Business School ranking with grey relational analysis: the case of Turkey

Ilker Murat Ar
Business Administration, Karadeniz Technical University, Trabzon, Turkey
Coşkun Hamzaçebi
Industrial Engineering, Karadeniz Technical University, Trabzon, Turkey, and
Birdogan Baki
Business Administration, Karadeniz Technical University, Trabzon, Turkey

Abstract

Purpose – The purpose of this paper is to explore the teaching performance of Turkish Business Schools (BSs). It also aims to determine the degree of importance of factors affecting the teaching performance of Turkish BSs. The final objective is to test the functionality and applicability of the model.

Design/methodology/approach – This study presents a ranking approach based on grey relational analysis (GRA). While evaluating the BSs, data were collected for 19 Turkish BSs in terms of five main criteria such as OSS score; Number of faculty members; Number of students per faculty member; the mean of KPSS score; and the standard deviation of KPSS score. In the analysis, three weighted methods were integrated into the GRA in order to weight the criteria.

Findings – According to this result, the main factor influencing the teaching performance of Turkish BSs is the OSS score. This study can also confirm that the results obtained from the ranking orders using the proposed methods are reliable and these results can help decision makers to identify the best alternative.

Research limitations/implications – In order to provide benchmarking data more effectively, in future, it would be helpful to collect data from both foundation and state universities with a research focus. Moreover, as an interesting suggestion for future research, fuzzy environment may be further integrated into the framework of GRA.

Originality/value – In contrast to prior research, this study makes comparisons based on the scores of national exams instead of different bibliometric indicators. Furthermore, there are no studies which have used GRA and these weighted methods as combined in education sector.

Keywords Grey systems, Business schools, Teaching, Turkey, Ranking, Teaching performance, Grey relational analysis, Sensitivity analysis

Paper type Research paper

1. Introduction

Higher education plays an important role in the education system. Universities, the institutions of the higher education system, are one of the most important sources of scientific and technological innovation because of scientific and technological resources. Moreover, they have an active force in the national economy and have been playing a strategic role in economic development (Yong *et al.*, 2009). Business Schools (BSs) are also important factors in this role of universities. Furthermore, the ongoing development in the business spheres and the increased competition among firms in a globalized world has

Grey Systems: Theory and Application
Vol. 3 No. 1, 2013
pp. 76-94

2043-9377
DOI 10.1108/20439371311293714

brought about a substantial demand for high quality managerial skills. This transformation has helped BSs to become important players in the education sector (Besancenot *et al.*, 2009). So, over the past decades, BSs have been among the fastest-growing segments in higher education. They have also attracted widespread debate about their value and role in society and business spheres (Antunes and Thomas, 2007).

Over the past several years, there has been a tremendous increase in the number of applicants to BSs and hence adequately measuring the performance of these BSs is an important issue (Paliwal and Kumar, 2009). If an institution expects to improve and achieve its goals, performance must be measured and evaluated (Kalaycı, 2009). Since higher education institutions, especially BSs find themselves in an environment of increased accountability for the quality of teaching and learning they provide students, an important question facing educators is how to fairly and accurately measure effective teaching (Calderon and Green, 1997). Since the quality of the next generation of business leaders will be determined by the ways in which BSs respond to changes in the environment of higher education, BSs will need to be more innovative and more efficient than ever before (Acito *et al.*, 2008). In this point, the ranking of universities are important for university administrators because it serves as a guide to the institution's strategic planning. Therefore, increasingly, institutions of higher education are required to evaluate student progress and program effectiveness through implementation of performance assessment practices (Cummings *et al.*, 2008). One of the ways of evaluating quality in higher education is the ranking of higher education institutions.

Rankings demonstrate the position or rather the significance of a scholar, university, or country relative to others (Frey and Rost, 2010). The ranking of academic departments can yield considerable policy benefits beyond the simple game of an order (Drew and Karpf, 1981). Kalanova (2008) stated that the overall assessment of the higher education institutions allow us to conclude that ranking is a strong contributor to the quality assurance of higher education. Industry monitors, rankings and league tables have mushroomed in the education sector across a variety of locations in the past 20 years (Free *et al.*, 2009). The aims of these rankings are as follows:

(1) to assist decision making for students who will take the university exam in future, government workers, funding organizations, employers and international organizations;

(2) to promote competition between higher education institutions; and

(3) to stimulate the creation and development of quality assurance within higher education institutions (Kalanova, 2008).

Widely publicized rankings of BSs are now being viewed with much foreseeing by many BS administrators. Such rankings are believed to affect subsequent recruitment of high quality students, perceptions of employers and placement of graduates. It is often reported that students use rankings as input into their choices of BSs (Siemens *et al.*, 2005). Rankings also can be used resource allocation and personnel decisions for administrators and political regulatory (Chan *et al.*, 2005). Moreover, BS rankings are also important for employers used them for employment decisions and students for enrollment decisions (Chan *et al.*, 2006). Ho *et al.* (2006) pointed out that four major higher education decision problems are resource allocation, performance measurement, budgeting and scheduling.

When the related literature was examined, it can be seen that studies about performance evaluation or rankings of BSs concentrated on two main areas. One of them is MBA graduate programs. Studies conducted by Kedia and Harveston (1998), Acito *et al.* (2008), Free *et al.* (2009) and Köksalan *et al.* (2010) can be samples for this research area. Other studies focus on academic or scientific performance of undergraduate programs. Studies of Ho (1998), Lackritz (2004), Siemens *et al.* (2005), Shin (2009) and Mamiseishvili and Rosser (2010) can be evaluated in this research area. However, evaluation of teaching has received less emphasis in the literature than the evaluation of research, partly because of a misplaced emphasis in academic life, where research is valued more than teaching and partly because of the difficulty in assessing teaching performance (Drew and Karpf, 1981). This study also contributes in various ways to the literature. First, in line with previous research, this study displays the ranking of the BSs. Second, in contrast to prior research, it compares based on the scores of national exams instead of different bibliometric indicators. The most important activity of faculties are teaching and research. In contrast to many papers on rankings which consider research or scientific performance of academicians, only teaching performances of BSs were compared in the scope of this study. Furthermore, national exam scores of students can be used as an indicator of teaching performance although the most common method to measure the teaching performance is through student evaluations of teachers (Gramlich and Greenlee, 1993).

There are several factors that influence the efficiency of a potential teaching performance. But there is no clear methodology for assigning this priority weight for the factors. Therefore, expert opinion is indeed required to estimate these factors weight values (Mazumdar *et al.*, 2010). Consequently, determining the teaching performance can be evaluated a multiple criteria decision making (MCDM) problem which involves evaluation of different alternatives based on multiple conflicting criteria. So, different MCDM methods can be useful for solving to this problem. Although there are many studies on educational evaluation conducted by Shaw and Gaynor (1982), Meyer and Hofmeyr (1995), Tang *et al.* (2004), Badri and Abdulla (2004), Chen and Tzeng (2009), Datta *et al.* (2009), Mazumdar *et al.* (2010) and Wu *et al.* (2011), the number of study measured teaching performance by using MCDM techniques is too few.

