MEASURING CORPORATE SUSTAINABILITY PERFORMANCE IN THE RUBBER COATING INDUSTRY: AN INTEGRATED MULTI-CRITERION FRAMEWORK

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Abstract: In today's competitive world, the success of firms is directly proportional to the extent to which sustainability is involved in business processes. Therefore, the sustainability performance evaluations of the firms have become a very important issue. In this study, it has been aimed to evaluate the corporate sustainability performance by using MCDM (Multi-Criteria Decision Making) methods. In this respect, the corporate sustainability performance of the firm Brisa, which operates in the international rubber and coating sector, has been evaluated on the basis of economic, environmental and social aspects. In the study on which the period of 2011-2015 has been taken as basis, the data needed has been obtained from the annual reports of the firm. In the study, only the objective weighting methods such as ENTROPY, CRITIC, SD (Standart Deviation) and MW (Mean Weight) techniques have been used in order to determine the relative importance of the criteria, while COPRAS and VIKOR methods have been used for the performance sequence on a yearly basis. An integrated single sequence has been obtained by combining the sequences obtained with the BORDA COUNT method, a data combining technique. As a result of the analysis, it has been concluded that the approach suggested in the study was an effective and appropriate approach that could be used in assessing the corporate sustainability performance.

Keywords: Corporate sustainability performance, mcdm, rubber coating industry.

INTRODUCTION

After Industrial Revolution, the rate of greenhouse gas emissions in the atmosphere increased due to the destruction of forests, the burning of fossil fuels, the use of land for different purposes, certain agricultural activities and increased industrialization. As a result, climate changes have come to the fore depending on the increase in global temperatures (DPT, 2000, p. 2). It has been emphasized in a United Nations Intergoverrmental Panel on Climate Change (IPCC) that people are responsible for the vast majority of the increase in gas emitted to the atmosphere (Black and Weisel, 2010, p. 8). This situation has increased the importance of sustainability in terms of society, state and businesses and has brought some debate on the agenda regarding to the sustainability.

The fundamental of sustainability concept is the idea of that while realizing the economic growth, the carrying capacity of the social and environmental factors must not be exceeded. It should be carried out without damaging the environment. In line with this, the carrying capacity can be defined as; the maximum number of people that can use an area without allowing any change in the physical environment and a decline in the quality of the recreational experience (Mathieson and Wall, 1982, p. 184).

The transport capacity should not be exceeded in order not to compromise from the ability of the natural systems to renew themselves and to sustain the existing lifestyle for a long time (Bayraktutan and Uçak, 2011, p. 18). Sustainable development may be defined as improvement of life standard without exceeding carrying capacity of natural systems needed for the life (Daly and Cobb, 1989).

The handling of the principles of sustainable development is defined as corporate sustainability (Signitzer and Prexl, 2008, p. 2). Corporate sustainability requires not only economic aspects but also social and environmental aspects of business activities to be taken into consideration. In this direction, there are three aspects of corporate sustainability: economic, environmental and social. The economic aspect, in short, can be defined as providing revenue to the shareholders over the average on one side and providing cash flow without facing liquidity shortage from other side in order for the businesses to be economically sustainable on the other side (Dyllick and

Hockerts, 2002, p. 133); environmental aspect can be defined as bringing hazardous wastes and emission rates to the lowest level in the production and facility planning of institutions and organizations, and increasing efficiency in resource utilization, and providing that future generations benefit from country resources in the best way (Mazurkiewicz, 2005, p. 7); social aspect can be defined as stakeholders' understanding of objectives of the business and their highly compliance with the value system of the business (Dyllick and Hockerts, 2002, p.134).

Recently, pressures increase on many firms around the world to become sustainable. In this direction, many firms share their economic, environmental and social performances with public and stakeholders at certain periods based on certain economic, environmental and social criteria by gathering them under the framework of the sustainability report and share them. Since the sustainability reporting which is based on volunteering rather than obligation come forward (Hu et al., 2011, p. 843), the profit-free global organizations and initiatives have formed and continue to form guidelines, principles and standards that guide businesses about how to do reporting (Önce et al., 2015, p. 231).

There are many different reporting frameworks globally accepted for the firms to be able to perform a clear, understandable and transparent sustainability reporting. However, the GRI guideline provides the most worldwide accepted international sustainability reporting framework (KPMG, 2008, p. 16). This guideline provides a framework which will be prepared by the firms at their own discretion, and by which the firms will be able to report their economic, environmental and social activities related to sustainability and the results of these activities. Firms, which prepare their reports based on GRI indicators, disclose them at various levels such as A, B, and C level. Each level of reporting criteria reflects a criterion related to the level or extent of implementation of the GRI Reporting Framework. Level A is the most comprehensive level of the GRI framework. Level A firms must respond to every core indicator, either reporting on it, or explaining why it is not material to their business. There must be minimum 20 indicators in the level B report, while 10 indicators in the level C being the lowest level (Tilt, 2009, p. 14). If the external audit has been utilized for the report, if the validation of the data in the report has been audited by another institution and the reliability approve has been taken, each level is declared as A+, B+ and C+. GRI has five versions as G4, G3, G3.1, G2, G1. The latest updated G4 guideline has published and put into effect in May 2013.

