Evaluation of NUTS Level 2 Regions of Turkey by TOPSIS, MOORA and VIKOR[1]

Onur Önay
Istanbul University
School of Business
Department of Quantitative Methods
Avcilar Campus, Avcilar 34850
Istanbul, Turkey.

Bahadır Fatih Yıldırım
Istanbul University
School of Transportation and Logistics
Avcilar Campus, Avcilar 34850
Istanbul, Turkey.

Abstract

Globalization makes foreign trade more important in the modern world. Continuity of foreign trade is one of the important indicators for national income and welfare. Trade activities may be differing for regions. Analyzing the Nomenclature of Units for Territorial Statistics (NUTS) Level 2 regions of Turkey according to differences between these regions is the subject of this study. In this study, NUTS Level 2 regions of Turkey are evaluated by TOPSIS, MOORA and VIKOR Methods with using 10 topics of foreign trade activities. There are 26 NUTS Level 2 regions in the Turkey. These are our alternatives. They are evaluated with 10 criteria which are the topics under the foreign trade activities. Results are given and regions are compared.

Keywords: Multi-criteria decision making; TOPSIS; MOORA; VIKOR; NUTS Level 2 regions

Introduction

People need miscellaneous products for maintaining their life. If people provide needs from their own region, they can supply it from their potentiality. Requirements may change in course of time and this change may depend on the changing of the world. A product sometimes becomes demand with this changing, even though it was not before. When a product meagre or it is not produce in a region, it can be bought from other regions. People can provide it closer regions as well as further regions. Thus people make trade. In that case, commercial products are comprised with various products from region to region. Commercial products may exhibit diversity according to geographical properties, logistics and transportation capability, education level, cultural structure and industrialization. While some kind of products can be supplied from specific region, some of them can be supplied from different regions with different amounts.

There are different application areas of the multi-criteria decision making methods like regional decision making problems in the literature. Some of regional decision making problems based on NUTS classification refer to multi criteria decision making methods. Kiszová and Nevima (2012) applied AHP for evaluating regional competitiveness in case of the Czech Republic NUTS 2 regional units. Hudec et al. (2014), aimed on their study that the importance of different criteria at the regional level (NUTS 2), based on the empirical research done in most of the regional governments in three Central European countries namely The Slovak Republic, Czech Republic and Hungary, to show their country specific differences. Diversified application areas of the TOPSIS method in the literature, such as operating system selection (Ballı & Korukoğlu, 2009), evaluation of higher education (Ding & Zeng, 2015) and quality credit evaluation (Zhu, Wang, Wang, Liang, Tang, Sun & Li, 2014).

[1] This study is rewritten and extended version of the proceeding which is the published in the I. International Caucasus-Central Asia Foreign Trade and Logistics Congress 2015 proceedings book.

Various application areas of the MOORA method in the literature, such as regional development in Lithuania (Brauers, Ginevičius & Podvezko, 2010), determining the popularity of tourist destinations (Önay & Çetin, 2012), ranking cloud storage technology firms (Yıldırım & Önay, 2013), optimization of welding process parameters (Gadakh, Shinde & Khemnar) and the production system life cycle (Attri& Grover , 2014).VIKOR method was applied to determine the best feasible solution according to the selected criteria, such as supplier selection (Akyüz, 2012; Tayyar & Arslan, 2013; Sanayei et al., 2010), personnel selection (Yildiz & Deveci, 2013; Liu et al., 2015; El-Santawy& El-Dean, 2012) logistics tool selection (Büyüközkan et al., 2012), marketing strategy selection (Mohaghar et al., 2012), material selection (Liu et al., 2013), performance evaluation (Karaatlı et al., 2014; Hajihassani, 2015; Kuo& Liang, 2011; 2012), evaluate and analyze the performance the development level of countries (Paksoy, 2015; Özden, 2012) and project selection (Yıldız, 2014).

In this study, 26 NUTS (Nomenclature of Units for Territorial Statistics) Level 2 regions of Turkey are assessed by TOPSIS, MOORA and VIKOR methods according to 10 criteria. The paper is organized in the following way: Firstly methods are defined, secondly the methods are applied and lastly the results are given, compared and reviewed.

2. Methods

In this section we present the application steps of the TOPSIS, MOORA and VIKOR methods which are the multi-criteria decision making methods.

