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ELECTRONIC DEVICE SELECTION IN INDUSTRIAL PRODUCTS AND MACHINERY INDUSTRY: COMPARATIVE ANALYSIS WITH OCRA AND MAUT METHOD

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Abstract

The diversity and abundance of product alternatives lead to vagueness on decisions related to procurement, production, and R & D management processes along with other decisions taken within the company and render purchasing, production and R&D decision processes, much more effortful. As choosing appropriate and effective decisions within purchasing, production, R&D, and all other departments are of great importance in today's competitive business environment, firms are strongly encouraged to concentrate on their decision processes. Within the scope of this study, the purchase decisions of electronic device alternatives are being analysed in industrial products and machinery industry with OCRA method. The importance levels of evaluation criteria for the purchase are obtained out of 100 points. These importance levels are then being used in OCRA method in an attempt to evaluate various electronic device alternatives. In order to scrutinize the results, it can be said that the same data set is compatible with MAUT, which is another multi-criteria decision making method. Information regarding the evaluation criteria as well as alternatives of electronic device has been gathered through focus group study that includes marketing and purchasing managers. The results provide useful information for the sector.

Keywords: *Production and Operations Management, Purchasing Decisions, Device Selection, OCRA, MAUT*

JEL codes: C44, C52

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Introduction

As being operated in a today's competitive market conditions, firms embark upon some methods and strategies enabling them to survive in such an environment. Appropriate and effective decision making processes have a vital impact on survival of firms. Given the fact that firms have to cope with various criteria and alternatives, decision-making processes have become much more challenging, therefore multi-criteria decision making methods have been applied to those processes in order to achieve the best decision.

This research paper aims to reveal the comparative analysis of Operational Competitiveness RAting (OCRA) and Multi Attribute Utility Theory (MAUT) in decision making processes. Operational Competitiveness RAting (OCRA) method have been proposed by Parkan (1994) in order to seek out solutions to issues stemming from performance of production units (PU) and productivity. As for, Multi Attribute Utility Theory (MAUT) method, it is constructed under the Multi Attribute Decision Making methods (MADM) and developed by Keeney and Raiffa (1976). Keeney and Raiffa (1976) claims that MAUT is concerned with determining the utilities of each attribute taken singly. As, there has not been any work done by using both OCRA and MAUT methods together this study and its results could make contribution to the current literature.

Within the scope of this study, in an attempt to provide information regarding the structures of OCRA and MAUT methods a literature review is done. Furthermore, processes of OCRA and MAUT methods and how these methods can be applied into decision making processes are explained in a detailed manner. A case study is conducted within an industrial products and machinery industry, explaining the research question of how to find the best electronic device alternative in the virtue of improved benefit of the facility. Required information regarding firm's operational activities, the importance of that electronic device to manufacturing processes of the firm, criteria and alternatives while making purchasing decisions of that device is gathered via focus group study. Last, the conclusion and recommendations are being assessed to add further knowledge to the future research areas.

Literature Review

Operational Competitiveness Rating (OCRA) has been used in various applications including operational competitiveness ratings of production units, measurement the performance of hotel operations, performance measurement in government services, measurement the

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operational performance of a public transit company, measurement the effect of a new point of sale system on the performance of drugstore operations, competitiveness analysis on software development, measurement of the performance of an investment bank using the operational competitiveness rating procedure, and measurement the performance of operations of Hong Kong's manufacturing industries (Parkan, ,1991, 1994, 1996, 1999, 2002, 2003; Parkan et al., 1997; Parkan and Wu, 1999a, 1999b). Within these applications, the OCRA method is claimed to be superior to the data envelopment analysis (DEA) method as OCRA enables the decision maker to determine the relative importance weights for input or output categories. However, OCRA uses an intuitive method for embodying the decision maker's preferences with the relative importance of the criteria (Martinez-Gomez, 2016). Parkan and Wang (2007) examined the performance of an imaginary global electronic component distributor's supply chain by using DEA and OCRA. The authors suggested that OCRA method is based on non-parametric model and it is suitable for such cases in which the relative importance weights can be specified exactly or as intervals. Moreover, OCRA can handle the cases where the relative importance weight distributions might vary in time with changing competitive priorities. According to Parkan (2002) "OCRA method provides with some technological advantages over the other performance measurement techniques and is applicable to both tangible and intangible data."

Özbek (2015) attemped to measure the effectiveness of the 32 commercial banks operating in Turkey for the years 2011-2014 with OCRA method.

