Data Article

Data on strategic performance of Greek universities during the economic recession: A multiple criteria approach

M. Chalaris a,*, S. Gritzalis b

a Manolis Chalaris, Department of Information and Communication Systems, University of the Aegean, Samos, Greece
b Stefanos Gritzalis, Laboratory of Systems Security, Department of Digital Systems, University of Piraeus, Piraeus, Greece

ARTICLE INFO

Article history:
Received 15 March 2020
Accepted 27 March 2020
Available online xxx

Keywords:
Decision making
Universities
Balanced score card
Decision support systems
Multiple criteria analysis

ABSTRACT

In this article we provide data from seven Greek Universities during the economic recession. Based on the data that has been collected we assess the strategic performance of the universities using the aggregation disaggregation theory of the Multiple Criteria Analysis. Via the proposed algorithm we reveal the cognitive style and the behavior style in order to assess the strategic performance of the universities and more over we elucidate possible strategic actions.

© 2020 The Author(s). Published by Elsevier Inc.
This is an open access article under the CC BY-NC-ND license. (http://creativecommons.org/licenses/by-nc-nd/4.0/)

* Corresponding author.
E-mail address: manoschalaris@yahoo.gr (M. Chalaris).

https://doi.org/10.1016/j.dib.2020.105528
2352-3409/© 2020 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license. (http://creativecommons.org/licenses/by-nc-nd/4.0/)
Specifications table

| Subject            | Social Science |
|--------------------|----------------|
| Specific subject area | Decision Sciences, Education |
| Type of data       | Table          |
| How data were acquired | Data was acquired through a structured questionnaire from the Hellenic Quality Assurance and Accreditation Agency |
| Data format        | Raw, analyzed  |
| Parameters for Data Collection | For the collection of Data, a structured questionnaire had been developed in order to collect the data for the key performance indicators of the examined universities. |
| Description of Data Collection | The Data depict the strategic performance of Greek Universities using a set of key performance indicators. For the collection of these data, a structured questionnaire had been developed which was delivered per email to the examined Universities. |
| Data source location | Greece |
| Data accessibility | Repository name: Mendeley  
Data identification number: 10.17632/3kgvf8dhsr.3  
Direct URL to data: https://data.mendeley.com/datasets/3kgvf8dhsr/draft?a=978951e0-3b4d-4a06-b7b0-a553fba53d41 |

Value of the data

- The data reveal the performance of the Greek Universities during the economic crisis
- The data can be used from other researchers in order to assess the performance of the Greek universities with other European Universities
- The proposed data can be used from researchers in order to test and implement new methodologies with the Balanced Score Card
- The proposed model depicts the behavior and the cognitive style of a decision maker
- The brief data analysis reveals a new approach in the area of strategic decision making

1. Data description

One of the main concerns across the globe in the universities is the quality assurance [1]. In such a period of crisis, the establishment of quality assurance mechanisms in universities is a very arduous and demanding task and the maturity level of the Quality Assurance Evaluation Procedures is relatively low [2]. In order to monitor, evaluate and moreover to implement education policies at the university sector the Greek Universities is recommended to establish the applicability of the Balanced Score Card [3]. In this paper we demonstrate the applicability of the Balance scorecard with data that never have been appeared in the research. Moreover, we assess the performance of seven universities for the academic year 2015–2016. In order to test the combination of the Balanced score card with MCDA [1] techniques and to elucidate the cognitive style and the behavior of the decision maker we evaluate 26 key performance indicators. Table 1 presents the performance of each University based on the selected key performance indicators. Table 2 elucidates the weights that have been derived by the evaluation of the Decision maker. Table 3 depicts the strategic performance of the selected Universities in Greece.