In the present paper, a methodology named grey relational analysis (GRA) characterized as a MCDM technique has been proposed in order to rank the BSs. Recently, there has been a trend of applying grey system theory in the field of education; a great deal of researches in exploring educational phenomena have been conducted based on grey system theory and the mathematical results are significant as compared to conventional methods of dealing with data analysis (Mu-Shang, 2007). The GRA approach differs from the other decision models such as ELECTRE, TOPSIS, SIR and PROMETHEE on the building of the complete preorders which is based on the relation index (grey relational grade (GRG)) linking an option to all others (Chan, 2008). Furthermore, these outranking methods are originally used to reflect the true differences among the alternatives but the setting of thresholds are sometimes subjective in nature when there is a lack of statistical data to support the setting of those values (Chan, 2008).

There are too few studies using GRA in the education area. For example, Xiangpei and Naiming (2009) evaluated the doctoral theses of 15 universities to assess the quality of postgraduate education and Rong and Gang (2009) set up a new model for teaching teachers' competence evaluation based on GRA. However, various methods such as data envelopment analysis (Kirjavainen and Loikkanen, 1998; Sarrico *et al.*, 1997; Sarrico and Dyson, 2000; Abbott and Doucouliagos, 2003; Johnes, 2006; Ruggiero, 2006; Essid *et al.*, 2010), regression analysis (Conboy *et al.*, 1995; Johnes, 1996; Cohn *et al.*, 2004; Chan *et al.*, 2006; Hartog *et al.*, 2010), correlation analysis (Calderon and Green, 1997), principal component analysis (Webster, 2001) and neural network (Paliwal and Kumar, 2009) were used to rank the educational departments by determining the teaching or academic performance. In conclusion, although various quantitative techniques have already been used to rank the educational departments, this study first attempts the application of GRA to rank the Turkish BSs.

This study addresses three objectives. Its first and main aim is to explore the teaching performance of Turkish BSs. Its second objective is to determine the degree of importance of factors affecting the teaching performance of Turkish BSs. The final objective is to test the functionality and applicability of the model by answering the question of whether results obtained from research model can reflect reality.

The sections of this paper, in the order in which they will be presented, are as follows: the next section describes the methodology; Section 3 presents the data and criteria; the penultimate section represents the results of the analytic hierarchy process (AHP) and GRA and the final section discusses the findings and draws a number of conclusions from the research.

2. Methods

In general, statistical analysis is a method to test data evaluation. The statistical methods can determine the various effects and relationships of teaching performance, but it may not be used under a lack of enough information and uncertain conditions. On the other hand, grey system theory provides an effective research method when the problem under research has lack of enough information or complexity. Due to the complexity of determining the performance of an educational institution and including uncertain condition, GRA is an application of grey system was preferred in this study.

In this study, GRA, which is basically a MCDM technique, was used. In addition, three different methods were used for determining criteria weights in GRA process. They are equal weights for every criterion, determining the weights by AHP and determining the weights by importance order. Thus, two of the MCDM techniques which used in this study – GRA and AHP – are described in this section.

Using the combined AHP and GRA technique gives better results than other techniques. This situation can be seen in many studies (Bing *et al.*, 2007; Hong-yi *et al.*, 2010; Li and Yan, 2011; Sundeep *et al.*, 2011; Hamzaçebi and Pekkaya, 2011; Peng, 2012). However, even though GRA was used in order to ranking and AHP was used to weighting by many researchers, there are no studies which used these techniques combined in the education sector.

2.1 Grey relational analysis

Grey system theory was developed by Deng in 1982 (Deng, 1989). It is concerned with solving problems which involves uncertainty or systems with incomplete information (Wang and Tong, 2003). It can be applied to solve several different problems including grey generating, GRA, grey forecasting and grey decision making. This study uses GRA that is the most important part of grey system theory. GRA is an evaluation method for analyzing the relation levels among dispersed series in the grey system (Lin *et al.*, 2011). There are two main reasons for using GRA in this study:

(1) GRA needs only a small amount of data and it is no need for typical data distribution (e.g. standard normal distribution). The sample size of this study is only 19 and it investigates only partially the Turkish BSs and does not consider population.

(2) GRA has rarely been used in the education researches although it has advanced in many research areas.

GRA is suitable for solving problems with complicated interrelationships between multiple factors and variables (Athawale and Chakraborty, 2011). It analyzes the degree of similarity between the reference series and other series. The feature of this approach is that both qualitative and quantitative relationships can be identified among complex factors (Kuo and Liang, 2011). It has been successfully applied in many fields such as management, economy and engineering (Chen and Ou, 2009).

As with much of the MCDM techniques, GRA is also sensitive to the weights of the criteria. The GRA methodology applied in this study is adapted from Hamzaçebi and Pekkaya (2011). Also, it can be seen in Appendix 1.

2.2 Analytic hierarchy process

Integrating the decision makers' opinion is a common method in the multi-attribute decision making. The weights play an important role because of the relative importance of the criteria and the decision preference of the decision makers. Hence, based on the integrating model of the decision makers' opinion, the calculation method of the weights which has subjective and objective information is a significant task (Youliang *et al.*, 2009). Therefore, the most important thing in ranking of the alternatives is to determine the weights of the criteria.

There are many weight calculation procedures, but the AHP has many advantages such that AHP is based on pair-wise comparison and it calculates the inconsistency index, which is the ratio of the decision-maker's inconsistency (Önüt and Soner, 2008). The importance of AHP and its usefulness in decision making also in weighting are best illustrated in a lot of studies (Saaty, 1994). Moreover, AHP calculations are not complex and if the judgments made about the relative importance of the attributes have been made coherently, then, AHP calculations lead to the logical consequence of those judgments (Tavana and Hatami-Marbini, 2011).

AHP has been taken into consideration for various MCDM problems since it was introduced by Saaty (1980). AHP is based on the pair-wise comparisons. The aim of this study is not to give details of AHP; detailed information about AHP and its various applications can be found in many studies (Saaty, 1994; Vaidya and Kumar, 2006). A short explanation was given to make the study meaningful. Saaty (2008) describes the method in four steps. They can be seen in Appendix 2.

3. Data

The socio-economic factors affected the process of the development of the universities in Turkey and new universities have been founded in different times. Therefore, the cycle of higher education in Turkey can be divided into five stages. In the first stage (between 1923 and 1950), there were only three universities and two of them included BS. In the second stage (between 1950 and 1980), the number of universities increased to 19.

In the third stage (between 1980 and 1990), ten new state universities were established and their numbers reached 29. Dramatic changes occurred during the fourth stage (between 1990 and 2000). The date of 1992 in this stage is very important for Turkish higher education. In total, 22 new state universities were established in 1992. In the fifth stage (2000 to the present), 15 new state universities have been established. All of these new universities were established in 2006. Furthermore, foundation universities have also been established in this stage. Finally, there are 103 state and 65 foundation universities in Turkey by June 2012. These universities were coordinated by The Council of Higher Education, labeled as YOK in Turkish, it is a leading management institution in higher education system in Turkey. It was established in 1981. It is a fully autonomous supreme corporate state body responsible for the planning, coordination, governance and supervision of higher education (www.yok.gov.tr/en/content/view/343/219/ (accessed June 6, 2011)).