Ercan and Kundakçı (2017) conducted a study in an effort to select the pattern software to be used in sample design in a textile company by using ARAS (Additive Ratio ASsesment) and OCRA (Operational Competitiveness RAting) which are Multi Criteria Decision Making (MCDM) methods.

According to Peters and Zelewski (2010) OCRA method can be used in such various fields as investment banking, public service buildings, industrial enterprises, hotels and food production facilities. The authors gauged the performance of 8 branches of a bank and established output factors: number of employees and active amount and input factors: number of customers and responses.

Chakraborty et al. (2013) considered five facility location selection criteria including fire history, access to infrastructures, reliability in operations, closeness to market, expert personnel availability, and earthquake possibility to find the best distribution center among four alternative distribution centers and used Grey Relational Analysis (GRA), Multi Objective Optimization on the Basis of Ratio Analysis (MOORA), Elimination of Choice Translating Reality (ELECTRE II), and Operational Competitiveness Rating Analysis (OCRA).

Based on the criteria consisting of yield strength, ultimate tensile force, elongation rate, durability, cost, corrosion rate, and wear rate Darji and Rao (2014) used OCRA method and calculated the pipe material alternative for being used in sugar industry.

As for Multi Attribute Utility Theory (MAUT), which is one of the Multi Criteria Decision Making methods (MCDM) using Weighted Sum Model (WSM), evaluates a number of alternatives in terms of a number of decision criteria (Shanmuganathan et al., 2018) and it has its roots in the expected utility theory (von Winterfeldt and Edwards, 1986; French, 1988).

MAUT is regarded as a simple and intuitive approach for the decision makers and this method allows decision makers to compare all alternatives simultaneously (Zietsman et al., 2006).

According to Min (1994: 3) “MAUT enables the decision maker to structure a complex problem in the form of a simple hierarchy and to subjectively evaluate a large number of quantitative and qualitative factors in the presence of risk and uncertainty. The author used MAUT to select the best foreign supplier alternatives among Mexican supplier, Taiwanese supplier, Korean supplier, Japanese supplier, and Canadian supplier considering the criteria of: financial terms, quality assurance, perceived risks, service performance, buyer-supplier partnerships, cultural and communication barriers, and trade restrictions, and several attributes based on these criteria. Moreover, Kainuma and Tawara (2006) performed MAUT approach to evaluate the performance of lean and green supply chain management methods from both managerial and environmental aspects.

Ahmed and Lam (2014) attempted to find the best material handling equipment out of four alternatives with three main criteria including “material” with attributes: type, shape, weight, volume, “move” with attributes: speed, facility, height, frequency, distance path and “method” with attributes: control safety, fixed costs, variable costs, maintenance, variability by using MAUT and Monte Carlo Simulation.

Adalı and Işık (2017) applied CRiteria Importance Through Intercriteria Correlation (CRITIC) and MAUT Methods for the contract manufacturer selection problem.

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Canbolat et al. (2007) used MAUT method to solve for the global manufacturing facility selection problem.

Wang et al. (2010) compared MAUT and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) methods.

Furthermore, Freitas et al. (2013) compared AHP and MAUT methods by applying them to the raw materials selection problem in Brazil. Whilst AHP (Analytical Hierarchy Process) can be used when data set is in different units, MAUT is only applicable when all the data are expressed in the same unit. However, MAUT hinges upon a fuzzy logic approach and there is less possibility of a human error comparing to an AHP technique (Shanmuganathan et al., 2018). One of the advantages of MAUT is its ability to cope with both deterministic and stochastic decision environments (Zionts, 1992).

In this research paper, these two methods including OCRA and MAUT are compared and the originality of this paper is highlighted as these two methods have not been compared hitherto. The best electronic device alternative for the industrial products and machinery industry is attempted to be determined. Next section demonstrates the way these two multi-criteria decision-making methods operate and the comparison analysis of them in aforementioned case.

Operational Competitiveness Rating (OCRA)

Operational Competitiveness Rating (OCRA) method is used for selecting the best alternative by analyzing many different selection criteria. OCRA method can be explained as follows (Darji & Rao, 2014, 2589).