2. Experimental design, materials and methods

2.1. Utastar algorithm-brief presentation

The UTASTAR method proposed by [4–6] is a variation of the UTA method which aims at inferring a set of additive value functions from a given ranking on a reference set of functions.
Table 1
Performance of each university on the selected kpis for each dimension of BSC.

| Education Dimension | active students | Degree Grade | Erasmus Students | Scholarships | Studies Duration | Number of UGP |
|---------------------|-----------------|--------------|------------------|--------------|-----------------|--------------|
| University 1        | 80.8            | 7.13         | 1.21             | 1.6          | 1.9             | 608.5        |
| University 2        | 44.2            | 6.97         | 3.5              | 1.6          | 19              | 1095.5       |
| University 3        | 72.6            | 6.97         | 0.13             | 0.1          | 23.5            | 615.2        |
| University 4        | 76.6            | 7.14         | 0.77             | 0.4          | 27.3            | 824.1        |
| University 5        | 70.5            | 6.9          | 0.34             | 0.4          | 15.4            | 918.8        |
| University 6        | 47.7            | 6.73         | 0.41             | 0            | 16              | 1180.6       |
| University 7        | 76.7            | 7.31         | 0.66             | 2            | 36.6            | 412          |

| Research Dimension | no of PhDs | Publications per PhD student | Publications with reviewers | Publications without reviewers | Citations | Research Expenditure | International Projects |
|--------------------|------------|-----------------------------|-----------------------------|--------------------------------|-----------|----------------------|------------------------|
| University 1       | 5.17       | 0.69                        | 40.76                       | 2.9                            | 725.47    | 0                    | 0.1115                 |
| University 2       | 5.75       | 0.14                        | 24.63                       | 2.86                           | 1029.92   | 0                    | 0.0928                 |
| University 3       | 7.25       | 0.71                        | 26.08                       | 2.91                           | 464.33    | 184.27               | 0.2558                 |
| University 4       | 6.75       | 1                           | 29.37                       | 1.89                           | 1145.9    | 218.74               | 0.105                  |
| University 5       | 10.75      | 0.46                        | 42.47                       | 2.01                           | 557.84    | 788.32               | 0.1277                 |
| University 6       | 11.67      | 0.89                        | 24.35                       | 2.26                           | 647.01    | 0                    | 0.3611                 |
| University 7       | 4          | 1.3                         | 55.42                       | 3.18                           | 1629.63   | 0                    | 0.1739                 |

| Personell Dimension | Prof ratio per UGP | Staff at MODIP | Staff at Manag. Dep. | Staff at Econ. Dep. | General Staff | no Of Staff at ELKE | no of staff at IT Department | Prof ratio per student |
|---------------------|---------------------|----------------|----------------------|--------------------|---------------|---------------------|----------------------------|-----------------------|
| University 1        | 28.67               | 0.61           | 14.11                | 6.13               | 3.07          | 11.04               | 4.29                       | 21.23                 |
| University 2        | 21.5                | 1.26           | 7.98                 | 5.88               | 4.2           | 15.15               | 5.46                       | 50.95                 |
| University 3        | 18.76               | 0.38           | 18.77                | 9.96               | 0             | 17.24               | 11.11                      | 32.79                 |
| University 4        | 28.06               | 1.59           | 4.76                 | 7.62               | 7.3           | 13.02               | 6.67                       | 29.37                 |
| University 5        | 29.13               | 0.6            | 2.41                 | 6.24               | 6.04          | 9.05                | 3.42                       | 31.55                 |
| University 6        | 20                  | 0.64           | 1.27                 | 7.64               | 4.46          | 15.29               | 6.37                       | 59.03                 |
| University 7        | 16.75               | 4.26           | 8.51                 | 10.64              | 4.26          | 25.53               | 8.51                       | 24.6                  |

| Financial Dimension | Public Funding | ESPA Funding | Subsidy for Ministry of Education | Funding from ELKE | Funding per Student |
|---------------------|----------------|--------------|----------------------------------|------------------|---------------------|
| University 1        | 24.03           | 39.62        | 100                              | 15.5             | 6764.11             |
| University 2        | 24.59           | 2.04         | 89.08                            | 64.85            | 3781.06             |
| University 3        | 52.21           | 60.19        | 86.39                            | 9.6              | 3116.8              |
| University 4        | 44.23           | 22.53        | 95.49                            | 4.51             | 2918.8              |
| University 5        | 37.72           | 9.6          | 86.08                            | 18.81            | 3247.42             |
| University 6        | 46.76           | 0            | 100                              | 1.11             | 2251.36             |
| University 7        | 21.71           | 7.19         | 100                              | 0                | 6134.38             |

In the context of the method, the additive value function is assumed to have the following form:

\[ u(g) = \sum_{i=1}^{n} u_i(g_i) - \sigma^+ + \sigma^- \]  \hspace{1cm} (1)
Table 2
Criteria Weights for each dimension of balanced score card.