2.1. The TOPSIS Method

Consider the our data set as suppose that there are *m* alternatives, $A = \{A_1, A_2, \ldots, A_m\}$ and n criteria, $C = \{C_1, C_2, \ldots, C_n\}$. x_{ij} is the rating of alternative A_i with respect to criterion C_j(Jahanshahloo, Lotfi, & Izadikhah, 2006).

The TOPSIS method is described in the following steps.

Step 1: The evaluation (decision) matrix $(x_{ij})_{mxn}$ consisting of *m* alternatives and *n* criteria is developed (Barros & Wanke, 2015).

Step 2: Decision matrix $(x_{ij})_{mxn}$ is normalized and define new nomalize decision matrix $(r_{ij})_{mxn}$ (Lourenzutti & Krohling, 2016).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

Step 3: Calculate the weighted normalized decision matrix $(v_{ij})_{mxn}$, (Wanke, Azad, & Barros, 2016);

$$v_{ij} = w_j . r_{ij} \tag{2}$$

where w_j is the weight of the criterion *j* and $\sum_{j=1}^{n} w_j = 1$.$W = \{w_1, w_2, \ldots, w_n\}$ be the set of weights of criteria.

Step 4: The positive ideal solution (PIS), A^+, and the negative ideal solution (NIS), A^-, define for each criterion. Usually $A^+ = \{v_1^+, v_2^+, \cdots, v_n^+\} = \{((\max)_j v_{ij} | i \in I), ((\min)_j v_{ij} | i \in J)\}$ and $A^- = \{v_1^-, v_2^-, \cdots, v_n^-\} = \{((\min)_j v_{ij} | i \in I), ((\max)_j v_{ij} | i \in J)\}$ where *I* is associated with benefit criteria and *J* is associated with cost criteria (Jahanshahloo, Lotfi, & Izadikhah, 2006).

Step 5: Calculate the separation measures for each alternative. Measuring the distance of alternatives from positive and negative ideal solutions (Lourenzutti & Krohling, 2016; Jahanshahloo, Lotfi, & Izadikhah, 2006).

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \ , \qquad i = 1,2, \ldots, m \tag{3}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \ , \qquad i = 1,2, \ldots, m \tag{4}$$

Step 6: Calculate the closeness coefficients to the ideal solution (Ramesh, Viswanathan, & Ambika, 2016).

$$CC_i = \frac{S_i^-}{S_i^* + S_i^-}, \quad (0 \le CC_i \le 1, i = 1,2, \dots, m) \tag{5}$$

Rank the alternatives according to CC_i. The higher value of CC_i, indicates a better alternative A_i (Lourenzutti & Krohling, 2016).

2.2. The MOORA Method

The MOORA method starts with develop a matrix $(x_{ij})_{mxn}$ which is consisting of *m* alternatives and *n* criteria. The MOORA method consists of two parts: the ratio system and the reference point approach (Brauers, Ginevičius, & Podvezko, 2010).

2.2.1 The Ratio System

The ratio system as a part of MOORA is developed in which each response of an alternative on an criterion is compared to a denominator, which is representative for all alternatives concerning that criterion (objective) (Chakraborty, 2011; Brauers & Zavadskas, 2006). This ratio can be defined as;

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{6}$$

x_{ij}^*: dimensionless number representing the normalized response of ***i-th*** alternative on ***j-th*** criterion (objective).

The normalized responses of the alternatives on the objectives usually belong to the interval $[0,1]$, $x_{ij}^* \in [0,1]$ but sometimes the interval could be $[-1,1]$ (Brauers, Zavadskas, Turskis, & Vilutienė, 2008).

For optimization, these normalized responses are added in case of maximization and subtracted in case of minimization (Görener, Dinçer, & Hacıoğlu, 2013).

$$y_i^* = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \tag{7}$$

$j = 1,2, \dots, g$; as the objectives to be maximized,

$j = g + 1,2, \dots, n$; as the objectives to be minimized,

An ordinal ranking of the y_i^* shows the final preference.

2.2.2 The Reference Point Approach

The reference point approach starts from the ratio found in formula (6). Reference points are determined for maximization by choosing he highest co-ordinate per objective of all the candidate alternatives and also they are determined by choosing the lowest co-ordinate for minimization. The distance between the alternatives and the reference point is measured by using the Tchebycheff Min-Max metric (Brauers & Zavadskas, 2006; Yıldırım & Önay, 2013);

$$min_i\{max_j|r_j - x_{ij}^*|\} \tag{8}$$

$i = 1,2, \dots, m$: are the alternatives,

$j = 1,2, \dots, n$: are the criteria (objectives),

r_j: the *j-th* objective reference point.