In the first step, non-beneficial attributes have been analyzed according to OCRA method. The lower values are better for non-beneficial attributes. The preference ratings can be calculated as in Equation 1.

i: $alternative\ in\ the\ problem$

j: $selection\ attribute\ in\ the\ problem$

m: $number\ of\ alternatives\ in\ the\ problem$

n: $number\ of\ attributes\ in\ the\ problem$

x_i^j: $performance\ value\ of\ alternative\ i\ with\ respect\ to\ the\ attribute\ j$

w_j: $the\ weight\ value\ of\ the\ non-beneficial\ attribute\ j$

$\bar{I}_i$: $preference\ rating\ of\ alternative\ i\ for\ non-beneficial\ attribute$

$$\bar{I}_i = \sum_{j=1}^{n} w_j \frac{\max\left(x_j^m\right) - x_i^j}{\min\left(x_j^m\right)}; i = 1,2,3,\ldots,m; j = 1,2,3,\ldots,n \quad (1)$$

Next step is to calculate the aggregate preference rating for the input factors. The aggregate preference rating can be calculated as in Equation 2.

$\bar{\bar{I}}_i$: $the\ aggregate\ preference\ rating\ of\ alternative\ i\ for\ non-beneficial\ attribute$

$$\bar{\bar{I}}_i = \bar{I}_i - \min(\bar{I}_i) \quad (2)$$

Then, beneficial attributes have been analyzed according to OCRA method. The higher values are better for beneficial attributes. The preference ratings for beneficial attributes can be calculated as in Equation 3.

h: $the\ beneficial\ attribute$

H: $the\ number\ of\ the\ beneficial\ attributes$

w_h: $the\ weight\ value\ of\ the\ beneficial\ attribute\ h$

$$\bar{O}_i = \sum_{h=1}^{H} w_h \frac{x_h^j - \min(x_h^m)}{\min(x_h^m)}; h = 1,2,3,\ldots,H \quad (3)$$

Next step four is to calculate the linear preference ratings for beneficial attributes according to OCRA method. The linear preference ratings for beneficial attributes can be found with Equation 4.

$\bar{\bar{O}}_i$: $the\ linear\ preference\ rating\ of\ alternative\ i\ for\ beneficial\ attribute$

$$\bar{\bar{O}}_i = \bar{O}_i - \min(\bar{O}_i) \quad (4)$$

The last step of the OCRA method is to compute the overall preference ratings for all alternatives. The overall preference ratings can be computed as in Equation 5.

P_i: $the\ overall\ preference\ rating\ of\ alternative\ i$

$$P_i = \left(\bar{\bar{I}}_i + \bar{\bar{O}}_i\right) - min\left(\bar{\bar{I}}_m + \bar{\bar{O}}_m\right) \quad (5)$$

According to calculations in OCRA method, the best alternative has got the highest overall preference rating value.

Multi Attribute Utility Theory (MAUT)

Multi attribute utility theory (MAUT) method is one of the multi criteria decision making methods which exists Euclidean space with all alternatives. MAUT method can be explained as follows (Zhu et al., 2017, 429-430).

i: $alternative\ in\ the\ decision\ making\ problem$

j: $selection\ attribute\ in\ the\ decision\ making\ problem$

m: $number\ of\ alternatives\ in\ the\ decision\ making\ problem$

n: $number\ of\ attributes\ in\ the\ decision\ making\ problem$

x_{ij}: $performance\ value\ of\ alternative\ i\ with\ respect\ to\ the\ attribute\ j$

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D: *the decision matrix*

In the first step of MAUT method, data should be collected for solving the multi criteria decision making problem. The decision matrix can be seen in Equation 6.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \qquad (6)$$

y_{ij}: the normalized *performance value of alternative i with respect to the attribute j*

The next step is to calculate the normalized performance values for all values in the decision matrix. The normalized performance values for beneficial attributes can be computed with Equation 7.

$$y_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \qquad (7)$$

The normalized performance values for non-beneficial attributes like time and cost can be computed with Equation 8.

$$y_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \qquad (8)$$

According to the calculations in Equation 7 and Equation 8, the normalized decision matrix can be formed as in Equation 9.

Y: *the normalized decision matrix*

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix} \qquad (9)$$

w_j: *the weight value of the* attribute *j*

U_i: *the* overall *weighted utility value of the* alternative i

The last step of MAUT method is to compute the overall weighted utility values of all alternatives in the multi criteria decision making problem. The overall weighted utility values of all alternatives can be calculated by using Equation 10.

$$U_i = \sum_{j=1}^{n} \left(w_j . y_{ij} \right) \qquad (10)$$

According to the phases of MAUT method, the highest overall weighted utility value shows the best alternative in the multi criteria decision making problem.