Firms share with public their sustainability performance through various reporting frameworks, but there are some challenges encountered in measuring corporate sustainability. Because corporate sustainability is a concept that includes conflicting criteria and decision points, therefore, the sustainability performance evaluation problem to be addressed is a typical MCDM problem, as these methods are a process that allows to make decisions in the presence of multiple, usually conflicting criteria (Hwang and Yoon, 1981, p. 1). The purposes of a MCDM are to classify and sort alternative options and to evaluate their consequences according to the criteria established and to define the parameters of the model (Zopounidis and Doumpos, 2002, p. 231). Alternatives are generally first evaluated explicitly with respect to each of the criteria to obtain some sort of criterion specific priority scores which are then aggregated into overall preference values (Choo et al., 1999, p. 527).

In this study, it has been aimed to evaluate the corporate sustainability performance of the firm Brisa by using MCDM methods. The other aim intended to be obtained in the study is; the comparison of the sequence values obtained as a result of the implementation of the different MCDM methods and the evaluation of the sequences put forwarded by the methods. With this regard, in this study firstly suitable indicators have been determined in terms of availability and data availability. Obtained indicators have been weighted by the Entropy, Critic, SD and MW techniques among the objective weighting techniques and through the help of the obtained weights, the performance sequence of Brisa firm has been performed by means of the help of Copras and Vikor methods. The obtained sequences have been combined with the Borda Count method, a data combination technique, and an integrated single sequence has been obtained.

The rest of the paper is organized as follows. The findings of previous studies have been presented in the first part of the study. In the second part, the mathematical notations and approaches of MCDM methods used in the study have been explained. Method and findings of the study have been presented in the third part and in the last part the results have been given.

LITERATURE REVIEW

This part, which has been created by compiling the related domestic and foreign literature, includes two stages. In the first stage, the studies under the sustainability heading where MCDM methods have been used, while in the second stage the studies covering the hybrid uses of the objective weighting methods have been referred to.

Studies Under the Sustainability Heading Used By the MCDM Methods

Alp, Öztel and Köse (2015), based on their studies where they took environmental and social aspects of the corporate sustainability as basis, measured the corporate sustainability performance of Linde, an international firm operating in the chemical sector, between the years 2009 and 2013 by means of MAUT (Multi Attribute Utility Theory) method, one of the MCDM methods. They determined the weights of criteria by the Entropy method. At the end of the study, the highest environmental sustainability performance has been found to be reached in the year 2011, while the highest social sustainability performance has been found to be reached in the year 2013.

Erol and Özmen (2008), evaluated the environmental sustainability of the three firms operating in the retail sector by using AHP (Analytic Hierarchy Process) and Topsis methods. In the study, the firms operating in and around İstanbul has been coded as A, B and it has been found the firm A has highest performance at the end of the analyzes.

Acar et al. (2015), evaluated the environmental sustainability performance of a corporate firm in the textile industry between 2008-2012 by using Topsis among the MCDM methods. Topsis analyzes have been conducted over two sets where different indicators have been used, and in both cases the highest performance year has been found to be the year 2010.

Yeh and Xu (2012), assessed the recycling sustainability performance of an electronic waste recycling firm operating in Australia by using Fuzzy Pairwise Comparison and Fuzzy Topsis method. In the study, e-waste products have been handled in 6 categories, and 8 criteria including 3 economical, 3 social and 2 environment criteria related to these categories have been determined. Criteria have been weighted in two different ways; optimal and equal weighting. As a result of these two cases, different sequences have emerged. In the case where the optimal weight has been used, the computer has been found to be the highest performance product, while the mobile phone used in equal weighting has been found to be the highest performance product.

Hsu et al. (2015), evaluated the corporate sustainability performance of the 30 high tech listed firms in 2011 using the modified Topsis method. They determined the weights of the criteria by means of Grey Entropy, Critic, Grey Relational Matrix Method and Combined Weight Method developed. Sensitivity analysis has been performed and as a result of this analysis it has been concluded that the results achieved by the Topsis analysis were reliable.

Rajesh and Ravi (2015), evaluated the sustainability performance of the 'ABC' firm in India based on six suppliers with the help of the GRA (Grey Relational Analysis) method. In addition, while the AHP (Analytic Hierarchy Process) and ANP (Analytic Network Process) method has been used in the study to compare the results obtained by the GRA method, the reliability of the results has been tested by using different weights by means of Sensitivity Analysis. As a result of the study, it has been observed that the sequences obtained by GRA, AHP and ANP were different.

Studies Covering the Hybrid Uses of the Objective Weighting Methods

When the studies of objective weight methods, in which hybrids have been used, have been taken into consideration, though low number of studies have been noted, it has been determined that the so-called studies have been performed for the performance evaluation purposes.

Diakoulaki et al., (1995), used the PCA (Prinicpal Component Analysis) method to measure financial performance of 8 Greek pharmaceutical firms. They preferred to use Critic, SD and MW methods, one of the objective weighting methods, for the weighting the three evaluation criteria they used. At the end of the study, it has been concluded that Critic method can be used easily in comparison between firms on the basis of multi-financial ratios.

Deng et al., (2000), weighted the evaluation criteria with Critic, Entropy, SD and MW methods in the study where they measured the performance of seven firms operating in Chinese textile industry, they ranked the firms by means of Topsis method according to their performances. At the end of the study, it has been concluded that the proposed approach was an appropriate approach in terms of performance comparisons between firms.

Wang and Luo (2010), weighted the evaluation criteria with CCSD (Correlation Coefficient (CC) and Standard Deviation (SD) integrated approach) method, which is among the objective techniques, in their study to compare 16 municipalities in China based on five economic indicators. They also compared the results obtained by the CCSD method with those obtained by the Entropy, Critic, SD and Ideal Point Method (Ma et al., 1999) techniques. At the end of the study, though it has been determined that the CCSD method was not sufficient to determine the weights of the criteria alone but was effective, this method has been found to be superior to the other methods since it does not require normalization.