2.2.3 Significance Coefficient

Criteria could be multiplied with its corresponding weights (significance coefficient), when some criteria (objectives) are more important than others (Chakraborty, 2011). In that case; formula (9) uses instead of formula (7) and formula (10) uses instead of formula (8) (Brauers, Zavadskas, Peldschus, & Turskis, 2008).

$$y_i^* = \sum_{j=1}^{g} w_j x_{ij}^* - \sum_{j=g+1}^{n} w_j x_{ij}^* \tag{9}$$

$$min_i\{max_j|w_j r_j - w_j x_{ij}^*|\} \tag{10}$$

2.3 The VIKOR Method

The VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje) method was introduced as one applicable MCDM technique by Opricovic (1998).

The VIKOR method determines the compromise ranking-list, the compromise solution. It was developed for multicriteria optimization of complex systems. The VIKOR method aims the weight stability intervals for preference stability of the compromise solution obtained with the determined weights (Opricovic, 1998; Opricovic & Tzeng, 2004). This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria and uses decision matrix like given below.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

The compromise ranking algorithm VIKOR has the following steps (Opricovic&Tzeng, 2004; Opricovic&Tzeng, 2007; Kuzu, 2014):

*Step 1***.** Determine the best and the worst values of all criterion

After building decision matrix, for each criterion ($j = 1, 2,...,n$) determine the best f_j^* and the worst f_j^- values. if the *j*. function represents a benefit f_j^* ve f_j^- values compute with,

$$f_j^* = \max_i x_{ij} \qquad (11)$$

$$f_j^- = \min_i x_{ij}$$

if the *j*. function represents a cost f_j^* ve f_j^- values compute with,

$$f_j^* = \min_i x_{ij} \qquad (12)$$

$$f_j^- = \max_i x_{ij}$$

equations.

*Step 2***.** Normalization process and generating normalization matrix

In a VIKOR decision model each alternative has a performance rating for each criteria, and performance scores for different attributes are usually measured by different units. Thus, normalization procedures are used to convert the different measurement units of the performance scores into a comparable unit. For this purpose, linear normalization procedure, max-min method, is preferred in VIKOR method (Celen, 2014).

Normalize *R* matrix values compute by given equation,

$$r_{ij} = \frac{f_j^* - x_{ij}}{f_j^* - f_j^-} \qquad (13)$$

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{12} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Step 3. Generating weighted normalize decision matrix

$$v_{ij} = r_{ij} \cdot w_j \qquad (14)$$

wherew_j are the weights of criteria, expressing the decision makers or experts preference as the relative importance of the criteria.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{12} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}$$

*Step 4.*Compute the values S_i and R_i

$$S_i = \sum_{j=1}^{n} v_{ij} \tag{15}$$

$$S_i = \sum_{j=1}^{n} w_j \cdot r_{ij}$$

$$S_i = \sum_{j=1}^{n} w_j \cdot \frac{f_j^* - x_{ij}}{f_j^* - f_j^-}$$

$$R_j = \max_j v_{ij} \tag{16}$$

$$R_j = \max_j \left(w_j \cdot r_{ij} \right)$$

$$R_j = \max_j \left(w_j \cdot \frac{f_j^* - x_{ij}}{f_j^* - f_j^-} \right)$$

*Adım 5.*Compute the values Q_i

For computing Q_i values, S^*, S^-, R^* and R^- parameters are used

$$S^* = \min_i S_i \tag{17}$$

$$S^- = \max_i S_i$$

$$R^* = \min_i R_i$$

$$R^- = \max_i R_i$$

$$Q_i = \frac{q \cdot \left(S_i - S^* \right)}{S^- - S^*} + \frac{(1-q) \cdot \left(R_i - R^* \right)}{R^- - R^*} \tag{18}$$

*q*is introduced as weight of the strategy of the maximum group utility, whereas 1-*q* is the weight of the individual regret.