Under the following normalization constraints:

\[
\begin{cases}
\sum_{i=1}^{n} u_i(g_i^\ast) = 1 \\
\forall i = 1, 2, \ldots, n \\
u_i(g_{is}) = 0
\end{cases}
\]

where \( g = \{g_1, g_2, \ldots, g_n\} \) is the set of criteria, \([g_i^\ast, g_i^\ast] \) is the criterion evaluation scale with \( g_i^\ast \) and \( g_i^\ast \) the worst and the best level of the ith criterion, \( u_i \) (\( i = 1, 2, \ldots, n \)) are the marginal value functions normalized between 0 and 1, \( \sigma^+ \) and \( \sigma^- \) are the overestimation and the underestimation error, respectively, and \( n \) is the number of criteria.

The UTASTAR method infers an unweighted form of the additive value function, equivalent to the form defined from relations (1) and (2), as follows:

\[
u'(g) = \sum_{i=1}^{n} u_i(g_i)
\]

under the normalization constraints:

\[
\begin{cases}
\sum_{i=1}^{n} u_i(g_i^\ast) = 1 \\
\forall i = 1, 2, \ldots, n \\
u_i(g_{is}) = 0
\end{cases}
\]

where \( u_i(g_i^\ast) \) have the role of \( p_i \) (weight of the ith criterion).
On the basis of the additive model (3)-(4), the value of each alternative $a \in A_R$ may be written as:

$$u[g(a)] = \sum_{i=1}^{n} u_i[g_i(a)] - \sigma^+(a) + \sigma^-(a)$$

where $\sigma^+$ and $\sigma^-$ are the overestimation and the underestimation error, respectively, relative to $u[g(a)]$.

Moreover, linear interpolation is used in order to estimate the corresponding marginal value functions in a piecewise linear form. For each criterion, the interval $[g_i^*, g_i^+]$ is cut into $(a_i - 1)$ equal intervals, and thus the end points $g_i^j$ are given by the formula:

$$g_i^j = g_i^* + \frac{j - 1}{a_i - 1} (g_i^+ - g_i^*) \forall j = 1, 2, \ldots, a_i$$

The marginal value of an action $a$ is approximated by a linear interpolation, and thus, for $g_i(a) \in [g_i^j, g_i^{j+1}]$:

$$u_i[g_i(a)] = u_i(g_i^j) + \frac{g_i(a) - g_i^j}{g_i^{j+1} - g_i^j} [u_i(g_i^{j+1}) - u_i(g_i^j)]$$

An important modification of the UTASTAR method concerns the monotonicity constraints of the criteria, which are taken into account through the transformations of the variables:

$$w_{ij} = u_i(g_i^{j+1}) - u_i(g_i^j) \geq 0 \forall i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, a_i - 1$$

and thus, the monotonicity conditions for $u_i$ can be replaced by the non-negative constraints for the variables $w_{ij}$.
Also, the set of reference actions $A_R = \{a_1, a_2, \ldots, a_m\}$ is also "rearranged" in such a way that $a_1$ is the head of the ranking (best action) and $a_m$ its tail (worst action). Since the ranking has the form of a weak order $R$, for each pair of consecutive actions $(a_k, a_{k+1})$ it holds either $a_k \succ a_{k+1}$ (preference) or $a_k \sim a_{k+1}$ (indifference). Thus, if

$$\Delta(a_k, a_{k+1}) = u(\mathbf{g}(a_k)) - u(\mathbf{g}(a_{k+1}))$$

then one of the following holds:

$$\begin{cases}
\Delta(a_k, a_{k+1}) \geq \delta & \text{iff } a_k \succ a_{k+1} \\
\Delta(a_k, a_{k+1}) = 0 & \text{iff } a_k \sim a_{k+1}
\end{cases}$$

(10)

where $\delta$ is a small positive number so as to discriminate significantly two successive equivalence classes of $R$.