Kılıç and Çerçioğlu (2016), made prioritization for railway connections in 78 locations such as Organized Industrial Zone, which has a high cargo carrying capacity of the State Railways of Republic of Turkey, factory. Criteria used in the evaluation of railway connections have been weighted by three different weighting methods: Critic, SD and MW. Six different orders of priority for these 78 locations have been identified by applying the Topsis and Vikor method from the MCDM methods. The determined sequences have been combined with the Borda Count method, and an integrated single sequence has been obtained. The sequences obtained by the MCDM methods have been compared according to the SSKK (Spearman's Rank Correlation Coefficient) method. At the end of the study, it has been determined that the Vikor sequence, in which criteria are weighted by MW method, is the closest sequence to the integrated sequence.

METHODOLOGY

Determining Sample of Research

Brisa firm has been selected for this study and the corporate sustainability performance of the firm has been evaluated through MCDM methods. Brisa, founded in 1974 under the brand name of Lassa and operating in the international tire and coating sector, Brisa leads the sector by means of many brands, services, trainings and alternative sales channels (http://www.brisa.com.tr). Brisa, whose first sustainability report published in 2012 according to the principles of the GRI Global Reporting Initiative, published the 2013 sustainability report by meeting the A+ level requirements of the GRI standard. The last sustainability report was published based on the GRI G4 guidelines in 2015.

Selecting Alternatives

One of the most fundamental features of the MCDM methods is that they have multiple options and multiple qualifications (Tabucanon, 1988, p. 5). In line with this, at least two alternatives for more than one contradictory criterion and decision must exist in order for the MCDM problem to occur. Thus, the decision maker can decide by choosing one among them. In this study, five years being 2011, 2012, 2013, 2014 and 2015 has been alternatively taken as basis in order to rank the corporate sustainability performance.

Selecting Performance Indicators

The data required for this study, where the economic, environmental and social aspects of the corporate sustainability have been taken into account, has been obtained from Brisa's annual reports (http://www.brisa.com.tr/brisa-way-of-sustainability/our-sustainability%E2%80%8B-reports). The economic, environmental and social indicators used in this study as well as their units and optimization status have been given in Table 1, Table 2 and Table 3, respectively. Based on the relevant year, criteria (EC1 ,…, EC7) given in Table 1 and given by the TL (Turkish Lira) have been converted to USD by benefiting from the information in the archive of the Central Bank of Republic of Turkey to avoid the adverse effect resulted from the inflation difference.

Table 1. Economic Indicators

Economic Indicators	Unit of Measure	Optimization State
EC1: Income	(USD)	Max
EC2: Operating Costs	(USD)	Min
EC3: Employee Wages and Other Provided Benefits	(USD)	Min
EC4: Payments to Pecuniary Resource Providers	(USD)	Min
EC5: Payments to the State	(USD)	Max
EC6: Social Investments	(USD)	Max
EC7: Protected Economic Value	(USD)	Max

Table 2. Environmental Indicators

Environmental Indicators	Unit of Measure	Optimization State
EN1: Energy Consumption	(GJ/ton)	Min
EN2: Energy Savings	(GJ/ton)	Min
EN3: Total Well Water Consumption	(m^3)	Min
EN4: Carbon Dioxide Emission	(ton CO_2-e/ production ton)	Min
EN5: Other Related Indirect Greenhouse Gas Emissions	(ton CO_2-e/ production ton)	Min
EN6: Air Emissions	(ton CO_2-e/ production ton)	Max
EN7: Total Waste Amount	(ton)	Min
EN8: Environmental Protection and Investment Expenditures	(USD)	Min

Table 3. Social Indicators

Social Indicators	Unit of Measure	Optimization State
SO1: Employee Trainings	(person/hour)	Max
SO2: Incidence Rate	(%)	Min
SO3: Severity Rate	(%)	Min
SO4: Absentee Rate	(%)	Min
SO5: Entry Level Wage by Minimum Wage	(%)	Max

Weighting of Criteria

The methods developed for Criterion weighting in the literature, have been categorized into three categories as subjective, objective and integrated. In subjective methods, the evaluation criteria are weighted according to the preferences and judgments of the decision makers, whereas in the objective methods, weighting is performed only by the help of decision matrix elements without referring to the judgments of the decision makers. In the integrated methods, on the other hand, weighting is made by using both the judgments of the decision makers and the decision matrix data together (Wang and Luo, 2010, p. 1). The subjective weighting which is made based on the knowledge of the decision maker is important in terms of the decision maker's statement of his/her expertise and experience on concerned subject; however in situations where the decision maker or the ideas change, certain question marks emerge towards solution of the problem and the problems arises in terms of reliability. The negative effects of subjective weighting are minimized by objective methods. Shannon's Entropy Method (Shannon, 1948), Critic Method (Diakoulaki et al, 1995), Multi Target Programming (Choo and Wedley, 1985), SD Method (Diakoulaki et al, 1995), MW Method (Diakoulaki et al, 1995), Maximizing Deviation Method (Wang, 1998) ve Ideal Point Method (Ma et al., 1999) can be given as an example for the objective methods.

Using objective methods that do not take into consideration the judgments of decision maker in the weighting of criterion gives more realistic outputs. Therefore, only the Entropy, Critic, SD and MW method, which considers the elements of the decision matrix and is among objective weighting methods, has been preferred in the determination of the weightings of the criteria.