Although there are a lot of Turkish universities, universities established in 1992 were considered as the sample of the study. The year 1992 is an important headstone for Turkish higher education system because 22 new state universities were established in this date. However, three of them were not included to the analysis. One, Galatasaray, have also performed as a foundation university before the 1992 and others, Izmir Institute of Technology and Gebze Institute of Technology, have not BS. Therefore, BSs of 19 state universities constituted in 1992 are sample of this study. They can be shown in first column in Appendix 3.

While these 19 BSs of universities were used for evaluation of teaching performance, a panel of expert academicians was established to identify the main criteria affect teaching performance of BSs. In conclusion, OSS score (OSSS), number of faculty member (NFM), number of students per faculty member (NSPFM), the mean of KPSS score (MKPSSS) and the standard deviation of KPSS score (SDKPSSS) were determined as teaching performance criteria. Details for these criteria were displayed in below.

OSSS. Student selection examination (OSS) is a national exam conducted by student selection and placement center (OSYM). Students who complete high school must take the exam in order to continue to the university. It consists of tests to measure mainly candidates' qualitative and quantitative reasoning abilities. These tests are basically composed of items which require academic knowledge of the high school curricula (OSYM, 2006). This exam ranks the students according to their score.

YOK publishes annual reports on the results of OSS. OSSSs take place for each university department, also BS, as lowest and highest in these reports. OSSSs of 19 Turkish BSs used in this study were also obtained from YOK report for 2005. Lowest test scores of enrolled students were taken into account instead of highest.

NFM. While a majority of faculty members indicates the specialize in different areas of BS, a minority of faculty member brings to many problems such as less specialization and teaching more course per faculty member. Furthermore, teacher competence refers to the professional knowledge and values in profession which individual teacher possesses is relevant to the successful teaching (Olson and Wyett, 2000 cited by Rong and Gang, 2009). So, NFM was used in this study as a factor affecting teaching performance.

NFM was obtained from legal BS web site. It was compiled for professor, associate professor and assistant.

Professor and the number of total faculty members employed on a full-time tenured basis during the four academic years (between 2005 and 2009) were considered when calculating the NFM. Students entering the BSs in 2005 have taken courses from these faculty members for four-year period.

NSPFM. It is expected that teaching performance increases if NSPFM decreases. Thus, NSPFM is an important factor for teaching performance. So, NSPFM was also used in addition to NFM.

It was calculated by dividing to NFM to number of students. Number of students was obtained from OSYM annual report for the results of 2005 OSS.

MKPSSS and SDKPSSS. KPSS is a national exam conducted by OSYM. Students who complete BS have to take the exam in order to be employed in any public institution. In this exam, some questions regarding the lessons learned at the university are asked to students. KPSS is an only exam measuring the success of the BS students.

It has been taken KPSS exam in 2009 and 2010 because the results of the KPSS for 2011 have not been presented. Since university education takes four years in Turkey, students entering the university in 2005 have graduated in 2009. Therefore, it has gone to four years back from declared the results of KPSS and the year 2005 OSSS were taken into consideration. KPSS scores were obtained from YOK annual report for 2009 and 2010. They were gathered as MKPSSS and SDKPSSS separately.

Data were collected from two-month period by researchers in terms of the criteria for 19 BSs. The year and the source of the obtained data for each criterion were introduced in Table I. However, research data set was formed based on these criteria for 19 BSs can be shown in Appendix 3.

4. Results

Implementation process of this research can be seen in Figure 1. According to it, there are two basic processes such as determining the weights an implementation of GRA. They were explained in below particularly.

Table I. The year and the source of the obtained data for each criterion

Criteria	Year	Source
OSSS	2005	YOK Report
NFM[a]	Between 2005 and 2009	The legal web site of BSs
NSPFM[b]	2005	OSYM Report
MKPSSS	2009 and 2010	YOK Report
SDKPSSS	2009 and 2010	YOK report

Notes: [a]The number of professor, associate professor and assistant professor employed on a full-time tenured; [b]NFM/number of students

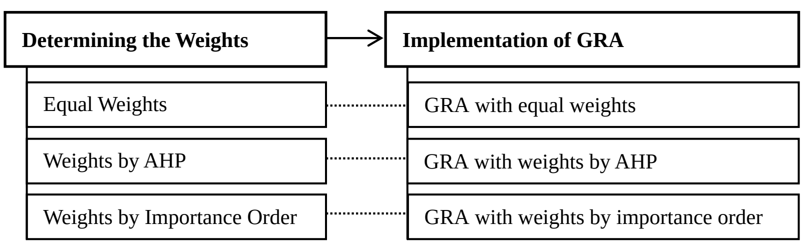

Figure 1. Implementation process

4.1 Determining the weights

In this study, three weighted methods, equal weights, weights by AHP and weights by importance order, were integrated into the GRA in order to weight the criteria. In this way, it is purpose that ranking can be made more realistic.

Equal weights. The approach of equal weights for every criterion is used in cases where decision-makers have no information about criteria weights or all criteria have equal importance. So, it is given equal weight to each criterion and the ranking is made according to it. Thus, it is considered the weight of 0.20 for each criterion as a result of the process of one divided to five as the number of the criteria. This criteria weight is used in the GRA.

Weights by AHP. In order to determine the weights of the criteria with AHP, first, the comparison matrix of the criteria should be created. This comparison matrix obtained by opinion of educational academicians can be shown in Table II.

In order to check the consistency of comparison matrix, consistency index (CI) and consistency ratio (CR) are calculated 0.02 and 0.05, respectively. The fact that CR is less than 0.10 indicates that the pair-wise comparison is acceptable and the weight priority vector obtained from this comparison is employable. Scores in the obtained weight priority vector are 0.53 for OSSS, 0.06 for both of NFM and NSPFM, 0.25 for MKPSSS and 0.10 for SDKPSSS. These weights of the criteria are used in the GRA.

Weights by importance order. In this approach, criteria are arranged by decision-makers towards the most important from the least. Equal importance is given in the criteria if they have equally important. It is discussed with educational researchers in order to determine the importance orders. According to their comments, importance orders were as follows: 1 is for OSSS, 2 is for MKPSSS, 3 is for SDKPSSS and 4 is for both of NFM and NSPFM. Based on these importance orders, weights of criteria were obtained using the formulation was given in equation (1). In this formula, w_j shows the weight of jth criterion and r_j indicates the importance order of the jth criterion. These weights of the criteria are used in the GRA. In conclusion, criteria and their weight set used in the process of GRA can be shown in Table III:

	OSS	NFM	NSPFM	MKPSSS	SDKPSSS
OSSS	1.00	7.00	7.00	3.00	5.00
NFM	0.14	1.00	1.00	0.20	0.50
NSPFM	0.14	1.00	1.00	0.20	0.50
MKPSSS	0.33	2.00	2.00	1.00	3.00
SDKPSSS	0.20	2.00	2.00	0.33	1.00

Table II.
Comparison matrix

Criteria	Equal weight	Weight set AHP	Importance order
OSSS	0.20	0.53	0.43
NFM	0.20	0.06	0.11
NSPFM	0.20	0.06	0.11
MKPSSS	0.20	0.25	0.21
SDKPSSS	0.20	0.10	0.14

Table III.
Criteria and weight set

$$w_j = \frac{1/r_j}{\sum_{j=1}^{n} 1/r_j} \quad (1)$$

4.2 Implementation of GRA

In order to rank the BSs with GRA, reference series were determined first. Suitability of the reference set to either situation of higher is better, lower is better and nominal is better was taken into consideration in determining the reference series. According to it, among which OSSS, NSPFM and SDKPSSS are the lower the better, whereas NFM and MKPSSS are the higher the better. Then, the data were normalized based on these situations. Second, the distances of alternatives to reference series were calculated before the grey relational coefficients were computed using the obtained distance values. Finally, it was achieved the GRG by multiplying the coefficients with the weights obtained from mentioned above methods. GRG is the influence degree of a compared series on the reference series that can be represented by the relative distance (Chen and Ou, 2009). They were obtained at the end of GRA process and can be shown in Table IV. Moreover, rankings of the universities determined according to their GRGs can be seen in the same table.