*Step 6.*Rank the alternatives and propose as a compromise solution

Rank the alternatives, sorting by the values S, R and Q in decreasing order. The results are three rankinglists. Compromise solution proposes if the following two conditions are satisfied

Condition 1. Acceptable advantage:

$$Q\left(A^1\right) - Q\left(A^2\right) \geq DQ \tag{19}$$

$A^2$is the alternative with second position in the ranking list by *Q* and *DQ* is

$$DQ = \frac{1}{m-1} \tag{20}$$

where*m* is number of alternatives.

Condition 2. Acceptable stability in decision making: The alternative A^1 must also be the best ranked by *S* or/and *R*. This compromise solution is stable within a decision making process, which could be the strategy of maximum group utility (when *q*>0.5 is needed), or "by consensus" *q*=0.5, or "with veto" (*q*<0.5). Where, *q* is the weight of decision making strategy of maximum group utility and 1-*q* is the weight of the individual regret.

If one of these conditions is not satisfied, then a set of compromise solutions is proposed

- If only the condition 2 is not satisfied both A^1 and A^2 alternatives proposed as compromise solution.
- If the condition 1 is not satisfied all of $A^1, A^2, \ldots, A^m$ alternatives proposed as compromise solution. *m*is determined by the relation $Q\left(A^m\right) - Q\left(A^1\right) < DQ$

The results by the VIKOR method are rankings by *S*, *R*, and *Q*, proposed compromise solution, compromise solution can be one or a set.

3. Application and Results

3.1 Data Set

Data set is obtained from Turkish Statistical Instıtute (TÜİK, 2015).Data set consists of the 26 NUTS Level2 regions of Turkey and their data of 10 different foreign trade topics of 2013. Thus we have 26 alternatives which are given at the Table1and 10 criteria which are given at the Table2.Our criteria are about the regional trade activities in different segments. Because of criterion importance can change from region to region and a trade activity may not supersede another for all regions, so we can assume that our criteria have equal significance. So our weights are; $w_i = 0.1, i = 1,2, \dots ,10$.

3.2 Analysis Results and Findings

According to results, TOPSIS, MOORA and VIKOR methods give same region at the top of the ranking list. TR10 is the region which consists of Istanbul city, at the first order on the ranking listfor each of methodat the Table3. In this case, Istanbul is the best alternative for these methods. TRA1 is the region which consists of Erzurum, Erzincan, Bayburt cities, at the end of the ranking list for each of methodat the Table3. TR51 is the region which consists of Ankara city, at the top three on the ranking list with different ranking number according to methods. TR31 is the region which consists of Izmir city, at the top four on the ranking list with different ranking number according to methods. TRA2 is the region which consists of Agri, Kars, Igdir and Ardahan cities, at the last three on the ranking list with different ranking number according to methods at the Table3.TRB2 region which consists of Van, Mus, Bitlis and Hakkari cities, at the last three on the ranking list with different ranking number according to TOPSIS, MOORA-Ratio system and VIKOR methods but it is fifth order at the last on the list according to MOORA-Reference point approach.

Differences of the calculation algorithms of the methods can cause to varieties between the rankings of the methods. But there are no important differences between them. Correlations between results of the methods are given at the Table4.

4. Conclusion

In this study, we evaluate 26 NUTS Level 2 regions of the Turkey with TOPSIS, MOORA and VIKOR methods according to 10 foreign trade activity topics which are published by Turkish Statistical Instıtute. Thus our problem is a multi-criteria problem which consists of 26 alternatives and 10 criteria.

Results of the analysis are given at the Table3 and compared at the Figure1. Some ranking differences are seen according to methods. Calculation variations of methods may cause it. Correlation coefficients show us that differences are not significant.

In future studies, researchers can use different criteria for NUTS Level2 regions about foreign trade and they can make new assessment. If importance of criteria changes from criterion to criterion, researchers can use related weights. Researchers can use other multi-criteria decision making methods for evaluation of NUTS Level2 regions, so they can obtain new ranking lists.

References

Akyüz, G. A. (2012). BulanikVIKORYöntemiileTedarikçiSeçimi [Supplier selection by using Fuzzy VIKOR]. *Atatürk ÜniversitesiİktisadiveİdariBilimlerDergisi*, 26(1), 197-215.

Attri, R., & Grover, S. (July-Sept 2014). Decision making over the production system life cycle: MOORA method. *Int J Syst Assur Eng Manag*, 5(3), 320–328.