Entropy Method

This concept proposed by Shannon (1948) has been developed by Wang and Lee (2009) as a weight calculation method. The Entropy method is an objective evaluation method because it calculates the criteria weights by considering the data without the subjective judgments of the decision makers in determining the importance levels of the criteria. The steps of the method are as follows (Hwang and Yoon, 1981, p. 128):

Step 1: The decision matrix D of multicriteria problem with m alternatives and n criteria is shown as follows:

$$D=\begin{array}{c} \\ A_1 \\ A_2 \\ . \\ . \\ . \\ A_m \end{array}\overset{\begin{array}{cccc} K_1 & K_2 & .... & K_n \end{array}}{\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}}$$

X_{ij}: is the value of success of alternative (i) according to the criterion (j).

Alternatives: $A = \{A_i \mid i = 1,2,...,\text{m}\}$

Criteria: $K = \{K_j \mid j = 1,2,...,\text{n}\}$

Step 2: Normalization of the decision matrix as:

$$NS_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \qquad \textbf{(1.1)}$$

NS_{ij} gives the value of normalized decision matrix elements.

Step 3: Calculate Entropy measure of every criteria using the following equation:

$$E_j = -k\sum_{i=1}^{m} NS_{ij} InNS_{ij} \ \forall_j \qquad \textbf{(1.2)}$$

In the equation **(1.2)**, k; represents a constant and $k = \frac{1}{\ln(m)}$.

E_j the Entropy value of criterion (j) is referred.

Step 4: Define the divergence through:

$$d_j = 1 - E_j, \ \forall_j \qquad \textbf{(1.3)}$$

d_j indicates a contrast intensity existing within the nature of j. Entropy value of criteria is referred with E_j.

Step 5: Obtain the normalized weights of criteria as:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \forall_i \qquad \textbf{(1.4)}$$

$0 \le w_j \le 1$ and $\sum_{j=1}^{n} w_j = 1$ is obvious.

Critic Method

The Critic method is the abbreviation of Criteria Importance Through Intercriteria Correlation. It determines the weights of attributes by considering not only the standard deviation of each attribute, but also the correlations among the attributes (Wang and Luo, 2010, p. 8). The steps of the method are as follows (Diakoulaki et al., 1995, p. 764-765; Jahan et al., 2012, p. 413).

Step 1: Normalize the decision matrix
Decision matrix elements are normalized by using the equations (**2.1**) and (**2.2**).

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}} \quad \text{for benefit criteria} \qquad \textbf{(2.1)}$$

$$r_{ij} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}} \quad \text{for cost criteria} \qquad \textbf{(2.2)}$$

$i = 1,\ldots,m \;\; j = 1,\ldots,\text{n}$

$x_j^{\max}$: best performance in criterion j,

$x_j^{\min}$: worst performance in criterion j.

Step 2: Calculate the correlation coefficients
The linear correlation coefficients (ρ_{jk}) are calculated with the help of equation **(2.3)** to measure the degree of relation between the evaluation criteria.

$$\rho_{jk} = \frac{\sum_{i=1}^{m}(\text{r}_{ij} - \bar{r}_j)(\text{r}_{ik} - \bar{r}_k)}{\sqrt{\sum_{i=1}^{m}(\text{r}_{ij} - \bar{r}_{\text{j}})^2 \sum_{i=1}^{m}(\text{r}_{ij} - \bar{r}_{\text{k}})^2}} \; j,k = 1,\ldots,n \qquad \textbf{(2.3)}$$

Step 3: Calculate the amount of information (C_j) andstandard deviation (σ_j)

Total information (C_j) in the criterion is calculated according to equation **(2.4)**; whereas the standard deviation (σ_j) is calculated according to equation (**2.5**).

$$C_j = \sigma_j \sum_{k=1}^{n}(1 - \rho_{jk}) \qquad \textbf{(2.4)}$$

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m}(\text{r}_{ij} - \bar{r}_j)^2}{m}} \qquad \textbf{(2.5)}$$

Step 4: Determine the criteria weigts (w_j)

The weights of the evaluation criteria are calculated with the help of equation **(2.6)**.

$$w_j = \frac{c_j}{\sum_{j=1}^{n} c_j} \quad (j = 1,2,\ldots,n) \qquad \textbf{(2.6)}$$

SD Method
SD (Standart Deviation) method determines the weights of the criteria in terms of their standart deviations. The steps of the method are as follows (Diakoulaki et al., 1995, p. 766).

Step 1: Normalization of the decision matrix
In the first stage, the decision matrix consisting of (m) number of alternative and (n) number of evaluation criteria is normalized through equations (2.1) and (2.2) which are available in the steps of Critic method.

Step 2: Calculation of standard deviation (σ_j) and criteria weights (w_j)

Standard deviation is calculated by means of equation **(2.5)** and criteria weights are calculated by means of equation **(3.1)**.

$$w_j = \frac{\sigma_j}{\sum_{j=1}^{n} \sigma_j} \quad j = 1,...,n \qquad \textbf{(3.1)}$$

MW Method

MW (Mean Weight) method is based on the assumption that all of the attributes are of equal importance. MW method should be used either when there is no information from the decision maker or when there is not enough information to distinguish the relative importance of criteria (Jahan et al., 2012, p. 413). The steps of the method are as follows (Jahan et al., 2012, p. 413).

$$w_j = \frac{1}{n} \qquad \textbf{(4.1)}$$

where n is the number of criteria.

Copras Method

The Copras method is processed based on step by step sequencing and evaluation process of alternatives in terms of importance and utility ratings (Özdağoğlu, 2013, p. 5). This method is used to evaluate the criteria values, and to increase the benefit criteria to the highest level and to evaluate the useless criteria by reducing them to the minimum level (Podvezko, 2011, p. 137). The steps of the method are as follows (Das et al., 2012, p. 237; Chatterjee et al., 2011, p. 853; Özdağoğlu, 2013, p. 6-7).