4.3 Sensitivity analysis

Another important issue in GRA is also sensitivity analysis. This paper is concerned with the sensitivity analysis based on GRGs. The effect of changing in distinguishing coefficient on ranking for each of the years 2009 and 2010 were analyzed by sensitivity. Further, sensitivity analysis was performed for the results of AHP. According to it,

	2009						2010					
	Equal weight		AHP		Importance order		Equal weight		AHP		Importance order	
Universities	GRG	R	GRG	R	GRG	R	GRG	R	GRG	R	GRG	R
1. Abant İzzet Baysal	0.535	17	0.518	17	0.524	16	0.554	16	0.535	15	0.541	15
2. Adnan Menderes	0.640	7	0.607	11	0.689	9	0.701	2	0.668	4	*0.679*	*1*
3. Afyon Kocatepe	0.703	3	0.629	7	0.657	7	*0.739*	*1*	0.640	7	0.676	2
4. Balıkesir	0.451	19	0.432	19	0.441	19	0.482	18	0.455	19	0.467	19
5. Celal Bayar	0.649	5	0.577	14	0.594	13	0.685	4	0.622	9	0.632	9
6. Çanakkale Onsekiz Mart	*0.744*	*1*	0.619	9	0.663	4	0.651	5	0.552	13	0.587	13
7. Dumlupınar	0.610	11	0.609	10	0.612	11	0.606	10	0.600	11	0.605	11
8. Gaziosmanpaşa	0.545	15	0.723	2	0.661	5	0.559	15	0.682	2	0.648	7
9. Harran	0.736	2	0.698	3	*0.706*	*1*	0.698	3	0.20	10	0.651	5
10. Kafkas	0.538	16	*0.728*	*1*	0.671	2	0.520	17	*0.711*	*1*	0.655	4
11. K.Sütçü İmam	0.553	13	0.668	5	0.633	8	0.593	11	0.680	3	0.658	3
12. Kırıkkale	0.546	14	0.487	18	0.510	17	0.568	14	0.500	17	0.526	16
13. Mersin	0.647	6	0.560	15	0.578	15	0.589	12	0.463	18	0.505	17
14. Muğla	0.477	18	0.524	16	0.506	18	0.471	19	0.509	16	0.496	18
15. Mustafa Kemal	0.584	12	0.625	8	0.612	10	0.615	9	0.626	8	0.627	10
16. Niğde	0.675	4	0.657	6	0.667	3	0.650	6	0.646	6	0.650	6
17. Pamukkale	0.629	8	0.579	13	0.592	14	0.620	8	0.549	14	0.574	14
18. Süleyman Demirel	0.615	9	0.585	12	0.595	12	0.620	7	0.572	12	0.592	12
19. Zonguldak Karaelmas	0.610	10	0.674	4	0.660	6	0.573	13	0.666	5	0.638	8

Note: Grey relational grade – GRG and rank – R

Table IV.
Results

this research analyzes the impact on the results of GRA when the distinguishing coefficient set at 0.1, 0.3, 0.5, 0.7 and 0.9, respectively.

The results of the sensitivity analysis are shown in Figures 2 and 3. According to it, in 2009, for all tested distinguishing coefficients, Kafkas (10), Gaziosmanpaşa (8) and Harran (9) are ranked 1, 2 and 3, respectively. However, Kafkas (10), Gaziosmanpaşa (8) and K.Sütçü İmam (11) are in first three ranks for all coefficients in 2010. These findings demonstrate that the impact of the distinguishing coefficient on the result of GRA is very small. Moreover, they indicate that weights by AHP are meaningful.

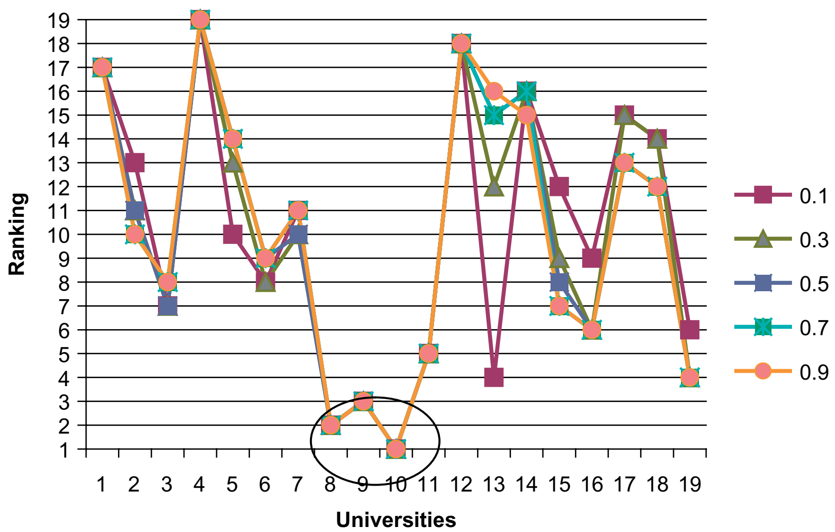

Figure 2.
The results of the sensitivity analysis (2009)

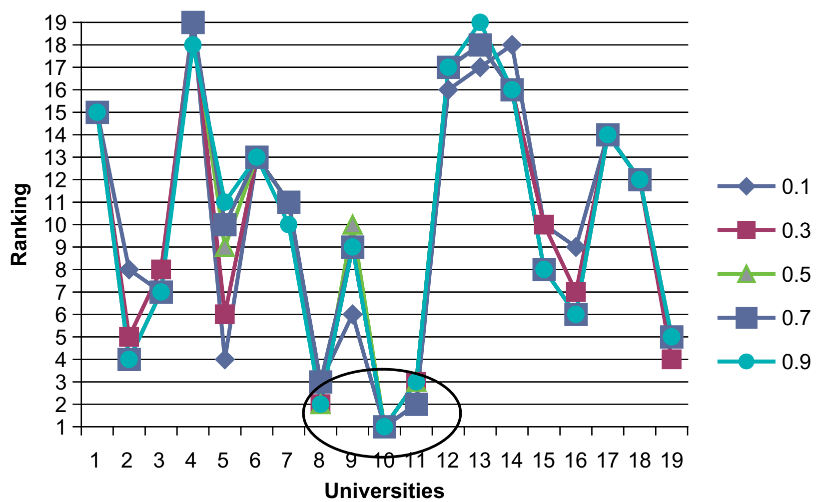

Figure 3.
The results of the sensitivity analysis (2010)

5. Discussion

When Table IV is examined, it can be shown that the results of the year 2009 show that Çanakkale Onsekiz Mart is in the first rank according to equal weights. Furthermore, Kafkas is in the first rank according to AHP while Harran is in the first rank according to importance order. The results of the year 2010 indicate that Afyon Kocatepe is in the first rank in terms of equal weight. Kafkas is in the first rank in terms of AHP and Adnan Menderes is in the first rank in terms of importance order. These results meet the first aim of this study which is to explore the ranking of Turkish BSs in terms of their teaching performance.

