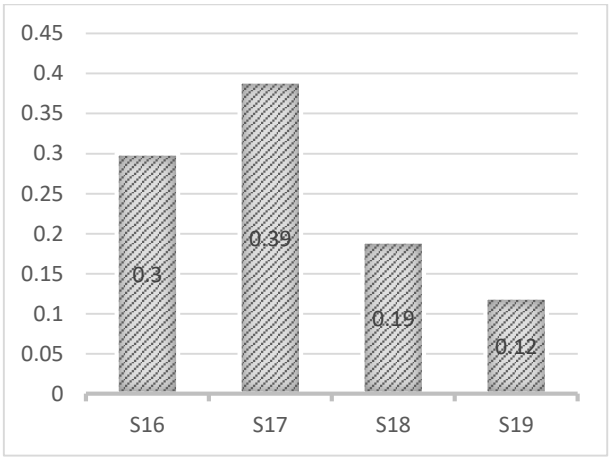


Figure 5. Weights of Main Crtirea: Agility.



III. DISCUSSION

After MCDM methods application has been determined to deal with SSP and avoid direct and indirect disadvantages of them. It can be easily set up production planning according to obtained results with extended version of MCDM. AHP application of SSP comes up with benefits of productivity and easiness of planning. Since supply chain has significant importance for each company and each product production process productivity of it can be improved and planning could be taking into account more properly. In this point advantages of AHP and MCDM can be seen and supplier selection strategy of any company can be revised. Optimization of supplier selection problem with proper methods and methodologies could set comparative advantage for any country.. More research and development studies should be done and implemented systematically in the supply chain process especially each case could be considered with its own MCDM model.

IV. CONCLUSION

In this study supplier selection problem of companies considered and analysed with MCDM method based on analytic hierarchy process and have been proposed. This paper reviewed multi-criteria decision-making approaches for

supplier performance evaluation and AHP application of it is proposed. For the future work, more detailed criteria set and detailed AHP , TOPSIS and VIKOR application should be applied to increase effectiveness and efficiency of the model.

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REFERENCES

1. Aragon_es-Beltr_an P, Mendoza-Roca JA, Bes-Pi_a A, et al. 2009. Application of multi criteria decision analysis to jar-test results for chemicals selection in the physical–chemical treatment of textile wastewater. J Hazard Mater 164(1):288–95.
2. Azadnia A.H., Samana M.Z.M., Wonga K.Y., Ghadimib P., Zakuanc N., 2012. Sustainable Supplier Selection Based on Self-organizing Map Neural network and Multi Criteria Decision Making approaches. Procedia - Social and Behavioral Sciences 65, 879 – 884.
3. Dey P.K., Bhattacharya A., Ho W., Clegg B., 2015. Strategic supplier performance evaluation: A case-based action research of a UK manufacturing organization. Int. J. Production Economics 166, 192–214.
4. "Faostat," from http://www.fao.org/faostat/en/
5. Gul M and Guneri AF. 2016. A fuzzy multi criteria risk assessment based on decision matrix technique: A case study for aluminum industry. J Loss Prev Process Ind 40:89–100
6. Gul M, Celik E, Aydin N, et al. 2016. A state of the art literature review of VIKOR and its fuzzy extensions on applications. Appl Soft Comput 46:60–89
7. Guneri AF, Gul M, and Ozgurler S. 2015. A fuzzy AHP methodology for selection of risk assessment
8. Liou J.J.H., Chuang Y.C., Tzeng G.H., 2014. A fuzzy integral-based model for supplier evaluation and improvement. Information Sciences 266, 199–217.
9. Luthra S., Govindan K., Kannan D., Mangla S.K., Garg C.P., 2017. An integrated framework for sustainable supplier selection and evaluation in supply chains. Journal of Cleaner Production 140, 1686-1698.
10. Ozdemir, Y., Basligil, H., & Ak, M. F. (2016). Airport Safety Risk Evaluation Based On Fuzzy Anp And Fuzzy Ahp. Uncertainty Modelling in Knowledge Engineering and Decision Making.
11. Saaty TL. 1990. How to make a decision: The analytic hierarchy process. Eur J Oper Res 48(1):9–26 Tzeng GH and Huang JJ. 2011. Multiple Attribute Decision Making: Methods and Applications. CRC Press, Boca Raton, FL
12. Stavrou, D. I., Ventikos, N. P., & Siskos, Y. (2016). Locating Ship-to-Ship (STS) Transfer Operations via Multi-Criteria Decision Analysis (MCDA): A Case Study. Multiple Criteria Decision Making,137-163
13. Yekta, T.S., Khazaei, M., Nabizadeh, R., Mahvi, A. H., Nasseri, S., Yari, A.R. (2015), Hierarchical distance-based fuzzy approach to evaluate urban water supply systems in a semi-arid region, Journal of Environmental Health Science and Engineering: 13(53): 1-12.
14. Zadeh, L. A. (1975). The Concept of a Linguistic Variable and its Application to Approximate Reasoning-I. Information sciences: 8: 199-249. Gul, M., & Ak, M. F. (2018). A comparative outline for quantifying risk ratings in occupational health and safety risk assessment. Journal of Cleaner Production, 196, 653-664.