Taking into account the previous conditions and assumptions, the UTASTAR algorithm may be summarized in the following steps:

**Step 1.** Express the global value of reference actions $u(\mathbf{g}(a_k)), k = 1, 2, \ldots, m$, first in terms of marginal values $u_i(g_i)$, and then in terms of variables $w_{ij}$ according to the formula (8), by means of the following expressions:

$$\begin{cases}
u_i(g^1_i) = 0 & \forall i = 1, 2, \ldots, n \\
u_i(g^j_i) = \sum_{t=1}^{j-1} w_{it} & \forall i = 1, 2, \ldots, n \text{ and } j = 2, 3, \ldots, \alpha_i - 1
\end{cases}$$

(11)

**Step 2.** Introduce two error functions $\sigma^+$ and $\sigma^-$ on $A_R$ by writing for each pair of consecutive actions in the ranking the analytic expressions:

$$\Delta(a_k, a_{k+1}) = u(\mathbf{g}(a_k)) - \sigma^+(a_k) + \sigma^-(a_k) - u(\mathbf{g}(a_{k+1})) + \sigma^+(a_{k+1}) - \sigma^-(a_{k+1})$$

(12)

**Step 3.** Solve the LP:

$$\begin{align*}
\text{[min]} z &= \sum_{k=1}^{m} \left[ \sigma^+(a_k) + \sigma^-(a_k) \right] \\
\text{subject to}
\end{align*}$$

$$\begin{cases}
\Delta(a_k, a_{k+1}) \geq \delta & \text{iff } a_k \succ a_{k+1} \\
\Delta(a_k, a_{k+1}) = 0 & \text{iff } a_k \sim a_{k+1}
\end{cases}$$

$$\forall k$$

$$\begin{cases}
\sum_{i=1}^{n} \sum_{j=1}^{\alpha_i - 1} w_{ij} = 1 \\
w_{ij} \geq 0, \sigma^+(a_k) \geq 0, \sigma^-(a_k) \geq 0 & \forall i, j \text{ and } k
\end{cases}$$

(13)

**Step 4.** Test the existence of multiple or near optimal solutions of the LP (13) (stability analysis); in case of non-uniqueness, find the mean additive value function of those (near) optimal solutions which maximize the objective functions:

$$u_i(g^j_i) = \sum_{j=1}^{\alpha_i - 1} w_{ij} \forall i = 1, 2, \ldots, n$$

(14)

on the polyhedron of the constraints of the LP (13) bounded by the new constraint:

$$\sum_{k=1}^{m} \left[ \sigma^+(a_k) + \sigma^-(a_k) \right] \leq z^* + \varepsilon$$

(15)

where $z^*$ is the optimal value of the LP in step 3 and $\varepsilon$ is a very small positive number.
2.2. Experimental design

One of the most useful outcomes of the proposed method is the criteria weights (Table 2). The UTASTAR algorithm depicts which key performance indicator of each dimension of the balanced score card is crucial for the decision maker in order to design and implement educational policies.

A brief analysis of the Table 2 depicts that the most important criterion for the decision maker in order to design and implement policies is the average number of students per undergraduate study program. In addition, criteria like studies duration is important because it consumes economic budget from the university affecting its financial performance. Beside the aforementioned criteria the scholarships are important too, because can affect positively the other dimensions of the balanced score card. Criteria like the number of Erasmus students and the degree grades are not important for the decision maker in the area of strategic performance.