In order to answer the question of whether results obtained from research model are reflected in reality, actual ranking was calculated and then it was compared with GRA ranking. Actual rank was determined for each BS based on OSSS and MKPSSS. It means that the teaching performance of a university is high if the university had lower ranking in OSSS and achieves better ranking in MKPSSS. First, BSs were ranked according to OSSS and MKPSSS. After, differences between the two rankings were calculated. Finally, a new ranking was made based on these differences in actual rank.

Correlation analysis summarizes the strength of the relationship between two variables and was used in order to determine the relationship between actual ranking and GRA ranking. Several different correlation coefficients can be calculated, but the two most commonly used are Pearson's correlation and Spearman's rank correlation. Since Spearman's rank correlation requires data that are at least ordinal and it has no such assumption as normal distribution, it is used in this study. The Spearman's correlation coefficient takes a value between -1 and $+1$. It shows a difference between actual and GRA ranking.

We used the Spearman coefficient calculated between ranking obtained from each weighting method (equal weight, AHP and importance order) and actual ranks for 2009 and 2010 separately. The actual rankings, in the first column of the ranking results of the year 2009 and 2010 and the Spearman correlation coefficients, in the last row, can be seen in Table V.

In the results of 2009, the coefficient for the AHP ($r = 0.725$) and importance order ($r = 0.618$) were statistically significant at 0.05 while the coefficient for equal weight ($r = 0.088$) was not statistically significant. In the results of 2010, the coefficient for the AHP ($r = 0.626$) and importance order ($r = 0.579$) were statistically significant while the coefficient for equal weight ($r = 0.289$) was not statistically significant. Thus, we have proven true our prediction since the positive correlation between actual ranking and GRA ranking for the weights by AHP and importance order. Statistically significant positive correlation exists for two years and is likely to be present at a similarity between actual and GRA results. Thus, this study can confirm that the results obtained from the ranking orders using the proposed methods are reliable and these results can help decision-makers to identify the best alternative.

The results of the Spearman correlation analysis also show that the results of the GRA ranking obtained from weights by AHP have the highest correlation with actual rankings in both the year 2009 and 2010. According to this result, the main influencing factor in the teaching performance of Turkish BSs is OSSS which has the highest weight (53 per cent) in AHP. Other relational factors are the MKPSSS (25 per cent), the SDKPSSS (10 per cent), the NFM (6 per cent) and the NSPFM (6 per cent), respectively. There are similar weights in importance order whose ranking results also show

Universities	2009 Actual	2009 Equal weight	2009 AHP	2009 Importance order	2010 Actual	2010 Equal weight	2010 AHP	2010 Importance order
1. Abant İzzet Baysal	17	17	17	16	8	16	15	15
2. Adnan Menderes	4	7	11	9	1	2	4	1
3. Afyon Kocatepe	15	3	7	7	14	1	7	2
4. Balıkesir	19	19	19	19	19	18	19	19
5. Celal Bayar	14	5	14	13	8	4	9	9
6. Çanakkale Onsekiz Mart	15	1	9	4	17	5	13	13
7. Dumlupınar	8	11	10	11	8	10	11	11
8. Gaziosmanpaşa	1	15	2	5	6	15	2	7
9. Harran	2	2	3	1	5	3	10	5
10. Kafkas	4	16	1	2	12	17	1	4
11. K.Sütçü İmam	4	13	5	8	6	11	3	3
12. Kırıkkale	18	14	18	17	18	14	17	16
13. Mersin	12	6	15	15	14	12	18	17
14. Muğla	13	18	16	18	12	19	16	18
15. Mustafa Kemal	2	12	8	10	2	9	8	10
16. Niğde	4	4	6	3	3	6	6	6
17. Pamukkale	8	8	13	14	8	8	14	14
18. Süleyman Demirel	8	9	12	12	14	7	12	12
19. Zonguldak Karaelmas	11	10	4	6	3	13	5	8
Spearman correlation coefficient		0.088**	*0.725* *	0.618*		0.289**	*0.626* *	0.579*

Notes: Significant at: *5 per cent level; non-significant at: **5 per cent level

Table V. Rankings and Spearman correlation coefficients

significant correlation with actual rankings. These findings support the results of Webster (2001) who revealed that the most significant ranking criterion for US national universities is the average SAT scores of enrolled students.

The weights are usually used to scale the relative importance of the criteria. The rationality of weights affects the order validity of decision making directly. So, the calculation model and algorithm of weights play an important role in the system analysis and assessment (Youliang *et al.*, 2009). The results of this study confirm that the determination of the criteria weight is an important and also pivotal issue for the GRA application process. The fact that there is no correlation between GRA rankings obtained from equal weight and actual rankings confirm this assumption. The experimental results of the study conducted by Hsu and Huang (2007) also advocated that the weighted GRA performs better precision then the non-weighted GRA. To sum up, the weighted GRA can improve the accuracy of prediction. Furthermore, sensitivity analysis indicated that weights by AHP are meaningful.

6. Conclusion

Since educational evaluation is a kind of value judgment for educational activities based on related educational information, evaluation results can be used by educational authorities in making a new policy (Xiangpei and Naiming, 2009). Furthermore, determining the teaching performance is increasingly complex in the modern higher education system, because various characteristics that cannot be measured directly must be improved in the contemporary higher education system. This study presents a ranking approach based on GRA to evaluate the teaching performance of Turkish BSs. For this purpose many weighting methods and GRA were combined to rank the Turkish universities, which utilize AHP, equal weights and importance order, to acquire criteria weights and GRA to obtain the final ranking order of universities. In doing so, a number of observations and conclusions can be made:

- The significance correlation coefficients for two weighting methods indicate that the proposed method is rational and has high applicability. Thus, it is concluded that GRA is an effective tool to rank the Turkish BSs.
- Based on the findings of this research, GRA ranking obtained by AHP has the highest correlation with actual ranking. Therefore, weight set of AHP can be taken into account in ordering the factors affecting teaching performance of Turkish BSs. It is crucial for academics and educators to explore the effect level of the factors. In this case, the most important factor is OSSS. According to it, the teaching performance of the BSs is closely related to their students' performance prior to register at a university. Other relational factors are the MKPSSS, the SDKPSSS, the NFM and the NSPFM, respectively.