Step 1: The formation of decision matrix

Decision matrix, consisted of X_{ij} values and denoted by *D*, is indicated in equation **(5.1)**.

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ . \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \qquad \textbf{(5.1)}$$

A_i :i th alternative $i = 1,2,...,m$; C_j : j th evaluation criteria $j = 1,2,...,n$

Step 2: Construction of the normalized decision matrix

Decision matrix is normalized with the help of equation (5.2).

$$x_{ij}^{*} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \ (\mathrm{j} = 1,2,...,\mathrm{n}) \qquad \textbf{(5.2)}$$

Step 3: Determining of the weighted normalized decision matrix D'

The weighted normalized decision matrix, which is denoted as *D* and includes d_{ij}, is formed by using the decision matrix normalized with weighted value of each evaluation criterion.

$$D' = \left[d_{ij} \right]_{mxn} = x_{ij}^{*}.\mathrm{w}_j \qquad \textbf{(5.3)}$$

where x_{ij}^{*} is the normalized performance value of ith alternative on jth criteria and w_j is the associated weight of the jth criteria.

Step 4: Calculation of the sums of weighed normalized criteria describing the *i*-th alternative

The sums S_{i+} and S_{i-} of weighted normalized values are computed for both beneficial and non-beneficial criteria respectively. For beneficial criteria, higher value is better and for non-beneficial criteria, lower value is better for the attainment of goal. These sums S_{i+} and S_{i-} are calculated using the following equations:

$$S_{i+} = \sum_{j=1}^{k} d_{ij} \quad j = 1,2,...,k$$ for beneficial criteria **(5.4)**

$$S_{i-} = \sum_{j=k+1}^{n} d_{ij} \quad j = k+1, k+2, ..., n$$ for non-beneficial criteria **(5.5)**

Step 5: Calculation of the relative weight (Q_i) of each alternative

The relative weight Q_i of i-th alternative is calculated as follows:

$$Q_i = S_{i+} + \frac{\sum_{i=1}^{m} S_{i-}}{S_{i-} \sum_{i}^{m} \frac{1}{S_{i-}}} \qquad \textbf{(5.6)}$$

The alternative which gains the highest relative importance value as a result of calculations is determined as the best alternative.

Step 6: Determine the priority order of alternatives
The highest relative importance value is found with the help of equation **(5.7)**.

$$Q_{\max} = \max\left(Q_i\right) \; \forall i = 1,2,...,m \qquad \textbf{(5.7)}$$

Step 7: Calculation of performance index value (P_i) for alternatives
Performance index (*Pi*) specified for each alternative is calculated with the help of equation (**5.8**).

$$P_i = \frac{Q_i}{Q_{\max}}.100\% \qquad \textbf{(5.8)}$$

The alternative whose performance index value (*Pi*) is 100, is the best alternative. The result is obtained by sorting the performance index value from biggest to smallest value.

Vikor Method

The Vikor method proposed by Serafim Opricovic (1998) has been started to be used in the solution of the MCDM problems with the study performed by Opricovic and Tzeng (2004). The name of the method, Vikor (VlseKriterijumska Optimizacija I Kompromisno Resenje), has been created by abbreviating the initials of the expression in Slavic origin. Its meaning in Turkish language can be expressed as multi-criteria optimization and compromise solution (Görener, 2011, p. 100). The basic concept of Vıkor lies in first defining the positive and negative ideal solutions. The positive ideal solution is the alternative with the highest value while the negative ideal solution is the one with the least test value (Chu et el., 2007, p. 1012). The steps of the method are as follows (Opricovic and Tzeng, 2007, p. 447-448):

Step 1: Determination the best **(** f_i^* **)** and the worst **(** f_i^- **)** values of all criterion functions

$$f_i^* = \max_j f_{ij},\; f_i^- = \min_j f_{ij},$$ If the i-th function represents a benefit **(6.1)**

$$f_i^* = \min_j f_{ij},\; f_i^- = \max_j f_{ij},$$ If the i-th function represents a cost **(6.2)**

i is the comparison criterion ($i = 1,2,...,n.$), j is the alternatives ($j = 1,2,...,m$).

Step 2: Computation the values S_j and R_j

S_j value refers to average group value; R_j refers to the worst group value.

$$S_j = \sum_{i=1}^{n} w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-), \qquad \textbf{(6.3)}$$

$$R_j = \max_i \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right], \qquad \textbf{(6.4)}$$

Here w_j are the weights of criteria, expressing their relative importance.

Step 3: Computation the values Q_j

Q_j values are found according to evaluation criteria by means of equation (**6.5**) for each alternative.

$$Q_j = v(S_j - S^*)/(S^- - S^*) + (1-v)(R_j - R^*)/(R^- - R^*) \tag{6.5}$$

Where;

$S^* = \min_j S_j$ $S^- = \max_j S_j$ $R^* = \min_j R_j$ $R^- = \max_j R_j$

Value (v) refers to the weight for the strategy that provides the maximum group benefit, while value (1 - v) refers to the weight of the minimum regret of those having opposite views (Opricovic and Tzeng, 2007, p. 516). Usually v = 0.5 is used (Opricovic and Tzeng, 2004, p. 451).

Step 4: Ranking the alternatives, sorting by the values S_j, R_j ve Q_j

The S_j, R_j ve Q_j values calculated for each alternative are sorted from small to large. The alternative with the smallest value of *Qj* is considered to be the best alternative.

