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Comparison of Max100, SWARA and Pairwise Weight Elicitation Methods

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ABSTRACT
Decision making is used in every part of life and realised by each action taken. The presence of correct and satisfactory solution to problems is very important for person, institution and organizations. Multiple Criteria Decision Making (MCDM) techniques are developed for this purpose. Based upon the former studies, it is seen that weight elicitation methods used in solving MCDM problems, have an important role at defining the importance of criteria and obtaining the best and satisfying results for decision makers. Theaim of the paperis to compare the results of range variability between the criteria for Max100, Stepwise Weight Assessment Ratio Analysis (SWARA) and Pairwise Comparison weight elicitation methods and to give suggestion about conditions of using of the methods. It is the first time SWARA is compared with Pairwise Comparison and Max100 methods, and it makes this study different from all the others.
When results of the study is considered, it is seen that variability of Pairwise Comparison method is higher than Max100 and SWARA methods. Besides, Max100 is found as the easiest method to use, and Pairwise Comparison method's way of scoring is defined as the most reliable. In the light of the results obtained from the methods, some conditions of usage are suggested.

Keywords: *Max100; SWARA; Pairwise Comparison;MCDM; Weight Elicitation Methods; Criteria Weighting*

I. INTRODUCTION

It is very well known that decision making process has a significantly important place and role in life. Decision making is defined as the action of choosing between alternative situations in order to reach the determined aim and target (Forman & Selly, 2001). When the number of alternatives increase, as well as the number of criteria that have big effect on the decision, it makes the decision making process longer and more difficult. "Multi Criteria Decision Making (MCDM) Techniques" is developed, in order to overcome the difficulty of decision making.Identifying process of criteria importance (weights) is one of the common features of MCDM techniques.The relative importance of criteria is determined by the mathematical methods or by decision maker(s). There are so many criteria weight elicitation methods, where decision makers assign the importance of criteria. The question "Which of the weight elicitation method will present better solutions?" became a research topic. In this regard, weight elicitation methods used in MCDM problem solutions, are seriously important in defining importance of criteria and obtaining the best and most satisfying results (Zardariet al., 2015). As a result of the literature review realised due to the importance, it is seen that not enough studies are realised which are related to criteria weighting methods. Subject of the study is determined via considering the importance of criteria weighting methods in MCDM process.At this study, it is aimed to find the terms of use with regard to the variability levels of Max100, SWARA andPairwise Comparison methods. Convenience and ease of use of these three methods and reliability of them for the decision makers are also examined. To apply the methods, "buying a new or used car problem" is used, which the participants can easily understand.A sample group, consists of 139 participants, is used forthis application. This study differs from others by comparing SWARA (Step-wise Weight Assessment Ratio Analysis), developed by Kersuliene et al. (2010), with Max100 and Pairwise Comparison. In addition, terms of use is suggested for the methods compared to each other.

II. LITERATURE REVIEW

Assigning criteria weights is an important step that has an impact on the result ofMCDM methods.The main purpose of criteria weighting methodsaredefined assigning cardinal or ordinal valuesto different criteria in order to assign relative importance of criteria inMCDM.These criteria values are used to evaluate the alternatives in MCDM problems (Zardariet al., 2015). In this regard, it is known that so many weight elicitation methods are developed. Therefore, it is a very important research topic whichweight elicitation methodwill give the most satisfying result for the decision makers.In this regard, some researches

about weight elicitation methods are made. We can sort these studies to three different groups as seen on the Table 1; as realised via survey, realised via simulation and realised via survey and simulation. When the literature review of the study is considered, it is seen that the study realised in 1965 by Eckenrode via survey with 24 participants is the first at comparing weight elicitation methods.

Table 1 Weight elicitation studies according to research method.