This study indicates that administrators of BSs could give more emphasis to enhancing the teaching performance of their school. In this context, the following recommendations to school administrators can be discussed:

- Strengths of the schools in terms of academic staff, social facilities and research infrastructure should be introduced to high school students to attract higher OSS scored students.
- In addition to the school curriculum being accepted across the world, the subjects of the national KPSS exam should be taken into account. Thus, diversification and enrichment of the curriculum can be made.
- Available physical and academic resources of the schools should be contributed in determining the student quotas.
- The variety of academics should be increased.

The future of business education will be shaped by the strategic decisions of individual schools. These decisions, in turn, will be shaped by each school's capabilities relative to the opportunities and threats their leaders perceive to be present in the environment. To the extent that a school develops its capabilities, it expands the range of options available in response to changing conditions. In this case, BSs should measure their teaching performance periodically. It can help academic leaders to create their remarkable schools.

This study is limited to results from 19 BSs of state universities in Turkey. In order to provide benchmarking data more effectively, it would be helpful to collect data from both foundation and state universities with a research focus in future. This would provide state BSs with the ability to benchmark themselves against their own performance, against other similar foundation schools. Since OSSS is the most important factor affecting the teaching performance, it can be focused on the relationship between OSSSs and academic reputation in further researches. For the future studies, the weights of criteria might be measured either by statistic methodologies or fuzzy sets theory. Moreover, as an interesting suggestion for future research, fuzzy environment may be further integrated into the framework of GRA. To build a more exhaustive research, it will be practical to include the criteria such as budget keeping and resource management in upcoming studies. The model of this study can be an example of similar cases in other disciplines such as engineering, science and letters and education. Also, in future, the proposed approach can be used for dealing with multi-criteria decision-making problems in management of other educational institutions.

References

Abbott, M. and Doucouliagos, C. (2003), "The efficiency of Australian universities: a data envelopment analysis", *Economics of Education Review*, Vol. 22, pp. 89-97.

Acito, F., McDougall, P. and Smith, D.C. (2008), "One hundred years of excellence in business education: what have we learned", *Business Horizons*, Vol. 51, pp. 5-12.

Antunes, D. and Thomas, H. (2007), "The competitive (dis)advantages of European business schools", *Long Range Planning*, Vol. 40, pp. 382-404.

Athawale, V.M. and Chakraborty, S. (2011), "Application of grey relational analysis method in solving supplier selection problems", *The IUP Journal of Operations Management*, Vol. 10 No. 1, pp. 18-28.

Badri, M.A. and Abdulla, M.H. (2004), "Awards of excellence in institutions of higher education: an AHP approach", *International Journal of Educational Management*, Vol. 18 No. 4, pp. 224-42.

Besancenot, D., Faria, J.R. and Vranceau, R. (2009), "Why business schools do so much research: a signaling explanation", *Research Policy*, Vol. 38, pp. 1093-101.

Bing, W., Wang, Z., Li, L. and Lu, J. (2007), "Optimization of BCHP schemes based on GRA and AHP", paper presented at ASME 2007 Energy Sustainability Conference, Long Beach, CA, USA, July 27-30.

Calderon, T.G. and Green, B.P. (1997), "Use of multiple information types in assessing accounting faculty teaching performance", *Journal of Accounting Education*, Vol. 15 No. 2, pp. 221-39.

Chan, J.W.K. (2008), "Product end-of-life options selection: grey relational analysis approach", *International Journal of Production Research*, Vol. 11 No. 1, pp. 2889-912.

Chan, K.C., Fung, H.-G. and Lai, P. (2005), "Membership on editorial boards and rankings of schools international business orientation", *Journal of International Business Studies*, Vol. 36, pp. 452-69.

Chan, K.C., Fung, H.-G. and Leung, W.K. (2006), "International business research: trends and school rankings", *International Business Review*, Vol. 15, pp. 317-38.

Chen, C.-H. and Tzeng, G.-H. (2009), "Combined DEMATEL technique with a novel MCDM method for creating the aspired intelligent assessment systems for Mandarin Chinese teaching materials", *Proceedings of the 10th Asia Pacific Industrial Engineering and Management System Conference*, pp. 2050-61.

Chen, F.L. and Ou, T.Y. (2009), "Grey relational analysis and multilayer functional link network sales forecasting model for perishable food in convenience store", *Expert Systems with Applications*, Vol. 36, pp. 7054-63.

Cohn, E., Cohn, S., Balch, D.C. and Bradley, J. (2004), "Determinants of undergraduate GPAs: SAT scores, high-school GPA and high school rank", *Economics of Education Review*, Vol. 23, pp. 577-86.

Conboy, M.E., Dusansky, R., Drukker, D. and Kildegaard, K. (1995), "The productivity of economics departments in the US: publications in the core journals", *Journal of Economic Literature*, Vol. 33, pp. 1966-71.

Cummings, R., Maddux, C.D. and Richmond, A. (2008), "Curriculum-embedded performance assessment in higher education: maximum efficiency and minimum disruption", *Assessment and Evaluation in Higher Education*, Vol. 33 No. 6, pp. 599-605.

Datta, S., Beriha, G.S., Patnaik, B. and Mahapatra, S.S. (2009), "Use of compromise ranking method for supervisor selection: a multi-criteria decision making (MCDM) approach", *International Journal of Vocational and Technical Education*, Vol. 1 No. 1, pp. 7-13.

Deng, J.L. (1989), "Introduction to grey system theory", *The Journal of Grey System*, Vol. 1, pp. 1-24.

Drew, D.E. and Karpf, R. (1981), "Ranking academic departments: empirical findings and a theoretical perspective", *Research in Higher Education*, Vol. 14 No. 4, pp. 305-20.

Essid, H., Ouellette, P. and Vigeant, S. (2010), "Measuring efficiency of Tunisian schools in the presence of quasi-fixed inputs: a bootstrap data envelopment analysis approach", *Economics of Education Review*, Vol. 29, pp. 589-96.

Free, C., Salterio, S.E. and Shearer, T. (2009), "The construction of auditability: MBA rankings and assurance in practice", *Accounting, Organizations and Society*, Vol. 34, pp. 119-40.

Frey, B.S. and Rost, K. (2010), "Do rankings reflect research quality?", *Journal of Applied Economics*, Vol. 13 No. 1, pp. 1-38.

Gramlich, E.M. and Greenlee, G.A. (1993), "Measuring teaching performance", *Journal of Economic Education*, Vol. 24 No. 1, pp. 3-13.

Hamzaçebi, C. and Pekkaya, M. (2011), "Determining of stock investments with grey relational analysis", *Expert Systems with Applications*, Vol. 38, pp. 9186-95.

Hartog, J., Sun, Y. and Ding, X. (2010), "University rank and bachelor's labor market positions in China", *Economics of Education Review*, Vol. 29, pp. 971-9.

Ho, K.K. (1998), "Research output among the three faculties of business, education, humanities and social sciences in six Hong Kong universities", *Higher Education*, Vol. 36, pp. 195-208.

Ho, W., Dey, P.K. and Higson, H.E. (2006), "Multiple criteria decision-making techniques in higher education", *International Journal of Educational Management*, Vol. 20 No. 5, pp. 319-37.

Hong-yi, L., Chu, Z. and Di, Z. (2010), "Stock investment value analysis model based on AHP and gray relational degree", *Management Science and Engineering*, Vol. 4 No. 4, pp. 1-6.