Step 5: Determination of the acceptable advantage (C_1) ve acceptable stability in decision making (C_2)
The alternative with the minimum *Qj* value is recommended as a compromise solution, if it meets the following acceptable advantage (C_1) and acceptable stability (C_2) conditions.

C1: "Acceptable Advantage"
For any alternative to be within C_1 cluster, such alternative should meet the condition indicated in equation (**6.6**).

$$Q(a'') - Q(a') \geq DQ \tag{6.6}$$

where a'' is the alternative with second position in the ranking list by $Q; DQ = 1/(J-1)$; J is the number of alternatives.

C2: "Acceptable Stability in Decision Making"
The alternative a′ must also be the best ranked by S or/and R. Alternatives available within both C_1 and C_2 clusters indicate the stable decision points according to the sense of sequence. If one of these two conditions is not provided, the set of compromise solution is proposed as follows:

Alternatives a' and a'' if only condition C2 is not satisfied, or

Alternatives $a', a'', ..., a^{(M)}$ if condition C1 is not satisfied; and $a^{(M)}$ is determined by the relation $Q(a^{(M)}) - Q(a^1) \langle DQ$ for maximum M. **(6.7)**

The best alternative, ranked by Q, is the one with the minimum value of Q.

Borda Count Method
The Borda Count method, one of the voting methods in social election theory, has been developed by Jean-Charles de Borda (1784). The Borda count is originally a voting method in which each voter gives a complete ranking of all possible alternatives (Erp and Schomaker, 2000, p. 444). In this method, a score zero (0) is assigned the least preferred alternative, one (1) for the next alternative and (n-1) (n refers to the number of alternatives) for the most preferred alternative.Then, alternatives are ranked as per their Borda scores.

APPLICATION

In this study, it has been aimed to measure the corporate sustainability performance of Brisa firm, which operates in the international tire and coating sector, by using MCDM techniques. In a study based on three aspects of corporate sustainability, the required data have been obtained from the annual reports of the said firm. Accessibility and data availability have been taken as basis in the determination of data. The economic, environmental and social aspects decision matrix and the weights calculated according to Entropy, Critic, SD and MW methods by using the equations **(1.1-4.1)** related to these aspects have been given Tables 4, 5 and 6, respectively.

Table 4. Economic Dimension Decision Matrix and Weights

		EC1	EC2	EC3	EC4	EC5	EC6	EC7
	ENTROPY	0,0039	0,0185	0,0080	0,0653	0,0643	0,5887	0,2513
	CRITIC	0,1463	0,2182	0,1272	0,1273	0,1062	0,1155	0,1593
	SD	0,1470	0,1424	0,1337	0,1397	0,1477	0,1466	0,1429
	MW	0,14286	0,14286	0,14286	0,14286	0,14286	0,14286	0,14286
	2011	890.248,13	696.144,62	107.632,84	51.904,92	13.318,63	310,93	20.936,19
	2012	768.658,67	544.027,41	99.799,94	64.960,41	12425,63	174,94	47270,34
	2013	856.228,93	578163,92	113580,08	74.012,69	13.676,42	714,39	87.695,38
	2014	808.831,68	533.760,80	111.010,86	84.070,57	11.476,62	213,05	76.653,51
	2015	795.351,80	504.419,12	125653,75	98925,45	7.127,02	119,04	59107,41

Table 5.Environmental Dimension Decision Matrix and Weights

		EN1	EN2	EN3	EN4	EN5	EN6	EN7	EN8
	ENTROPY	0,0134	0,0470	0,8208	0,0318	0,0175	0,0211	0,0107	0,0377
	CRITIC	0,1054	0,1021	0,0978	0,0996	0,0868	0,0944	0,1979	0,2160
	SD	0,122807	0,118743	0,121216	0,139141	0,121048	0,121048	0,121309	0,134688
	MW	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
	2011	201	830	567.362	265	217	178	6841	880.195
	2012	248	968	530.738	276	235	221	6933	1.098.097
	2013	213	1086	443.755	221	221	183	7035	1.198.410
	2014	202	1222	438,486	204	177	167	7279	847.566
	2015	198	1313	490.120	202	196	166	8393	869.000

Table 6. Social Dimension Decision Matrix and Weights

		SO1	SO2	SO3	SO4	SO5
	ENTROPY	0,4230	0,2527	0,2018	0,0531	0,0694
	CRITIC	0,2283	0,2371	0,1815	0,1398	0,2133
	SD	0,2048	0,2077	0,2002	0,1934	0,1939
	MW	0,20	0,20	0,20	0,20	0,20
	2011	76,59	0,74	15,13	5,36	7,85
	2012	77,96	0,69	14,79	5,68	7,31
	2013	89,3	0,71	13,42	5,09	7,31
	2014	102,2	0,86	12,27	5,34	6,98
	2015	94,02	0,82	14,62	5,61	6,94

Weighting of Criteria

The first step of application is to determine the weights of the performance evaluation criteria. The weight values obtained for each of the three aspects by using four different objectives weight methods are shown in Table 4, Table 5 and Table 6.

Performance Measurement by Copras and Vikor Methods

Firm performance has been measured with Copras and Vikor methods by using weights obtained by means of Entropy, Critic, SD and MW methods in the second phase of application.

Application of Copras Method

In the application conducted with Copras method, first of all, the criteria have been normalized by means of equation **(5.2)**. Normalized values are shown on the Table 7. The same process is repeated for other dimensions.