Authors	Year	Compared Weighting Methods	Research Method
Eckenrode	1965	Partial Pairwise Comparisons I, Partial Pairwise Comparisons II, Complete Pairwise Comparisons, Successive Comparisons, Ranking, Rating	Survey
Schoemaker&Waid	1982	Multiple Regression, AHP, Trade-off, Point Allocation, Equal Weights	Survey
Fischer	1995	Trade-off, Swing, Direct Pointing Method	Survey
Leon	1997	SMART, SMARTS, GRAPA	Survey
Hajkowicz et al.	2000	Point Allocation, Direct Rating, Ordinal Ranking, Graphical Weighting Method, Pairwise Comparisons Method	Survey
Poyhonen&Hamalainen	2001	AHP1, AHP2, AHP3, AHP4, SMART, Point Allocation, Swing, Trade-off	Survey
Ginevicius&Podvezko	2004	Ranking, Direct Approach, Indirect Approach, Pairwise Comparisons Method	Survey
Barron & Barrett	1996a	Equal weights, Rank Sum, Rank Reciprocal, Rank-Order Centroid (ROC)	Simulation
Jia et al.	1998	Equal weights, Ratio Scale Weighting, Rank Sum, Rank-Order Centroid (ROC)	Simulation
Roberts & Goodwin	2002	Rank Sum, Rank Reciprocal, Rank-Order Centroid (ROC), Rank-Order Distribution (ROD)	Simulation
Srivastava et al.	1995	Value Hierarchy, Swing, Rank Sum, Rank-Order Centroid (ROC)	Survey and Simulation
Doyle et al.	1997	SMART, SMARTS, GRAPA	Survey and Simulation
Bottomley et al.	2000	Direct Rating, Point Allocation	Survey and Simulation
Bottomley & Doyle	2001	Direct Rating, Max100, Min10	Survey and Simulation

Six methods; Partial Pairwise Comparisons I,Partial Pairwise Comparisons II, Complete Pairwise Comparisons,Successive Comparisons, Ranking and Rating (Direct Rating); are compared with each other in terms of time efficiency and reliability.Results of the analysis show that, all methods are at almost at the same level with each other in terms of reliability, however in terms of ease of use, Ranking method comes first and Partial Pairwise Comparisons II method comes second (Eckenrode, 1965).

Schoemakerand Waid(1982) compared five different methods; Multiple Regression, AHP, Trade-off, Point Allocation and Equal Weights; in terms of their predictive abilities and weights, as well as reliability and difficulty at application of the methods for decision makers.Verbal scholastic aptitude, high school cumulative average, extra-curricular activity and quantitative scholastic aptitude are the criteria in this study. Two different test groups of 34 and 36 participantsevaluated college applications according to the methods.The distinguishing features of this study are focusing on the estimation abilities of the methods, benefiting from pairwise choices for related criteria,examining the impact on the subjects of the methods in terms of difficulty and reliability.It is found that there is no important difference between the average weights of the Multiple Regression, Analytic Hierarchy and Trade-off methods. Point Allocation method has the narrowest rangeamong all methods. It is concluded that Analytic Hierarchy and Trade-off methods are more complicated and less credible than the others.

Fischer (1995) comparedTrade-off, Swing and Direct Pointing methods.As a result of the analysis of the surveys applied to two different experiment group in this study; it is found that Trade-off method gives a relatively higher weight value to the best criterion than Swing and Direct Pointing methods.

Leon(1997) compared SMART, SMARTS and GRAPA (Graphical version of Point Allocation) methods. Leon, searched the ease of use of these methods and if they are applicable in real life. At the end of the analysis applied, the high level of compliance between the weights and ranking of alternatives indicates that bothSMART and GRAPA are acceptable weight elicitation methods. When the aim is being applicable in real life and ease of use, it is concluded that GRAPA is the appropriate method.

Hajkowiczet al. (2000) compared Point Allocation, Direct Rating, Ordinal Ranking, Graphical weighting method and Pairwise Comparisons. Methods are examined in terms of ease of use and explanation of the level of decision problems. At the questions related to the ease of use of the methods and level of explaining decision problem, seven-point scale is used. Besides, decision makers also replied the question of, when they evaluate in general which method they think, is the best or is the worst. The Pairwise Comparison method is considered the worst method by 57% of the participants. In spite of this, in terms of how much it helped to explain the decision problem, by having wide standard deviation; Pairwise Comparison method is chosen the best among others. Nevertheless, Ordinal Ranking method is chosen as the easiest to use by decision makers.

PoyhonenandHamalainen (2001)applied surveys through internet. This study differs from previous by using a big sample group consisting of407 participants and it gives decision makers the chance to choose what they want from the criteria set.Four version of the Analytic Hierarchy Process (where Saaty's nine point scale and balanced scale submitted by Saloand Hamalainen(1997)), SMART, Point Allocation, Swing and Trade-off methods are compared in this study. The results of the study are as follows; Point Allocation, Swing and Trade-off methods do not give different weights, decision makers give high weight ratios via AHPand SMART, as the number of criteria increases, inconsistency between the statements increases, and as the decision makers chosetheir responses from a limited set of numbers is the reason why different weights are obtained.