Hsu, C.-J. and Huang, C.-Y. (2007), "Improving effort estimation accuracy by weighted grey relational analysis during software development", *Proceedings of the 14th Asia-Pacific Software Engineering Conference*, pp. 534-41.

Johnes, J. (1996), "Performance assessment in higher education", *European Journal of Operational Research*, Vol. 89 No. 1, pp. 18-33.

Johnes, J. (2006), "Data envelopment analysis and its application to the measurement of efficiency in higher education", *Economics of Education Review*, Vol. 25, pp. 273-88.

Kalanova, S. (2008), "The methodology of ranking higher education institutions in Kazakhstan", *Higher Education in Europe*, Vol. 33 Nos 2/3, pp. 303-10.

Kalaycı, N. (2009), "Methods used in the evaluation process of faculty members' teaching performance in higher education", *Educational Administration: Theory and Practice*, Vol. 15 No. 60, pp. 625-56.

Kedia, B.L. and Harveston, P.D. (1998), "Transformation of MBA programs: meeting the challenge of international competition", *Journal of World Business*, Vol. 33 No. 2, pp. 203-17.

Kirjavainen, T. and Loikkanen, H. (1998), "Efficiency differences of Finnish senior secondary schools: an application of DEA and Tobit analysis", *Economics of Education Review*, Vol. 17, pp. 377-94.

Köksalan, M., Büyükbaşaran, T., Özpeynirci, Ö. and Wallenius, J. (2010), "A flexible approach to ranking with an application to MBA programs", *European Journal of Operational Research*, Vol. 201, pp. 470-6.

Kuo, M.-S. and Liang, G.-S. (2011), "Combining VIKOR with GRA techniques to evaluate service quality of airports under fuzzy environment", *Expert Systems with Applications*, Vol. 38, pp. 1304-12.

Lackritz, J.R. (2004), "Exploring burnout among university faculty: incidence, performance and demographic issues", *Teaching and Teacher Education*, Vol. 20, pp. 713-29.

Li, S. and Yan, H. (2011), "Study on applying fuzzy AHP and GRA in selection of agent construction enterprise", *World Academy of Science, Engineering and Technology*, Vol. 78, pp. 993-9.

Lin, P.-Y., Lee, T.-R. and Dadura, A.M. (2011), "Using grey relational analysis and TRIZ to identify KSFs and strategies for choosing importers and exporters", *Journal of Manufacturing Technology Management*, Vol. 22 No. 4, pp. 474-88.

Mamiseishvili, K. and Rosser, V.J. (2010), "International and citizen faculty in the United States: an examination of their productivity and research universities", *Research in Higher Education*, Vol. 51, pp. 88-107.

Mazumdar, A., Datta, S. and Mahapatra, S.S. (2010), "Multi-criteria decision making (MCDM) models for the evaluation and appraisal of teachers' performance", *International Journal of Productivity and Quality Management*, Vol. 6 No. 2, pp. 213-30.

Meyer, S. and Hofmeyr, J. (1995), "Evaluation needs in South African education: a policy perspective", *Evaluation and Program Planning*, Vol. 18 No. 4, pp. 355-63.

Mu-Shang, Y. (2007), "Grey system theory and multiple attribute decision making: an innovative approach to education research", doctorate thesis, Texas A&M University, Kingsville, TX.

Önüt, S. and Soner, S. (2008), "Transshipment site selection using the AHP and TOPSIS approaches under fuzzy environment", *Waste Management*, Vol. 28, pp. 1552-9.

OSYM (2006), "Selection and placement of students in higher education institutions", OSYM Report, Ankara, available at: www.osym.gov.tr/belge/1-2629/a-condensed-english-version.html (accessed June 15, 2011).

Paliwal, M. and Kumar, U.A. (2009), "A study of academic performance of business school graduates using neural network and statistical techniques", *Expert Systems with Applications*, Vol. 36, pp. 7865-72.

Peng, J. (2012), "Research on the optimization of green suppliers based on AHP and GRA", *Journal of Information and Computational Science*, Vol. 9 No. 1, pp. 173-82.

Rong, R.R. and Gang, X. (2009), "A model for university teaching teacher's competence evaluation based on grey relational analysis and harmony factor", *Proceedings of the Second International Conference on Intelligent Computation Technology and Automation*, pp. 130-3.

Ruggiero, J. (2006), "Measurement error, education production and data envelopment analysis", *Economics of Education Review*, Vol. 25, pp. 327-33.

Saaty, T.L. (1980), *The Analytic Hierarchy Process*, McGraw-Hill, New York, NY.

Saaty, T.L. (1994), *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, RWS Publications, Pittsburgh, PA.

Saaty, T.L. (2008), "Decision making with the analytic hierarchy process", *International Journal of Services Sciences*, Vol. 1 No. 1, pp. 83-98.

Sarrico, C.S. and Dyson, R.G. (2000), "Using DEA for planning in UK universities – an institutional perspective", *Journal of the Operational Research Society*, Vol. 51, pp. 789-800.

Sarrico, C.S., Hogan, S.M., Dyson, R.G. and Athanassopoulos, A.D. (1997), "Data envelopment analysis and university selection", *Journal of the Operational Research Society*, Vol. 48, pp. 1163-77.

Shaw, R.E. and Gaynor, J. (1982), "Goal-oriented evaluation for program planning: a case study", *Evaluation and Program Planning*, Vol. 5 No. 2, pp. 141-8.

Shin, J.C. (2009), "Classifying higher education institutions in Korea: a performance-based approach", *Higher Education*, Vol. 57, pp. 247-66.

Siemens, J.C., Burton, S., Jensen, T. and Mendoza, N.A. (2005), "An examination of the relationship between research productivity in prestigious business journals and popular press business school rankings", *Journal of Business Research*, Vol. 58, pp. 467-76.

Sundeep, M., Kumanan, S. and Vinodh, S. (2011), "Supplier selection using combined AHP and GRA for a pump manufacturing industry", *International Journal of Logistics Systems and Management*, Vol. 10 No. 1, pp. 40-52.

Tang, W.-H., Hung, C.-Y. and Tzeng, G.-H. (2004), "Evaluating the strategies of enhancing educational effects of the department of command & general staff of army of defense university – a case study of the application of fuzzy integral", *Proceedings of the 17th International Conference on Multiple Criteria Decision Analysis*, pp. 1-8.

Tavana, M. and Hatami-Marbini, A. (2011), "A group AHP-TOPSIS framework for human spaceflight mission planning at NASA", *Expert Systems with Applications*, Vol. 38, pp. 13588-603.

Vaidya, O.S. and Kumar, S. (2006), "Analytic hierarchy process: an overview of applications", *European Journal of Operational Research*, Vol. 169, pp. 1-29.

Wang, C.-H. and Tong, L.-I. (2003), "Quality improvement for dynamic ordered categorical response using grey relational analysis", *International Journal of Advanced Manufacturing Technology*, Vol. 21, pp. 377-83.

Webster, T.J. (2001), "A principal component analysis of the US News & World Report tier rankings of colleges and universities", *Economics of Education Review*, Vol. 20, pp. 235-44.