Table 7. Normalized Decision Matrix

	EC1	EC2	EC3	EC4	EC5	EC6	EC7
2011	0,2161	0,2437	0,1930	0,1388	0,2295	0,2029	0,0718
2012	0,1866	0,1905	0,1790	0,1737	0,2141	0,1142	0,1621

2013	0,2079	0,2024	0,2037	0,1980	0,2357	0,4662	0,3007
2014	0,1964	0,1869	0,1991	0,2249	0,1978	0,1390	0,2628
2015	0,1931	0,1766	0,2253	0,2646	0,1228	0,0777	0,2027

Then, weighted standard decision matrix has been formed by multiplying decision matrix elements normalized by equation (**5.3**) with four different weight sets obtained. The weights obtained by using the Entropy method are given at Table 8. The same process was repeated for other weighting techniques.

Table 8: Weighted Standart Decision Matrix

		EC1	EC2	EC3	EC4	EC5	EC6	EC7
	2011	0,0008	0,0045	0,0015	0,0091	0,0148	0,1194	0,018
	2012	0,0007	0,0035	0,0014	0,0113	0,0138	0,0672	0,0407
	2013	0,0008	0,0037	0,0016	0,0129	0,0152	0,2744	0,0756
	2014	0,0008	0,0035	0,0016	0,0147	0,0127	0,0818	0,066
	2015	0,0008	0,0033	0,0018	0,0173	0,0079	0,0457	0,0509

By using the weighted standard decision matrix formed and by taking into account the optimization aspects of the criteria, useful and useless criteria have been determined with the help of equations **(5.4)** and **(5.5)** and given at Table 9.

Table 9. Useful and Useless Criteria

		S_+	S_-		S_+	S_-		S_+	S_-		S_+	S_-
	2011	0,153	0,015	**CRITIC**	0,091	0,095	**SD**	0,106	0,080	**MW**	0,103	0,082
	2012	0,122	0,016		0,089	0,086		0,099	0,075		0,097	0,078
	2013	0,366	0,018		0,157	0,095		0,177	0,084		0,173	0,086
	2014	0,1613	0,020		0,108	0,095		0,116	0,085		0,114	0,087
	2015	0,1053	0,022		0,083	0,101		0,087	0,092		0,085	0,095

After calculating the relative importance levels Q_i with the help of equation (**5.6**), the final sequence has been performed by finding performance indexes with the help of equality (**5.8**).

Table 10. Relative Importance Value and Ranking

		Q_i	P_i	Rank		Q_i	P_i	Rank		Q_i	P_i	Rank		Q_i	P_i	Rank
	2011	0,1748	45,52	3	**CRITIC**	0,1843	73,51	4	**SD**	0,1919	74,09	3	**MW**	0,1919	74,46	3
	2012	0,1428	37,16	4		0,1922	76,64	3		0,1904	73,52	4		0,1910	74,11	4
	2013	0,3841	100	1		0,2508	100	1		0,2589	100	1		0,2577	100	1
	2014	0,1780	46,33	2		0,2018	80,46	2		0,1973	76,22	2		0,1975	76,65	2
	2015	0,1200	31,25	5		0,1710	68,17	5		0,1615	62,38	5		0,1620	62,87	5

Application of Vikor Method

The best (f_i^*) and the worst (f_i^-) values in the Vikor method application have been determined by the help of equations **(6.1)** and **(6.2)**. This application was implemented for each dimension.

Table 11: The Best and Worst of Each Criterion

	EC1	EC2	EC3	EC4	E5	EC6	EC7
f^+	890.248,13	504.419,12	99.799,94	51.904,92	13.676,42	714,39	87.695,38
f^-	768.658,67	696.144,62	125653,75	98925,45	7.127,02	119,04	20.936,19

Then, S_j ,R_j, and Q_j scores have been calculated for each alternative by using equations **(6.3)**, **(6.4)** and **(6.5)**.While the weight values obtained with Entropy, Critic, SD and MW methods have been used in the calculation of the S_j and R_j scores, (v) has been taken as 0.5 in the calculation of values of Q_j by adopting the general practice in the literature.

Table 12: The Value of S_j , R_j, Q_j

		S_j	R_j	Q_j		S_j	R_j	Q_j		S_j	R_j	Q_j		S_j	R_j	Q_j
	2011	0,675	0,399	0,728		0,500	0,218	0,805		0,433	0,143	0,663		0,434	0,143	0,693
	2012	0,724	0,533	0,879		0,448	0,146	0,473		0,463	0,147	0,719		0,455	0,143	0,715
	2013	**0,043**	**0,031**	**0,00**	**CRITIC**	**0,253**	**0,084**	**0,00**	**SD**	**0,233**	**0,071**	**0,00**	**MW**	**0,238**	**0,076**	**0,00**
	2014	0,612	0,496	0,775		0,433	0,098	0,274		0,470	0,123	0,570		0,469	0,120	0,559
	2015	0,837	0,589	1		0,659	0,1273	0,662		0,744	0,148	1		0,744	0,143	1

Two conditions to be satisfied in step 5 of the VIKOR method have been met in all sequences.

Application of Borda Count Method

In the last stage of the application, a single integrated performance sequence has been formed with the Borda Count algorithm from the eight sequence lists obtained for each aspect by means of Copras and Vikor methods by using four different weight sets in the previous step. In this direction, first of all, score 4 has been given to the alternative that has the highest performance for all the sequences obtained, and score 0 has been given to the alternative that is ranked last. Then, the obtained sequence scores have been added and a single score has been obtained. This has been repeated for three aspects. According to the total scores, the alternative that received the highest score was the first and the alternative that received the least score was the last. The results obtained by the Copras and Vikor methods and the integrated sequence results obtained by the Borda Count Method according to four different objective weight methods are given in Table 13.