Ginevicius and Podvezko (2004) compared Direct, Indirect, Ranking and Pairwise Comparison Methods. 27 experts took part in the study. The deviation levels of the weight elicitation methods from the average value were examined. The calculations revealed that weights of direct method have the least deviation from the average value. The direct weight elicitation method may be considered only relatively accurate,because as the number of criteria analysed increases, it becomes more difficult for an expert to handle the entire set and to determine the weight of one criterion against the other.

All of these studies were carried out with the help of surveys. Besides; Barron and Barrett (1996a), Jiaet al. (1998), Roberts and Goodwin (2002) studieswere performedwith help of simulation;Srivastava et al. (1995), Doyle et al. (1997), Bottomleyet al. (2000), Bottomleyand Doyle (2001) studies were performed with help of surveys and simulation.Thearticlesgiven at Table 1compared at least one of these properties of weight elicitation methods; reliability,ease of use, level of satisfaction, range and applicability in real life.

Edwards and Barron (1994), Barron and Barrett (1996b),Figueira and Roy (2002),Mustajokiet al. (2005), ÖztürkandBatuk (2007), Ahnand Park (2008), Alfaresand Duffuaa (2008), AlfaresandDuffuaa (2009), Eshlaghyet al. (2011), Wang et al. (2011), Riabacke (2012), Jahanand Edwards (2013),Roszkowka (2013),Iwaroet al. (2014),Meng and Chi (2015), Kumar et al. (2015), Zardariet al. (2015), Alemi-Ardakani et al. (2016), Almeida et al. (2016),Goodridge (2016),Krawczyńska-Piechna (2016) and Zhang et al. (2016) are other studies in this area. Instead of comparing weight elicitation methods each other they made contributions such as innovations, improvements and creating newresearch topicsabout weight elicitation methods.

In conclusion of the literature search, several points are observed as follows; (1) weight elicitation methods are very important at MCDM problems, (2) studies realised at this field are not enough. For these reasons it is very important finding the most appropriate weight elicitation method for the decision problem chosen.

Max100 method was chosen as the most reliable and the best method in Bottomley and Doyle's (2001) and also in Zardari et al. (2015). Pairwise Comparison method is mostly used to determine weights in MCDM problems. SWARA is a new weight elicitation method developed by Kersuliene et al. in 2010.From this point of view,in this study Max100, Pairwise Comparison and SWARA methods were examined in terms of their criterion weights variability.The methods are also compared with regard to the ease of usage, satisfaction level among decision makers and efficiency.

III. CRITERIA WEIGHTING METHODS

MCDM problems include criteria which have different importance levels due to decision makers' preferences. That is why, information about the relative importance of criteria, is necessary. This is provided by assigning weight to each criterion. Deriving the weights is the central step in revealing decision makers preferences (Malczewski, 1999; Alemi-Ardakini et al., 2016). That is the reason why different weight elicitation methods are developed in order to use in different MCDM problems (Zardariet al., 2015). The main purpose of weight elicitation methods is thatdefining relative importance of criteria in MCDM methods and assigning cardinal and ordinal

values to those criteria. It is known that these criteria values are used at evaluating alternatives in MCDM problems (Zardariet al., 2015; Panchendrarajan et al. 2016). While criteria weights at weight elicitation methods are identified, a lot of information is needed such as decision matrix, rank information of criteria, maths formulas and models, subjective judgements of decision makers etc.

By considering all these, for weight elicitation methods, several classifications are made by Weber andBorherding (1993), Tzenget al. (1998), Jiaet al. (1998), EshlaghyandRadfar (2006), Wang et al. (2009)andAhn (2011).Among these, it is known that classifications made by Wang et al.and Ahn are almost the same and most up to date and complicated classifications. At this classification, criteria weighting methods are separated into three groups as subjective, objective and combinativecriteria weighting methods.Subjective weight elicitation methods are the ones where criteria weights are determined only by decision makers' preferences. Objective weight elicitation methods are the ones where criteria weights are determined by mathematical methods. The combinativeweight elicitation methods combined of these two methods are named as mixed weight elicitation methods. Thisstudy focus on subjective weight elicitation methods, so objective and combinativeweight elicitation methods are not discussed within this study. The subjective weight elicitation methods used at this study are given below.