Wu, H.-Y., Lin, Y.-K. and Chang, C.-H. (2011), "Performance evaluation of extension education centers in universities based on the balanced scorecard", *Evaluation and Program Planning*, Vol. 34 No. 1, pp. 37-50.

Xiangpei, K. and Naiming, X.I.E. (2009), "Evaluation research of university's doctoral theses based on grey relational analysis", *Proceedings of the IEEE International Conference on Grey Systems and Intelligent Services*, pp. 888-92.

Yong, L., Lirong, J. and Hongfang, M. (2009), "Evaluation of dynamic competitiveness of the university of listed companies based on grey relational analysis", *Proceedings of the IEEE International Conference on Grey Systems and Intelligent Services*, pp. 124-8.

Youliang, C., Hongfa, K. and Yingsheng, L. (2009), "Grey relational analysis algorithm on weights in multi-attribute group decision-making", *Proceedings of the IEEE International Conference on Grey Systems and Intelligent Services*, pp. 1029-32.

Appendix 1. GRA methodology

(1) *Definition of the problem.* Determination of alternatives ($i = 1, \ldots, m$) and criteria ($j = 1, \ldots, n$):

$$\chi_i = (\chi_i(1), \chi_i(2), \chi_i(3), \ldots, \chi_i(n)) \quad \text{(A1)}$$

(2) *Determination of the reference series.* Reference series occur by the minimum or the maximum values of the alternative series or by a nominal value:

$$\chi_0 = (\chi_0(1), \chi_0(2), \chi_0(3), \ldots, \chi_0(n)) \quad \text{(A2)}$$

(3) *Normalization.* Normalization process makes the values free of unit. This process is called grey relational generating. The normalization process can occur in three types:

$$\text{Higher is better}: \quad \chi_i(k) = \frac{\chi_i^0(k) - \min \chi_i^0(k)}{\max \chi_i^0(k) - \min \chi_i^0(k)} \quad \text{(A3)}$$

$$\text{Lower is better}: \quad \chi_i(k) = \frac{\max \chi_i^0(k) - \chi_i^0(k)}{\max \chi_i^0(k) - \min \chi_i^0(k)} \quad \text{(A4)}$$

$$\text{Nominal is better}: \quad \chi_i(k) = 1 - \frac{|\chi_i^0(k) - \chi^0|}{\max \chi_i^0(k) - \chi^0} \quad \text{(A5)}$$

where $x_i(k)$ is the value after the normalization, $x_i^o(k)$ is the value before the normalization and $\min x_i^o(k)$, $\max x_i^o(k)$ are the smallest and largest values of the kth response before the normalization respectively.

(4) *Calculation of the grey relational coefficient.* Grey relational coefficient is an indicator of the similarity between the reference series and alternative series:

$$\varepsilon(\chi_0(k), \chi_i(k)) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{oi}(k) + \xi\Delta_{max}} \quad \text{(A6)}$$

(5) *Calculation of the GRG.* GRG shows the final evaluation of alternatives according to the all criteria. The GRG values are used to rank the alternatives according to the similarity to reference series. The higher GRG value indicates the higher similarity. If the all criteria have equal importance, the GRG can be calculated by equation (A7), for different weights of the criteria, the GRG can be calculated by equation (A8):

$$\gamma(\chi_0, \chi_i) = \frac{1}{n}\sum_{k=1}^{n} \varepsilon(\chi_o(k), \chi_i(k)) \quad \text{(A7)}$$

$$\gamma(\chi_0, \chi_i) = \sum_{k=1}^{n} w_i(k)\varepsilon(\chi_o(k), \chi_i(k)) \quad \text{(A8)}$$

Appendix 2. AHP methodology

To make a decision in an organized way to generate priorities, it is need to decompose the decision into the following steps:

(1) definition of the problem and knowledge seeking;

(2) determination of the decision hierarchy;

(3) construction of the pair-wise comparison matrices; and

(4) determination of the weights from the comparison matrices.

Comparison matrices use the scale numbers. Scale numbers represent how many times more important or dominant one element is over another element with respect to the criterion or property which they are compared. This pair-wise comparison is a vital important issue while using AHP. Scale numbers are 1 (equal importance), 2 (equal plus), 3 (moderate importance), 4 (moderate plus), 5 (strong importance), 6 (strong plus), 7 (very strong importance), 8 (very strong plus) and 9 (extreme importance).

After creation of consistent pair-wise comparison matrix, the weights can be obtained from this matrix. Let A_{nxn} is comparison matrix. The weight vector can be obtained by solving the equation (A9):

$$Aw = \lambda_{max} w \quad \text{(A9)}$$

where λ_{max} is the largest eigenvector of A matrix. $\lambda_{max} = n$ if the pair-wise comparison is completely consistent. However, all comparison matrixes do not guarantee the complete consistence. For this reason the CI and CR should be determined. The CR shows a measure of acceptance of the pair-wise comparison. If the CR is less than 0.1, the comparison matrix will be acceptable. The CI and CR can be calculated by equation (A10) where RI is random index and its values change according to the matrix dimension (n) (Saaty, 1994; Hamzaçebi and Pekkaya, 2011):

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}, \quad CR = \frac{CI}{RI} \quad \text{(A10)}$$

Appendix 3

Table AI.
Research data set

Universities	OSSS	NFM	NSPFM	MKPSSS 2009	MKPSSS 2010	SDKPSSS 2009	SDKPSSS 2010
1. Abant İzzet Baysal	299.700	11	21.45	7.73	9.27	3.73	3.83
2. Adnan Menderes	297.742	12	9.83	8.08	10.17	3.71	3.74
3. Afyon Kocatepe	296.753	25	7.36	7.51	8.38	3.83	3.66
4. Balıkesir	301.354	6	18.17	6.65	8.21	3.81	3.80
5. Celal Bayar	301.493	21	12.62	8.90	10.75	4.21	4.33
6. Çanakkale Onsekiz Mart	300.162	13	9.15	8.34	9.04	3.22	3.67
7. Dumlupınar	296.729	18	17.78	7.69	8.64	3.82	3.93
8. Gaziosmanpaşa	294.477	5	30.80	8.58	8.26	4.05	3.59
9. Harran	298.292	5	6.40	9.08	9.07	3.34	3.45
10. Kafkas	293.491	4	28.00	7.09	7.75	3.61	3.84
11. K.Sütçü İmam	294.684	7	20.57	7.49	8.27	3.83	3.63
12. Kırıkkale	299.627	11	9.64	6.74	7.92	4.06	3.94
13. Mersin	306.823	7	7.86	9.28	9.28	3.74	3.69
14. Muğla	299.137	7	35.86	8.08	8.94	3.86	3.91
15. Mustafa Kemal	296.686	8	16.75	8.16	8.94	3.69	3.58
16. Niğde	295.909	17	10.06	7.61	8.91	3.68	4.15
17. Pamukkale	299.656	16	12.88	8.49	9.08	3.88	3.81
18. Süleyman Demirel	297.675	18	12.89	7.81	8.41	4.02	3.87
19. Zonguldak Karaelmas	294.946	8	18.75	7.16	8.83	3.40	3.93

Corresponding author
Ilker Murat Ar can be contacted at: ilkerar@ktu.edu.tr