Ballı, S., & Korukoğlu, S. (2009). Operating System Selection Using Fuzzy Ahp And Topsis Methods. *Mathematical and Computational Applications*, 14 (2), 119-130.

Barros, C. P., & Wanke, P. (2015). An analysis of African airlines efficiency with two-stage TOPSIS and neural networks. *Journal of Air Transport Management, 44-45*, 90-102.

Brauers, W. K. M., & Zavadskas, E. K. (2006). The MOORA method and its application to privatization in a transition economy. *Control and Cybernetics, 35*(2), 445-469.

Brauers, W. K. M., Ginevičius, R., & Podvezko, V. (2010). Regional development in Lithuania considering multiple objectives by the MOORA method. *Technological and Economic Development of Economy, 16*(4), 613–640.

Brauers, W. K.M., Zavadskas, E. K., Peldschus, F., & Turskis, Z. (June 26-29, 2008). Multi-objective optimization of road design alternatives with an application of the MOORA method. *The 25-th International Symposium on Automation and Robotics in Construction ISARC* (pp. 541-548). Vilnius, Lithuania: Institute of Internet and Intelligent Technologies Vilnius Gediminas Technical University.

Brauers, W. K. M., Zavadskas, E. K., Turskis, Z., & Vilutienė, T. (2008). Multi-Objective Contractor's Ranking By Applying The MOORA Method. *Journal of Business Economics and Management, 9*(4), 245–255.

Büyüközkan, G., Arsenyan, J., & Ruan, D. (2012). Logistics tool selection with two-phase fuzzy multi criteria decision making: A case study for personal digital assistant selection. *Expert Systems with Applications*, 39(1), 142-153.

Celen, A. (2014). Comparative analysis of normalization procedures in TOPSIS method: with an application to Turkish deposit banking market. *Informatica*, 25(2), 185-208.

Chakraborty, S. (2011). Applications of the MOORA method for decision making in manufacturing environment. *Int J Adv Manuf Technol, 54*, 1155–1166.

Ding, L., & Zeng, Y. (2015). Evaluation of Chinese higher education by TOPSIS and IEW — The case of 68 universities belonging to the Ministry of Education in China.*China Economic Review,* 36, 341–358.

El-Santawy, M. F., & El-Dean, R. A. Z. (2012). On Using VIKOR for Ranking Personnel Problem. *Life Science Journal*, 9(4), 1534-1536.

Gadakh, V. S., Shinde, V. B., & Khemnar, N. S. (2013). Optimization of welding process parameters using MOORA method. *Int J Adv Manuf Technol,* 69, 2031–2039.

Görener, A., Dinçer, H., & Hacıoğlu, Ü. (2013). Application of Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) Method for Bank Branch Location Selection. *International Journal of Finance & Banking Studies, 2*(2), 41-52.

Hajihassani, V. (2015). Using VIKOR Method in the Performance Evaluation Cement Industry. *Cumhuriyet Science Journal*, 36(3), 420-429.

Hudec, O., Suhányi, L., & Urbancikova, N. (2014). Regional Decision-Making Criteria: Strategic Investment in the Central Europe. Theoretical and Empirical Researches in Urban Management, 9(2), 104-117.

Jahanshahloo, G. R., Lotfi, F. H., & Izadikhah, M. (2006). Extension of the TOPSIS method for decision-making problems with fuzzy data. *Applied Mathematics and Computation, 181*, 1544–1551.

Karaatlı, M., Ömürbek, N., & Köse, G. (2014). Analitik Hiyerarşi Süreci Temelli TOPSIS ve VIKOR Yöntemleri Ile Futbolcu Performanslarinin Değerlendirilmesi [Analyzing the Performances of Football Players Using Analytic Hierarchy Process based TOPSIS and VIKOR Methods]. *Dokuz Eylül Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 29(1), 25-61.

Kiszová, Z., & Nevima, J. (2012). Usage of analytic hierarchy process for evaluating of regional competitiveness in case of the Czech Republic. In Proceedings of the 30th international conference Mathematical methods in economics 2012, 402-407.

Kuo, M. S., & Liang, G. S. (2011). Combining VIKOR with GRA techniques to evaluate service quality of airports under fuzzy environment. *Expert Systems with Applications*, 38(3), 1304-1312.