3.1. Pairwise comparison method

The Pairwise Comparison method was introduced by Fechner (1860) and developed by Thurstone (1927).This method gained its popularity by Saaty whoproposed Analytic Hierarchy Process (AHP) that can provide efficient methods in order to calculate inconsistency level and sorting and which can handle with several numbers of criteria at the same time. (Saaty, 1977;Kulakowskiet al., 2014; Kumar et al., 2015). By means of the Saaty's study, by submitting the hierarchy and inconsistency index, Pairwise Comparison Method became available to use in real life applications.

Let's assume, for Pairwise Comparison method, relative weights of "*n*" numbers of alternativesare needed to be compared pairwise. Alternatives are assigned as$A_1, A_2, \dots, A_n$and unknown weights are assigned in order as$w_1, w_2, \dots, w_n$.Pairwise Comparisons can be represented via a matrix as below:

$$A = \begin{array}{c|cccc} & A_1 & A_2 & \dots & A_n \\ \hline A_1 & w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ A_2 & w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \vdots & \vdots & \vdots & & \vdots \\ A_n & w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{array} \quad (1)$$

This matrix ispositive and meets the feature of taking reciprocals of its elements$a_{ij} = 1/a_{ji}$. When the *A* matrix is multiplied with the transpose of the weights$w^T \equiv (w_1, \dots, w_n)$ vector, it is seen that it is equal tonw vector. So the problem can be written as;

$$Aw = nw \quad (2)$$

Here, in order to find *w* weights, equation (3) has to be solved.

$$(A - nI)w = 0 \quad (3)$$

If the equation 3 has a solution different than zero, if and only if"*n*" is the Eigen value of *A* matrix. Meaning "*n*" is a root of *A*characteristic equation. Besides, as each line is a fixed multiplication of first line, *A* matrix has unit order. So *A* matrix is a matrix where its lines are a scalar times of each other. Thus all eigenvalues $\lambda_i, i = 1, \dots, n$ of *A* are zero expect one. At the same time;

$\sum_{i=1}^{n} \lambda_i = tr(A) \equiv sum\ of\ t\square e\ diagonal\ elements = n$ (4)

is known as mentioned above. That is why$\lambda_{max} = n$and$\lambda_i = 0,\ \lambda_i \neq \lambda_{max}$. $\lambda_{max}$is the biggest eigenvalue of *A* matrix (Saaty, 1977). From this point forward, equation (3);

$$(A - \lambda_{max} I)w = 0 \quad (5)$$

can be defined as mentioned above. By taking λ_{max}as a base to solve equation (5), *w*Eigen vector is achieved (Tzengand Huang, 2011:18). Achieved *w*Eigen vector defines the importanceranking of criteria (Cheng & Li, 2004). Besides this, in order to use at pairwise comparisons, as it has the best consistency among 25 different scales, Saaty's 9point scale is chosen (Saaty, 1977:247). Also, in order to provide the consistency of subjective perceptions and accuracy of relative weights, two indexes are offered as; Consistency Index (CI) and Consistency Ratio(CR). Consistency Index (CI) can be calculated via the formula below:

$$CI = (\lambda_{max} - n)/(n - 1) \quad (6)$$

Here, as mentioned before, $\lambda_{max}$is the biggest Eigen value, *n*is the total criteria number. In 1980, Saaty suggested that CI value should not exceed 0.1 to have reliable result. Consistency Ratio (CR) can be calculated via the formula below:

$$CR = CI/RI \quad (7)$$

Here RI represents"Random Consistency Index". RI values due to different sized matrices (*n*), are shown in Table 2 (Tzeng& Huang, 2011).

Table 2 Random consistency index

n	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Random Consistency Index	0,52	0,89	1,11	1,25	1,35	1,40	1,45	1,49	1,51	1,54	1,56

To get reliable results, CR should be under 0.1 and can be tolerated to max level is 0.2 (Tzeng& Huang, 2011).