Table 13. Copras, Vikor, Borda Count Method Analysis Results and Performance Ranking

ECONOMIC DIMENSION																		
	ENTROPY				**CRITIC**				**SD**				**MW**				**BORDA COUNT**	
	COPRAS		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**			
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank		
2011	45,52	3	0,73	2	73,51	4	0,81	5	74,09	3	0,66	3	74,46	3	0,69	3	14	3
2012	37,16	4	0,88	4	76,64	3	0,47	3	73,52	4	0,72	4	74,11	4	0,72	4	10	4
2013	100	1	0,00	1	100	1	0,00	1	100	1	0,00	1	100	1	0,00	1	32	1
2014	46,33	2	0,78	3	80,46	2	0,27	2	76,22	2	0,57	2	76,65	2	0,56	2	23	2
2015	31,25	5	1	5	68,17	5	0,66	4	62,38	5	1	5	62,87	5	1	5	1	5
ENVIRONMENTAL DIMENSION																		
	ENTROPY				**CRITIC**				**SD**				**MW**				**BORDA COUNT**	
	COPRAS		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**			
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank		
2011	12,36	5	1	5	86,37	2	0,09	3	82,15	2	0,38	3	82,17	2	0,55	3	15	3
2012	13,02	4	0,96	4	81,12	5	0,59	4	78,64	5	1	5	78,83	5	1	5	3	5
2013	14,93	2	0,78	2	81,78	4	0,06	2	80,75	4	0,08	1	80,77	3	0,08	1	21	2
2014	100	1	0,00	1	100	1	0,05	1	100	1	0,30	2	100	1	0,5	2	30	1
2015	13,79	3	0,88	3	83,34	3	1	5	81,26	3	0,59	4	80,75	4	0,82	4	11	4
SOCIAL DIMENSION																		
	ENTROPY				**CRITIC**				**SD**				**MW**				**BORDA COUNT**	
	COPRAS		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**		**COPRAS**		**VIKOR**			
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank		
2011	89,02	5	1	5	94,46	3	0,75	3	94,29	3	0,75	3	94,40	3	0,76	3	12	3
2012	90,89	4	0,88	4	94,40	4	0,78	4	93,88	4	0,90	4	93,85	4	0,85	4	8	4
2013	97,97	2	0,07	1	100	1	0,00	1	100	1	0,00	1	100	1	0,00	1	31	1
2014	100	1	0,13	2	98,42	2	0,70	2	98,63	2	0,68	2	98,65	2	0,68	2	22	2
2015	94,21	3	0,35	3	94,01	5	0,89	5	93,74	5	0,93	5	93,73	5	1	5	4	5

CONCLUSIONS

The importance of sustainability increases for the businesses day by day. Businesses, which want to survive in today's highly competitive environment, involve the sustainability into their business processes and share their progress on the way to sustainability with the public and stakeholders. At this point, the evaluation of corporate sustainability performance of the firms has become important and a number of methods have been developed to measure sustainability performance. In line with this, in this study, MCDM methods, which provide an appropriate framework for corporate sustainability measurement, have been applied.

In this study, in which the corporate sustainability performance of the firm Brisa has been assessed by using the MCDM methods, first of all, appropriate indicators have been determined for three aspects of corporate sustainability. After calculating the determined weights of the indicators by using the Entropy, Critic, SD and MW objective weight methods, the performance sequence for the years 2011-2015 has been made by means of Copras and Vikor methods. According to the results obtained, it has been seen that MCDM methods give close results for their performance sequences when they are compared with each other.

When the results in Table 13 are examined, it has been determined that Copras and Vikor sequences obtained by different weighting techniques have generally similar results and close to the sequence obtained according to the Borda Count method . In the economic aspect, in all of the Copras and Vikor sequences obtained by four different weighting methods, the year 2013 has been found to have the highest performance. According to the Borda Count method and the integrated counting method conducted, the year 2013 has been found to have the highest performance, whereas the year 2015 has been found to be the last.

When the environmental aspect results have been evaluated, except for the Vikor sequence weighted by SD and MW method, the year 2014 has been found as the year with the highest performance in all other sequences. In the SD and MW based Vikor sequence, the year 2013 has been found as the year with the highest performance. According to the Borda Count method and the integrated counting method conducted, the year 2014 has been found to have the highest environmental sustainability performance, whereas the year 2012 has been found to be the last.

When the sequence results have been evaluated in terms of social aspect, except for the Copras sequence weighted by Entropy method, the year 2013 has been found as the year with the highest performance in all other sequences. In the Entropy based Copras sequence, the year 2013 has been found to be second rank. According to the Borda Count Method and the integrated counting method conducted, the year 2013 has been found to have the highest performance, whereas the year 2015 has been found to be the last rank.

It has been found that the trends obtained are similar, but there were some minor deviations in the sequences reached as a result of the MCDM methods. In this respect, in order to obtain a more rational result, a single sequence has been obtained by integrating the sequence list achieved by using Copras and Vikor methods with the help of different weighting techniques with the Borda Count method.

Since the methods used in the evaluation of sustainability performance in this study were mathematical methods, which are out of judgement, objective and precise results have been achieved. Therefore, it can be said that the proposed method is a suitable method for analyzing corporate sustainability performance. The use of only objective weighting methods for the weighting of the indicators can be shown as a limitation of study. In future studies, performance evaluation can be carried out with integrated methods in which both objective and subjective techniques are evaluated together. Furthermore, the sensitivity analysis of the study can also be achieved by changing and reducing some of the selected criteria or by assigning values ranging from 0 to 1 to the (v) weight value used in the Vikor method.

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