Kuo, M. S., & Liang, G. S. (2012). A soft computing method of performance evaluation with MCDM based on interval-valued fuzzy numbers. *Applied Soft Computing*, 12(1), 476-485.

Kuzu, S. (2014). VIKOR. In B. Yıldırım & E. Önder (Eds.), *Çok Kriterli Karar Verme Yöntemleri [Multi Criteria Decision Making Methods]*. Bursa: Dora Yayıncılık.

Liu, H. C., Mao, L. X., Zhang, Z. Y., & Li, P. (2013). Induced aggregation operators in the VIKOR method and its application in material selection. *Applied Mathematical Modelling*, 37(9), 6325-6338.

Liu, H. C., Qin, J. T., Mao, L. X., & Zhang, Z. Y. (2015). Personnel Selection Using Interval 2-Tuple Linguistic VIKOR Method. *Human Factors and Ergonomics in Manufacturing & Service Industries*, 25(3), 370-384.

Lourenzutti, R., & Krohling, R. A. (2016). Ageneralized TOPSIS method for group decision making with heterogeneous information in a dynamic environment. *Information Sciences, 330*, 1-18.

Mohaghar, A., Fathi, M. R., Zarchi, M. K., & Omidian, A. (2012). A combined VIKOR–fuzzy AHP approach to marketing strategy selection. *Business Management and Strategy*, 3(1), 13-27.

Opricovic, S., 1998. Multicriteria Optimization of Civil Engineering Systems, *Faculty of Civil Engineering*, Belgrade, 2(1), 5-21.

Opricovic, S., & Tzeng, G. H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research*, 156(2), 445-455.

Önay, O., & Çetin, E. (2012). Turistik Yerlerin popülaritesinin belirlenmesi:Istanbul örneği [Determining The Popularity Of Tourist Destinations: Istanbul Case]. *İ.Ü. İşletme Fakültesi İşletme İktisadı Enstitüsü Yönetim Dergisi*, 23 (72), 90-109.

Özden, Ü. H. (2012). AB'ye Üye Ülkelerin Ve Türkiye'nin Ekonomik Performanslarına Göre VIKOR Yöntemi İle Sıralanması [The Eu Member Countries And Turkey's Economic Performances According To VIKOR Method Without Parts Return Without Repair], *İstanbul Ticaret Üniversitesi Sosyal Bilimler Dergisi*, 11(21), 455-468.

Paksoy, S. (2015). Ülke Göstergelerinin Vikor Yöntemi ile Değerlendirilmesi [Assessment of Country Indicators with VIKOR Method]. *The International Journal of Economic and Social Research*, 11(2), 153-170.

Ramesh, S., Viswanathan, R., & Ambika, S. (2016). Measurement and optimization of surface roughness and tool wear via grey relational analysis, TOPSIS and RSA techniques. *Measurement, 78*, 63–72.

Sanayei, A., Mousavi, S. F., & Yazdankhah, A. (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. *Expert Systems with Applications*, 37(1), 24–30.

Tayyar, N., & Arslan, A. G. P. (2013). Hazır Giyim Sektöründe En İyi Fason İşletme Seçimi İçin AHP ve VIKOR [Selection of the Best Sub-Contractor in Clothing Sector Using AHP and VIKOR Methods]. *Celal Bayar Üniversitesi Sosyal Bilimler Dergisi*, 11(1), 340-358.

TÜİK Data, online: http://tuikapp.tuik.gov.tr/Bolgesel/degiskenlerUzerindenSorgula.do# (28/04/2015).

Wanke, P., Azad, A. K., & Barros, C.P. (2016). Predicting efficiency in Malaysian Islamic banks:A two-stage TOPSIS and neural networks approach. *Research in International Business and Finance, 36*, 485–498.

Yıldırım B.F., &ÖnayO., (2013).BulutteknolojisifirmalarınınbulanıkAHP – MOORAyöntemikullanilaraksiralanması [Ranking Cloud Storage Technology Firms Using Fuzzy AHP – MOORAMethod].*İ.Ü. İşletmeFakültesiİşletmeİktisadıEnstitüsüYönetimDergisi*, 24 (75), 59-81.

Yıldız, A. (2014). BulanıkVIKORYönteminiKullanarakProjeSeçimSürecininİncelenmesi [Analysis of Project Selection Process Applying with Fuzzy VIKOR Method], *Anadolu University Journal of Social Sciences*, 14(1), 115-128.