3.2. Max100 method

Bottomleyand Doyle (2001) used two different methods in their studies in order to compare with Direct Rating method. At one of these, decision maker gives 100 points to the criterion he/she thinks the most important from a scale with an interval of 0-100. Then, in order, by comparing all other criteria with the one he/she thinks the most important, due to their relative importance, scores the other criteria points between 0-99. On the other one, decision maker scores 10 points to the criteria he/she thinks the most unimportant. Then, in order, by comparing all other criteria with the one he/she thinks the most unimportant, due to their relative importance, scores the other criteria accordingly and there is no upper limit. Bottomleyand Doyle also named first process as "Max100", and second process as "Min10" within this study.With this study, Max100 method is found easier to use and also more reliable than the other two methods Direct Rating and Min10 (Bottomley& Doyle, 2001). In the study of Zardariet al. (2015) it is observed that Max100 methods weights take pretty close values to each other and the range is small.

3.3. SWARA

SWARA method is submitted first by Kersulieneet al.in 2010. Thismethod involves expert opinions or opinionsabout the importance of criteria ratios that disagree with each other. At SWARA, it is provided to estimate importance differences in order to define criteria weights(Kersulieneet al. 2010;Kersuliene&Turskis, 2011).

The implementation of the SWARA method is summarized as follows; at first step, criteria defined for the decision problem, are ranked due to their importance by decision makers. At second step, general ranks are defined by taking averages of the ranks determined by the experts. At third step, each expert defines how important isj^{th}criteria from $(j+1)^{th}$criteria and importance difference is assigned as to be multiplies of 5%. At fourth step, by taking average of importance differences, general importance differences (s_j)

between criteria coming one after another are defined. At fifth step, while assigning one value to first criteria, other criteria values are written by adding one to general importance differences. At sixth step, as the value of first criteria remains as one; values of other criteria are calculated as dividing it to the criteria value coming to the same line of the former criteria at fifth step. Finally at seventh step, by dividing the sum of criteria values obtained at previous step, normalised final criteria weights are achieved (Kersulieneet al., 2010; Zolfani&Bahrami, 2014).

SWARA method is considered useful for collecting data from experts and cooperation.Besides, it is considered as a simple method and experts can work together easily. The most important advantages of this method are defined as; not needing prior information to evaluate range of criteria at some problems and attributing the priorities to company policies(Zolfaniet al., 2013; Zolfani&Bahrami, 2014). Based on the information given above, at SWARA method application, it is benefited from the averages of anexpert group's decision values. But within this study, at the application of SWARA method, second and fourth steps are not applied and instead values obtained from decision makers at the third step are used and continued from fifth step. Thereby, SWARA method is used personally instead of a group of experts. From this point of view, it is considered that this brings a difference to the usage of the SWARA and to the study.

IV. METHODOLOGY

When the previous studies about weight elicitation methods are considered, it is seen that surveys and simulations are used. This study is also realised via surveys. As the survey topic that all decision makers can overcome easily, "buying a new orused car problem" is used. To determine appropriate criteria it is benefited from the studies of Bottomleyet al. (2000), Bottomleyand Doyle (2001), GüngörandİşIer (2005) and the following criteria; Visual Appeal, Safety, Comfort, Performance and Fuel Consumption; are used, as these are considered the most important of all. A survey is prepared for threepilot groups which consist of the undergraduates, postgraduates and academicians who have information about MCDM techniques.

There are three sections in the survey. At first section;it is measured the demographic information, information level of and interest of the participants aboutthe cars. At second section; explanation and evaluation of the study take place. The third section includes, statements where five pointLikert scale is used about the ease of use of the methods, reliability of them and if it is reflecting the ideas of the decision maker. In order to provide the methods to be understood correctly and also applied correctly, students taking the Statistics and Operational Research courses are included in the study, along with the academicians. To get the most beneficial results from the students, a presentation, that includes how to use the methods and how to fill the survey, is prepared and presented to them in details. Meanwhile to the Academicians, it is explained personally how the methods are used and how the survey is filled in details and applied after that. Besides these, especially for Pairwise Comparison method, to get consistent results, it is explained to the participants with a sample that they need to pay attention to consistency. Addition to these information; it is written clearly at the second part of the survey, how the methods are applied.

At Max100 method, first of all the most important criteria is defined by the decision maker and 100 points is assigned to this criteria. The most important criteria can be more than one. After assigning the most important criterion/criteria, each criteria apart from this/these are compared with the most important one/ones and due to that their points are determined between 0-99. After assigning all criteria points criteria weights are obtained by normalisation process. Max100 method at this study, is applied as it is shown atTable 4.