Application

Within the scope of this study, a purchasing decision regarding an electronic device, namely a hot air welding equipment of an industrial products and machinery industry, which was founded in 2013 in İstanbul, based in Switzerland is analyzed. Since its establishment, the firm has started to operate in many different and wide areas such as roof and foundation insulation of buildings, environmental insulation applications, pond bundling, plastic tank manufacturing, packaging, drying processes in various printing and lamination operations. The firm provides the best quality products, materials and equipment for all kinds of insulation and insulation applications in the environment and building industry, and offer these services with expert technical teams. The hot air welding equipment is among the firm`s most crucial supplied component, hence purchasing decision of that equipment is of great importance both managerially and operationally. In order to satisfy customers` requirements of insulation, environmental and plastic welding applications, the firm has to handle its procurement and purchasing processes effectively and in a timely manner.

Background information regarding firm's operational activities, the importance of the hot air welding equipment to manufacturing processes of the firm, criteria, attributes, and alternatives while making purchasing decisions of that device is gathered via focus group study. Firms` managers from purchasing department have been dealing with the purchasing decisions based roughly on the past decisions. However, since global competition is pitiless, decisions should be taken under a well-defined procedure and technique. Therefore, with the help of focus group study, employees who are responsible for purchasing decisions are gathered together, this focus group study encouraged them to clarify their views and requirements explicitly. According to the results of the focus group study, it can be concluded that there are five various alternatives including Alternative A, Alternative B, Alternative C, Alternative D, and Alternative E from which the firm can buy that hot air welding equipment, however the firm has also some attributes including performance, compatibility, lead time, cost, work habits, after sale services.

The first step is to collect data set for solving this problem. The attributes and the alternatives are in Table 1.

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Table 1: Data Set

Attribute Type	Beneficial	Beneficial	Non-Beneficial	Non-Beneficial	Beneficial	Beneficial
Attribute Code	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute 6
Attribute Name	Performance	Compatibility	Lead Time	Cost	Work Habits	After Sale Services
Measurement Unit	(1-100 Performance Grade)	(1-100 Performance Grade)	(Day)	(TL)	(1-100 Performance Grade)	(1-100 Performance Grade)
Alternative A	96,00	99,00	14,00	9000,00	99,00	87,50
Alternative B	95,00	96,50	14,00	8500,00	96,50	87,50
Alternative C	85,00	90,00	18,00	8000,00	80,00	75,00
Alternative D	80,00	80,00	21,00	7500,00	72,50	65,00
Alternative E	70,00	60,00	27,00	7000,00	50,00	50,00

The weights are obtained by taking averages after managers distributed 100 points to each alternative.

The weight values, the maximum and the minimum values of the attributes can be seen in Table 2.

Table 2: Weight Values, Maximum and Minimum Values

Attribute Code	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute 6
Weight Values	0,375	0,325	0,070	0,090	0,075	0,065
Maximum Values	96,00	99,00	27,00	9000,00	99,00	87,50
Minimum Values	70,00	60,00	14,00	7000,00	50,00	50,00

The normalized performance values of alternatives for beneficial and non-beneficial attributes without weights according to OCRA method can be seen in Table 3.

Table 3: The Normalized Performance Values without Weights

Attribute Code	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute 6
Alternative A	0,371429	0,650000	0,928571	0,000000	0,980000	0,750000
Alternative B	0,357143	0,608333	0,928571	0,071429	0,930000	0,750000
Alternative C	0,214286	0,500000	0,642857	0,142857	0,600000	0,500000
Alternative D	0,142857	0,333333	0,428571	0,214286	0,450000	0,300000
Alternative E	0,000000	0,000000	0,000000	0,285714	0,000000	0,000000

The weighted normalized performance values of alternatives for beneficial and non-beneficial attributes with weights according to OCRA method can be seen in Table 4.

Attribute Code	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute 6
Alternative A	0,139286	0,211250	0,065000	0,000000	0,073500	0,048750
Alternative B	0,133929	0,197708	0,065000	0,006429	0,069750	0,048750
Alternative C	0,080357	0,162500	0,045000	0,012857	0,045000	0,032500
Alternative D	0,053571	0,108333	0,030000	0,019286	0,033750	0,019500

Alternative E	0,000000	0,000000	0,000000	0,025714	0,000000	0,000000

Table 4: The Weighted Normalized Performance Values

The preference rating values and the aggregate preference rating values of alternatives for non-beneficial attributes can be calculated by using Equation 1 and Equation 2. The preference rating values and the aggregate preference rating values of alternatives for non-beneficial attributes are in Table 5.