Yildiz, A., &Deveci, M. (2013). BulanıkVIKORYöntemineDayalıPersonelSeçimSüreci [Based on Fuzzy VIKOR Approach to Personnel Selection Process]. *Ege Academic Review*, 13(4), 427-436.

Zhu, X., Wang, F., Wang, H., Liang,C., Tang, R., Sun, X., Li, J. (2014). TOPSIS method for quality credit evaluation: A case of air-conditioning market in China. *Journal of Computational Science*, 5, 99–105.

Table 1. List of the alternatives

Region code	Cities of the regions	Region Code	Cities of the regions
TRA1	Erzurum, Erzincan, Bayburt	TR41	Bursa, Eskisehir, Bilecik
TRA2	Agri, Kars, Igdir, Ardahan	TR42	Kocaeli, Sakarya, Duzce, Bolu, Yalova
TRB1	Malatya, Elazig, Bingol, Tunceli	TR51	Ankara
TRB2	Van, Mus, Bitlis, Hakkari	TR52	Konya, Karaman
TRC1	Gaziantep, Adiyaman, Kilis	TR61	Antalya, Isparta, Burdur
TRC2	Sanliurfa, Diyarbakir	TR62	Adana, Mersin
TRC3	Mardin, Batman, Sirnak, Siirt	TR63	Hatay, Kahramanmaras, Osmaniye
TR10	Istanbul	TR71	Kırıkkale, Aksaray, Nigde, Nevsehir, Kirsehir
TR21	Tekirdag, Edirne, Kirklareli	TR72	Kayseri, Sivas, Yozgat
TR22	Balikesir, Canakkale	TR81	Zonguldak, Karabuk, Bartin
TR31	Izmir	TR82	Kastamonu, Cankiri,Sinop
TR32	Aydin, Denizli, Mugla	TR83	Samsun, Tokat, Corum, Amasya
TR33	Manisa, Afyon, Kutahya, Usak	TR90	Trabzon, Ordu, Giresun, Rize, Artvin, Gumushane

Table 2: List of criteria

C1:	Export by economic activities (1000 USA Dollars): Total
C2:	Export and import per person (USA Dollars): Export per person
C3:	Import by economic activities (1000 USA Dollars): Total
C4:	Import by economic activities (1000 USA Dollars): Agriculture and forestry
C5:	Export and import per person (USA Dollars): Import per person
C6:	Export by economic activities (1000 USA Dollars): Agriculture and forestry
C7:	Export by economic activities (1000 USA Dollars): Mining and quarrying
C8:	Import by economic activities (1000 USA Dollars): Mining and quarrying
C9:	Export by economic activities (1000 USA Dollars): Manufacturing
C10:	Import by economic activities (1000 USA Dollars): Manufacturing