Table 4 Max 100 method used in the survey

Criteria	**Given Point (0-100)**
Aesthetic appeal	
Safety	
Comfort	
Performance	
Fuel consumption	

At Pairwise Comparison method, criteria are compared as pairwise. First which of the criterion is more important from the pair, has to be determined, and then how many times more important this criterion from the other one, it is decided by decision maker. Pairwise Comparison method is applied as shown at Table 5.

Table 5 Pairwise Comparison method used in the survey with Saaty's nine-point scale

←	Left Important									Right Important								→
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Aesthetic appeal																		Safety
Aesthetic appeal																		Comfort

Aesthetic appeal																	Performance
Aesthetic appeal																	Fuel consumption
Safety																	Comfort
Safety																	Performance
Safety																	Fuel consumption
Comfort																	Performance
Comfort																	Fuel consumption
Performance																	Fuel consumption

The Scale and Its Description	
Intensity of Importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgements

Source, Saaty, 1977

At SWARA method, first criteria are ranked from the most important to the least important. Then, from two criteria that follow each other at this rank, it is decided how much important is the more important criteria than other, in percentages, and while making this operation, multiplies of 5% is applied. SWARA method is applied as shown at Table 6.

Table 6 SWARA method used in the survey

Rank	**Criteria**	**Importance Difference (%)**
1		
2		Between **1-2**:
3		Between**2-3**:
4		Between**3-4**:
5		Between**4-5**:

After entering all the data in to Excel for each method, criteria ranks and weights are calculated, with averages of methods' criteria weights, standard deviations and ranges. The data set which is designed at Excel and ready to be analysed, is converted to SPSS 18.0 program. At the so called data set, frequencies and descriptive are examined, and it is applied parametric ANOVA or its nonparametric corresponding according to Kolmogorov-Smirnov test results.

V. FINDINGS

Within this study, the five criteria used buying a new or used car problems in previous studies, is evaluated via three different criteria weighting methods; Max100, Pairwise Comparisons and SWARA, important findings are attained. Even though there is difference between the personal choices of the participants replying the survey; it is observed that Safety criteria is the first, Fuel consumption is the second, Performance is the third, Comfort is the fourth and Visual Appeal is the fifth for criterionranks at three criteria weighting methods. When criteria weights are checked, weight averages of the methods are different from each other.

At Table 7details about the methods' ranges are given. Range; can be defined as the difference between the highest valued criteria weight and lowest valued criteria weight in related method.A range for a participantis given by the difference between the highest and lowest criteria weight.On the other hand, mean of a method at the Table 7is found by the average of all the participants.When the values shown at Table 7 are examinedfor Max100 method, smallest rangevalue being 1% means five criteria have very close values to each other. Similar situation occurs for SWARA method, with a value of 3.9%.But, when the smallest rangeof Pairwise Comparisons is checked, 17.5%value shows that criteria weights do not get close to each other as they are at the other two methods. When the biggest values of ranges are examined, for Max100 and SWARA differences are about 45%, for Pairwise Comparison method, this value reaches to 61%.

Table 7 Range statistics

	Range of Max100	**Range of Pairwise Comparison**	**Range of SWARA**

Mean	0,114	0,425	0,202
SD	0,079	0,097	0,111
Min	0,010	0,175	0,039
Max	0,450	0,607	0,457

Friedman's ANOVA test, which is applied in order to test if ranges differ due to the methods or not, shows that ranges are not distributed homogenously (χ^2_2=208.79 and p=0.000). According to results of the Wilcoxon test, which is applied to test which method is different than the others; it is seen that three methods have different distributions from each other. When the box graphic at Figure 1 is examined, it is seen that; Max100 method is the lowest of the range average with 11.4%, SWARA is middle level with 20.2% and Pairwise Comparison is the highest with a 42.5%. It is seen that Max100 method ranges values are approximately between 1% and 27%, SWARA method values are between 5% and 45%, Pairwise Comparison method values are between 18% and 60%.