Table 5: $\bar{I}_i$ and $\bar{\bar{I}}_i$ Values

Alternative	$\bar{I}_i$ Values	$\bar{\bar{I}}_i$ Values
Alternative A	0,065000	0,039286
Alternative B	0,071429	0,045714
Alternative C	0,057857	0,032143
Alternative D	0,049286	0,023571
Alternative E	0,025714	0,000000

The preference rating values and the aggregate preference rating values of alternatives for beneficial attributes can be calculated by using Equation 3 and Equation 4. The preference rating values and the aggregate preference rating values of alternatives for beneficial attributes are in Table 6.

Table 6: $\bar{O}_i$ and $\bar{\bar{O}}_i$ Values

Alternative	$\bar{O}_i$ Values	$\bar{\bar{O}}_i$ Values
Alternative A	0,472786	0,472786
Alternative B	0,450137	0,450137
Alternative C	0,320357	0,320357
Alternative D	0,215155	0,215155
Alternative E	0,000000	0,000000

The overall preference ratings for all alternatives in OCRA method can be computed as in Equation 5. The results are in Table 7.

Table 7: $\bar{P}_i$ Values

Alternative	$\bar{P}_i$ Values
Alternative A	0,512071

Alternative B	0,495851
Alternative C	0,352500
Alternative D	0,238726
Alternative E	0,000000

According to the values in Table 7, the best alternative is A. The order of the alternatives is A, B, C, D and E respectively.

After analysing the alternatives according to OCRA method, another multi criteria decision making method (MAUT) has been applied to the same data set for checking the results. The data set in Table 1 is the decision matrix of MAUT according to Equation 6. The next step is to calculate the normalized performance values for all values in the decision matrix in MAUT method. The normalized performance values for beneficial attributes can be computed with Equation 7. The normalized performance values for non-beneficial attributes like time and cost can be computed with Equation 8. The normalized decision matrix can be formed as in Equation 9. The normalized decision matrix is in Table 8.

Table 8: The Normalized Performance Values for MAUT Method

Attribute Code	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	Attribute 6
Alternative A	1,000000	1,000000	1,000000	0,000000	1,000000	1,000000
Alternative B	0,961538	0,935897	1,000000	0,250000	0,948980	1,000000
Alternative C	0,576923	0,769231	0,692308	0,500000	0,612245	0,666667
Alternative D	0,384615	0,512821	0,461538	0,750000	0,459184	0,400000
Alternative E	0,000000	0,000000	0,000000	1,000000	0,000000	0,000000

The last step of MAUT method is to compute the overall weighted utility values of all alternatives in the multi criteria decision making problem. The overall weighted utility values of all alternatives can be calculated by using Equation 10. The results can be seen in Table 9.

Table 9: $\overline{U_i}$ Values

Alternative	$\overline{U_i}$ Values
Alternative A	0,910000
Alternative B	0,893417
Alternative C	0,649059
Alternative D	0,471144
Alternative E	0,090000

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When the results in Table 7 and Table 9 are compared, the sorting is exactly same.

Conclusion

Considering the fact that, there are plenty of alternatives and evaluation criteria, this entails difficulties on decisions related to procurement, production, and R & D management processes along with other decisions taken within the company and render decision-making processes, much more demanding.

As choosing appropriate and effective decisions within purchasing, production, R&D, and all other departments are of great importance in today’s competitive business environment, firms are strongly urged to focus on their decision-making processes.

Within this study, an electronic device purchasing decision in industrial products and machinery industry was attempted to be analysed. Out of the five alternative brands and six attributes including performance, compatibility, lead time, cost, work habits, after sale services, the best alternative was found with the help of such methods as OCRA and MAUT.

According to the results of these methods, the ranking of the five manufacturer alternatives is found as A-B-C-D-E. According to the ranking order, it is advised to the company to choose the A, beacuse the alternative A was determined as the most optimum result on behalf of the facility.

This study demonstates an exemplary application of OCRA and MAUT methods which are among the multi-criteria decision making methods. As, these two methods have not been compared with each other in the existing literature yet, our study and its results could lead to contribution in the context of practical implications.

Furthermore, our study highlights several potential directions for future research areas. Since both methods do not contain complex and hard computational procedures, this application intends to not only use these methods for similar decisions but also to use other decision–making problems to be encountered in the future. Additionally, the number of criteria and alternatives for the electronic device selection problem may be changed so the impacts of any changes in values may be analyzed by sensitivity analysis.

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