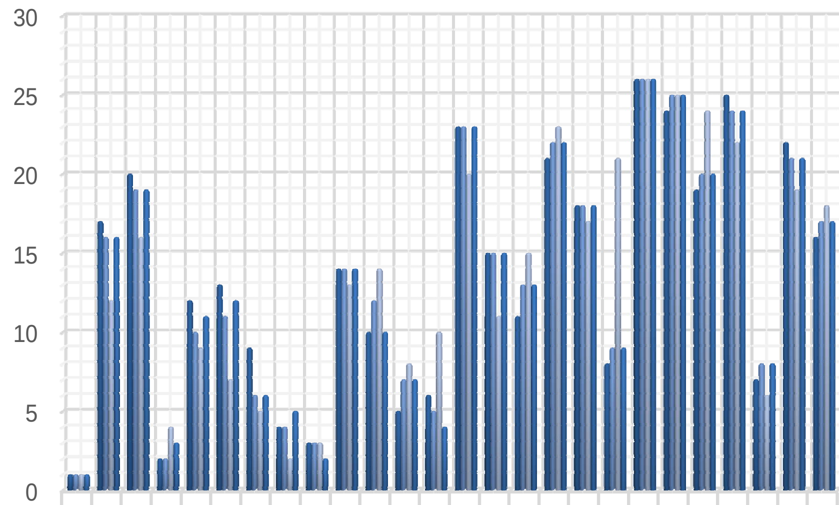
Table 3:Results and Findings

	TOPSIS				MOORA				VIKOR			
Region Code	S-	S*	C	Rank	The Ratio System	Rank	The Reference Point Approach	Rank	Si	Ri	Qi (q=0.50)	Rank
TR10	0.267	0.014	0.949	1	0.826	1	0.014257	1	0.028	0.028	0.000	1
TR21	0.013	0.262	0.047	17	0.030	16	0.098037	12	0.963	0.100	0.978	16
TR22	0.007	0.265	0.027	20	0.019	19	0.098426	16	0.976	0.100	0.985	19
TR31	0.068	0.229	0.229	2	0.171	2	0.092186	4	0.752	0.097	0.853	3
TR32	0.023	0.255	0.083	12	0.058	10	0.096939	9	0.921	0.100	0.957	11
TR33	0.020	0.256	0.074	13	0.053	11	0.096440	7	0.926	0.099	0.958	12
TR41	0.043	0.238	0.154	9	0.112	6	0.092668	5	0.857	0.097	0.908	6
TR42	0.055	0.234	0.189	4	0.129	4	0.090938	2	0.839	0.099	0.907	5
TR51	0.067	0.230	0.224	3	0.153	3	0.091436	3	0.804	0.093	0.848	2
TR52	0.015	0.260	0.053	14	0.035	14	0.098057	13	0.954	0.099	0.971	14
TR61	0.029	0.259	0.100	10	0.052	12	0.098279	14	0.916	0.099	0.953	10
TR62	0.058	0.247	0.189	5	0.110	7	0.096719	8	0.832	0.100	0.914	7
TR63	0.050	0.238	0.174	6	0.121	5	0.097207	10	0.835	0.098	0.904	4
TR71	0.004	0.267	0.015	23	0.010	23	0.098636	20	0.988	0.100	0.994	23
TR72	0.013	0.260	0.049	15	0.034	15	0.097582	11	0.956	0.100	0.977	15
TR81	0.028	0.256	0.099	11	0.048	13	0.098311	15	0.944	0.100	0.971	13
TR82	0.007	0.267	0.024	21	0.012	22	0.098765	23	0.984	0.100	0.992	22
TR83	0.010	0.263	0.037	18	0.023	18	0.098622	17	0.971	0.100	0.984	18
TR90	0.048	0.257	0.158	8	0.076	9	0.098715	21	0.871	0.100	0.934	9
TRA1	0.000	0.270	0.001	26	0.002	26	0.098787	26	1.000	0.100	1.000	26
TRA2	0.002	0.269	0.007	24	0.005	25	0.098774	25	0.995	0.100	0.998	25
TRB1	0.009	0.266	0.033	19	0.018	20	0.098771	24	0.976	0.100	0.988	20
TRB2	0.002	0.269	0.007	25	0.005	24	0.098765	22	0.995	0.100	0.998	24
TRC1	0.046	0.241	0.159	7	0.106	8	0.095231	6	0.863	0.100	0.928	8
TRC2	0.006	0.266	0.022	22	0.013	21	0.098636	19	0.984	0.100	0.992	21
TRC3	0.013	0.263	0.048	16	0.027	17	0.098626	18	0.963	0.100	0.981	17

Table 4: Correlation coefficients of rankings according to methods

	TOPSIS	The Ratio System	The Reference Point Approach	VIKOR
TOPSIS	1			
The Ratio System	0.986	1		
The Reference Point Approach	0.858	0.902	1	
VIKOR	0.988	0.997	0.889	1

Figure 1: Comparison of rankings



	TR10	TR21	TR22	TR31	TR32	TR33	TR41	TR42	TR51	TR52	TR61	TR62	TR63	TR71	TR72	TR81	TR82	TR83	TR90	TRA1	TRA2	TRB1	TRB2	TRC1	TRC2	TRC3
TOPSIS	1	17	20	2	12	13	9	4	3	14	10	5	6	23	15	11	21	18	8	26	24	19	25	7	22	16
The Ratio System	1	16	19	2	10	11	6	4	3	14	12	7	5	23	15	13	22	18	9	26	25	20	24	8	21	17
The Reference Point Approach	1	12	16	4	9	7	5	2	3	13	14	8	10	20	11	15	23	17	21	26	25	24	22	6	19	18
VIKOR	1	16	19	3	11	12	6	5	2	14	10	7	4	23	15	13	22	18	9	26	25	20	24	8	21	17