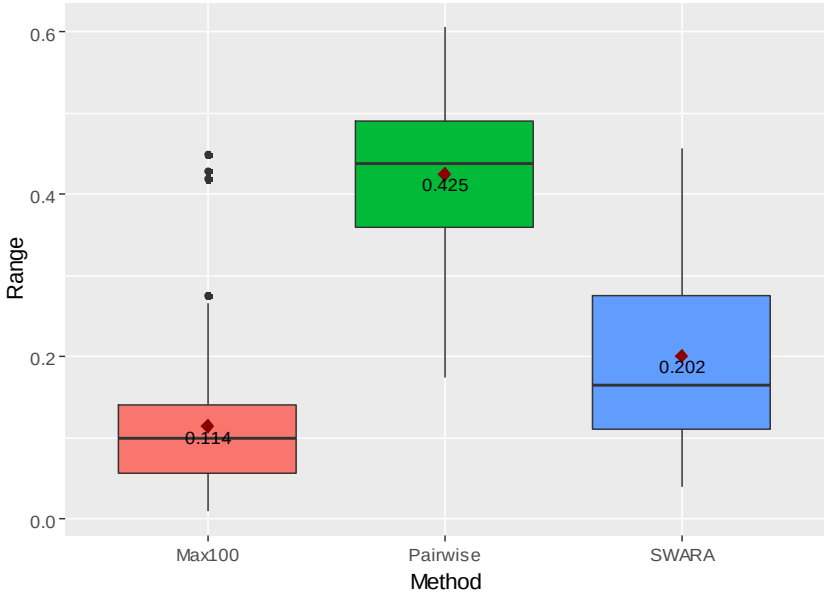

Figure 1. Weight range of methods

Friedman's ANOVA test, which is applied in order to test if standard deviations differ due to the methods or not, shows that standard deviations are not distributed homogenously (χ^2_2=213.34 and p=0.000). Wilcoxon tests results show that standard deviation for the three methods have different distributions from each other. Figure 2 shows the standard deviations and averages of the methods, it is seen that with 17.5% Pairwise Comparison method has the highest standard deviation average and it is followed by SWARA with 8.1% and then Max100 with 4.6%.

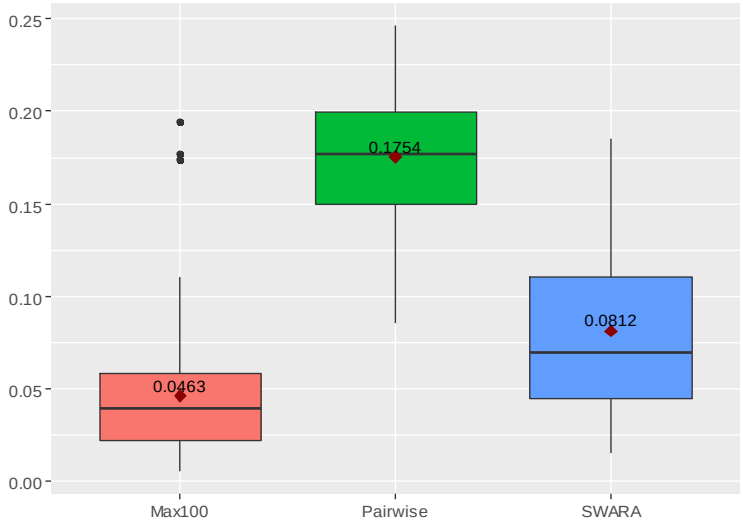

Figure 2. Standard deviation distributions of weights

Table 8 shows statistics on the ease of use of the methods, reliability and how accurately the opinions of decision makers about the criteria are reflected. The data in the Table 8 were obtained from participant views and "*n*" is number of participants. 6.5% of the participants said that the method was not easy to use and 83.5% of the participants indicated that it was easy to use the Max100. 23.8% of the participants stated that the use of the Pairwise Comparison method was not easy and 51.1% of the participants said that it was easy to use. For the SWARA method also, 20.8% of the participants indicated that it was not easy to use and 65.4% of the participants said that it was easy. In this case, it seems that the Max100 method is the easiest to use and the Pairwise Comparison method is the most difficult to use. For the Max100, 12.3% of the participants responded negatively and 62.6% responded positively to the expression "The method is reliable." For the Pairwise Comparison method, 10.8% of the participants responded negatively and 73.3% responded positively. For the SWARA, 14.4% of the participants responded negatively and 50.3% responded positively.