Analysing the personnel dimension, it’s obvious that the most important factors for the decision maker are the criteria of professors’ ratio per student and the professors’ ratio per UGP. A brief approach of the outcomes elucidated that these aforementioned criteria are crucial for a university to be more productive in terms of academic excellence and more competitive among the other universities. On the other hand, criteria like the number of personnel in several administrative positions are not important for the decision maker in order to design possible strategic actions.

Analysing the research dimension, the least important criteria for the decision maker are criteria like international projects, publications with or without reviewer indicating that these criteria are not crucial in order to improve them. On the other hand, the most important factors are the criteria of number of PhDs and the number of citations indicating that for the decision maker research activities like PhDs, citations are the key components for the strategic performance of the universities.

The financial perspective of the balanced score reveals that the most important criterion for the decision maker in order to rank the universities and more over to draw strategic actions is the criterion of ESPA funding. This outcome elucidates that due to the financial crisis in Greece the policy makers focused on the actions like ESPA in order to finance the Greek universities.

Beside the criteria weights the algorithm depicts the performance of kpis in each dimension of the balanced score card (Table 3).

It should be noted that the performance scores are normalised between 0 and 1. Analyzing the education dimension of the Balanced Score Card we observe that the University 4 and the University 2 have better performance among the assessed Universities. Thus, Universities like University 6 and University 3 must improve the kpis that belong to the dimension of the balanced scored based on the views of the decision maker.

Analysing the personnel dimension, we observe the worst performance at the University 7 and the University 3. On the other hand, the University 2 and the University 6 have the best performance among the examined universities because they perform better in kpis like professor’s ratio per student and professors ration per undergraduate study program.

Another dimension that plays an important role in the implementation of the strategy at the Universities is the performance in the area of research dimension. A brief analysis of the research dimension indicates that the best performance is observed at the following universities: University 5, University 4 and University 2. This outcome demonstrates that the Universities of the sample that do not perform as well as the others should design and implement policies in areas like research expenditure, quality of research and moreover to attract PhD students.

Analyzing the financial dimension of the balanced score card it’s obvious that the best performance is observed on the University 1, University 3 and the University 4. The decision maker attributes high performance at these Universities because their performance in kpis like ESPA funding and public funding is crucial in order to design strategic actions.

Based on the above presented methodological approach, in which it is combined for the first time, the Balanced Score Card with MCDA (Utastar algorithm) techniques in educational data
of higher education institutions we reveal the cognitive and the behavior style of the academic strategy decision maker.

Acknowledgments

The authors are grateful to the Hellenic Quality Assurance and Accreditation Agency for its cooperation.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding resources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi: 10.1016/j.dib.2020.105528.

References

[1] S.H. Zolfani, A.S. Ghadikolaei, Performance evaluation of private universities based on balanced scorecard: empirical study based on Iran, J. Bus. Econ. Manag. 14 (4) (2013) 696–714.

[2] M. Chalaris, I. Chalaris, S. Gritzalis, C. Sgouropoulou, Maturity level of the quality assurance evaluation procedures in higher education – A qualitative research", in: International Journal on Integrated Information Management, 21st Pan-Hellenic Conference 2017, 2017, doi: 10.1145/3139367.3139438.

[3] M. Chalaris, Ioannis Chalaris, Stefanos Gritzalis, A. Tsolakidis, Modeling and transformation of the evaluation mechanism of Greek higher education institutes using balanced scorecard technique, Int. J. Integr. Inform. Manag. 02 (2015) (2015), doi: 10.15556/IJIIM.02.01.004.

[4] Y. Siskos, D.X.-I. Operacional, undefined 1985, UTASTAR: an ordinal regression method for building additive value functions, (n.d.).

[5] Y. Siskos, E. Grigoroudis, N.F. Matsatsinis, UTA methods, Int. Ser. Oper. Res. Manag. Sci. 233 (2016) 315–362, doi: 10.1007/978-1-4939-3094-4_9.

[6] E. Grigoroudis, Y. Siskos, Preference disaggregation for measuring and analyzing customer satisfaction: the \protect(MUSA) method, Eur. J. Oper. Res. 143 (2002) 148–170 https://www.sciencedirect.com/science/article/pii/S0377221701003320 .