Table 8 Statistics of Likert scale questions about methods

	Max100		**Pairwise Comparison**		**SWARA**	
The method is easy to use.	**n**	**%**	**n**	**%**	**n**	**%**
Strongly Disagree	3	2.2	9	6.5	7	5.0
Disagree	6	4.3	24	17.3	22	15.8
Neutral	14	10.1	35	25.2	26	18.7
Agree	55	39.6	52	37.4	63	45.3
Strongly Agree	61	43.9	19	13.7	21	15.1
The method is reliable.	**n**	**%**	**n**	**%**	**n**	**%**
Strongly Disagree	4	2.9	3	2.2	7	5.0
Disagree	13	9.4	12	8.6	13	9.4
Neutral	35	25.2	22	15.8	49	35.3
Agree	56	40.3	69	49.6	48	34.5
Strongly Agree	31	22.3	33	23.7	22	15.8
The method accurately reflects my views about the criteria.	**n**	**%**	**n**	**%**	**n**	**%**
Strongly Disagree	2	1.4	3	2.2	4	2.9
Disagree	7	5.0	8	5.8	7	5.0
Neutral	22	15.8	17	12.2	28	20.1
Agree	64	46.0	69	49.6	66	47.5
Strongly Agree	44	31.7	42	30.2	34	24.5

Thus, it can be said that the most reliable method is the Pairwise Comparison method and SWARA method is also least reliable.Furthermore, the Max100 method revealed the following results; 6.4% of the participant responded negatively and 77.7% responded positively for the phrase "The method accurately reflects my views about the criteria". 8% of the participants responded

negatively and 79.8% responded positively for the Pairwise Comparison method. For the SWARA, 7.9% of the participants responded negatively and 72% responded positively. In light of this information, The Pairwise Comparison is the method that best reflects the decision maker's views. SWARA is the method that least reflect the decision maker's views.

VI. DISCUSSION AND CONCLUSION

When all the findings are considered, it is seen that Pairwise Comparison method assigns higher weight to the most important criteria and lower weight to the most unimportant criteria when compared to other methods. These results are confirmed also by the variability statistics of the methods. It is seen that, the method which has the highest standard deviation and range is Pairwise Comparison method, and it is followed by SWARA and Max100 methods, respectively.

Max100 method is determined as the easiest one to use, and this is followed by SWARA and Pairwise Comparison methods with similar points. When the reason of this is asked to the some participants; they thought at Pairwise Comparison method, as each criteria is compared to each other separately, leads to more reliable results. However, when this method is applied to a large sample group or increased in the number of comparisons and if the consistency analysis results are not appropriate, it is observed that getting back to the decision makers one more time and repeating the analysis, will not only increase the work load of both the researcher and the decision makers, but also will prolong the time of the research (Song & Kang, 2016). When all the findings obtained as a result of this study are considered, some terms of usage can be suggested for these three methods. When a decision maker faces an MCDM problem, it can be suggested that if the decision maker wants criteria weights to have very different values than each other Pairwise Comparison method, if the decision maker wants criteria weights to have very close values to each other Max100 method, for the situations in between these two SWARA method is more appropriate to use. But while making this decision, it is important to consider the number of decision makers and comparisons. When the previous studies (Schomaker&Waid, 1982; Hajkowicz et al., 2000; Tayyar&Arslan, 2013; Song & Kang, 2016) realised via Pairwise Comparison method are considered, it is concluded thatthe method can give weight to decision-makers that are unsatisfactory when a small number of decision makers are applied. In order to prevent this, after obtaining the criteria weights, it has to be presented to the decision makers and have to be asked if they found the weights appropriate or not. When the weights are not found appropriate, at least two more methods must be applied and the weights should be examined by the decision makers again, and which method's result is appropriate, that method should be used, or if results are close to each other, average weights of two methods should be used. In addition, it may be appropriate in order to ensure consistency to work with experts when the number of criteria is high and to work with a large sample when the number of criteria is low in the Pairwise Comparison method

As a result of the study, it is explained which method, under which circumstances, giving what kind of results; and also their appropriate levels of usage. When these results are used by decision makers in business world or social life, it is expected to get the best and most satisfying results in return. This study differs from previous similar studies realised; as it includes SWARA method compared to Max100 and Pairwise Comparison methods. Additionally SWARA is used personally instead of a group of experts and this form has also proved to give good results with the paper.

The shortcomings of the paper can be seen as working with only five criteria and three methods. In future work, the number of criteria and the number of weight elicitation methods can be increased.By applying surveys on the internet, participants can be asked about their opinion on the criteria weights obtained as a result of the methods.

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