Data on Strategic Performance of Greek Universities during the economic recession: A Multiple criteria Approach

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Article Title

Data on Strategic Performance of Greek Universities during the economic recession: A Multiple criteria Approach

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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 behaviour style in order to assess the strategic performance of the universities and more over we elucidate possible strategic actions.

Keywords: Decision making, Universities, Balanced Score Card, Decision Support Systems, Multiple Criteria Analysis

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 behaviour 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 behaviour 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.

[INSERT HERE TABLE 1]

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

$$u(\mathbf{g}) = \sum_{i=1}^{n} u_i(g_i) - \sigma^+ + \sigma^- \quad (1)$$

Under the following normalization constraints:

$$\begin{cases} \sum_{i=1}^{n} u_i(g_i^*) = 1 \\ u_i(g_{i*}) = 0 \end{cases} \quad \forall i = 1,2,\ldots,n \quad (2)$$

where $\mathbf{g} = \{g_1, g_2, \ldots, g_n\}$ is the set of criteria, $[g_i^*, g_{i*}]$ is the criterion evaluation scale with g_{i*} and g_i^* the worst and the best level of the *i*-th criterion, u_i $(i = 1,2,\ldots,n)$ are the marginal value functions normalized between 0 and 1, σ^+ and σ^- 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:

$$u'(\mathbf{g}) = \sum_{i=1}^{n} u_i(g_i) \tag{3}$$

under the normalization constraints:

$$\begin{cases} \sum_{i=1}^{n} u_i(g_i^*) = 1 \\ u_i(g_{i*}) = 0 \end{cases} \quad \forall i = 1, 2, \ldots, n \tag{4}$$

where $u_i(g_i^*)$ have the role of p_i (weight of the *i*-th criterion).

On the basis of the additive model (3)-(4), the value of each alternative $a \in A_R$ may be written as:

$$u[\mathbf{g}(a)] = \sum_{i=1}^{n} u_i[g_i(a)] - \sigma^+(a) + \sigma^-(a) \tag{5}$$

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

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 $(\alpha_i - 1)$ equal intervals, and thus the end points g_i^j are given by the formula:

$$g_i^j = g_{i*} + \frac{j-1}{\alpha_i - 1}\left(g_i^* - g_{i*}\right) \quad \forall j = 1, 2, \ldots, \alpha_i \tag{6}$$

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

$$u_i[g_i(a)] = u_i(g_i^j) + \frac{g_i(a) - g_i^j}{g_i^{j+1} - g_i^j}\left[u_i(g_i^{j+1}) - u_i(g_i^j)\right] \tag{7}$$

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:

$$w_{ij} = u_i(g_i^{j+1}) - u_i(g_i^j) \geq 0 \quad \forall i = 1, 2, \ldots, n \text{ and } j = 1, 2, \ldots, \alpha_i - 1 \tag{8}$$

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 $a_k \; ? \; a_{k+1}$ (indifference). Thus, if

$$\Delta(a_k, a_{k+1}) = u[(\mathbf{g}(a_k)] - u[(\mathbf{g}(a_{k+1})] \tag{9}$$

then one of the following holds:

$$\begin{cases} \Delta(a_k, a_{k+1}) \geq \delta & \text{iff} \quad a_k \succ a_{k+1} \\ \Delta(a_k, a_{k+1}) = 0 & \text{iff} \quad a_k \; ? \; a_{k+1} \end{cases} \tag{10}$$

where δ 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:

$$\begin{cases} u_i(g_i^1) = 0 & \forall i = 1, 2, \ldots, n \\ u_i(g_i^j) = \sum_{t=1}^{j-1} w_{it} & \forall i = 1, 2, \ldots, n \text{ and } j = 2, 3, \ldots, \alpha_i - 1 \end{cases} \tag{11}$$

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

$$\begin{aligned} \Delta(a_k, a_{k+1}) = u[\mathbf{g}(a_k)] &- \sigma^+(a_k) + \sigma^-(a_k) \\ &- u[\mathbf{g}(a_{k+1})] + \sigma^+(a_{k+1}) - \sigma^-(a_{k+1}) \end{aligned} \tag{12}$$

Step 3. Solve the LP:

$$\begin{cases} [\min] z = \sum_{k=1}^{m} [\sigma^+(a_k) + \sigma^-(a_k)] \\ \text{subject to} \\ \left.\begin{array}{ll} \Delta(a_k, a_{k+1}) \geq \delta & \text{if} \quad a_k \succ a_{k+1} \\ \Delta(a_k, a_{k+1}) = 0 & \text{if} \quad a_k \; ? \; a_{k+1} \end{array}\right\} \quad \forall k \\ \sum_{i=1}^{n} \sum_{j=1}^{\alpha_i - 1} w_{ij} = 1 \\ w_{ij} \geq 0, \; \sigma^+(a_k) \geq 0, \; \sigma^-(a_k) \geq 0 \quad \forall i, j \text{ and } k \end{cases} \tag{13}$$

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:

$$u_i(g_i^*) = \sum_{j=1}^{\alpha_i - 1} w_{ij} \quad \forall i = 1, 2, \ldots, n \tag{14}$$

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

$$\sum_{k=1}^{m} \left[\sigma^+(a_k) + \sigma^-(a_k) \right] \leq z^* + \varepsilon \tag{15}$$

where z^* is the optimal value of the LP in step 3 and ε 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.

[INSERT HERE TABLE 2]

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.

[INSERT HERE TABLE 3]

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.

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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.

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Table 1. Performance of each university on the selected kpis for each dimension of BSC

Edcation Dimension								
	active students	Degree Grade	Erasmus Students	Scholaships	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 withour reviewers	Citations	Research Expenditure	Internationa l 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			

Table 2: Criteria Weights for each dimension of Balanced Score Card

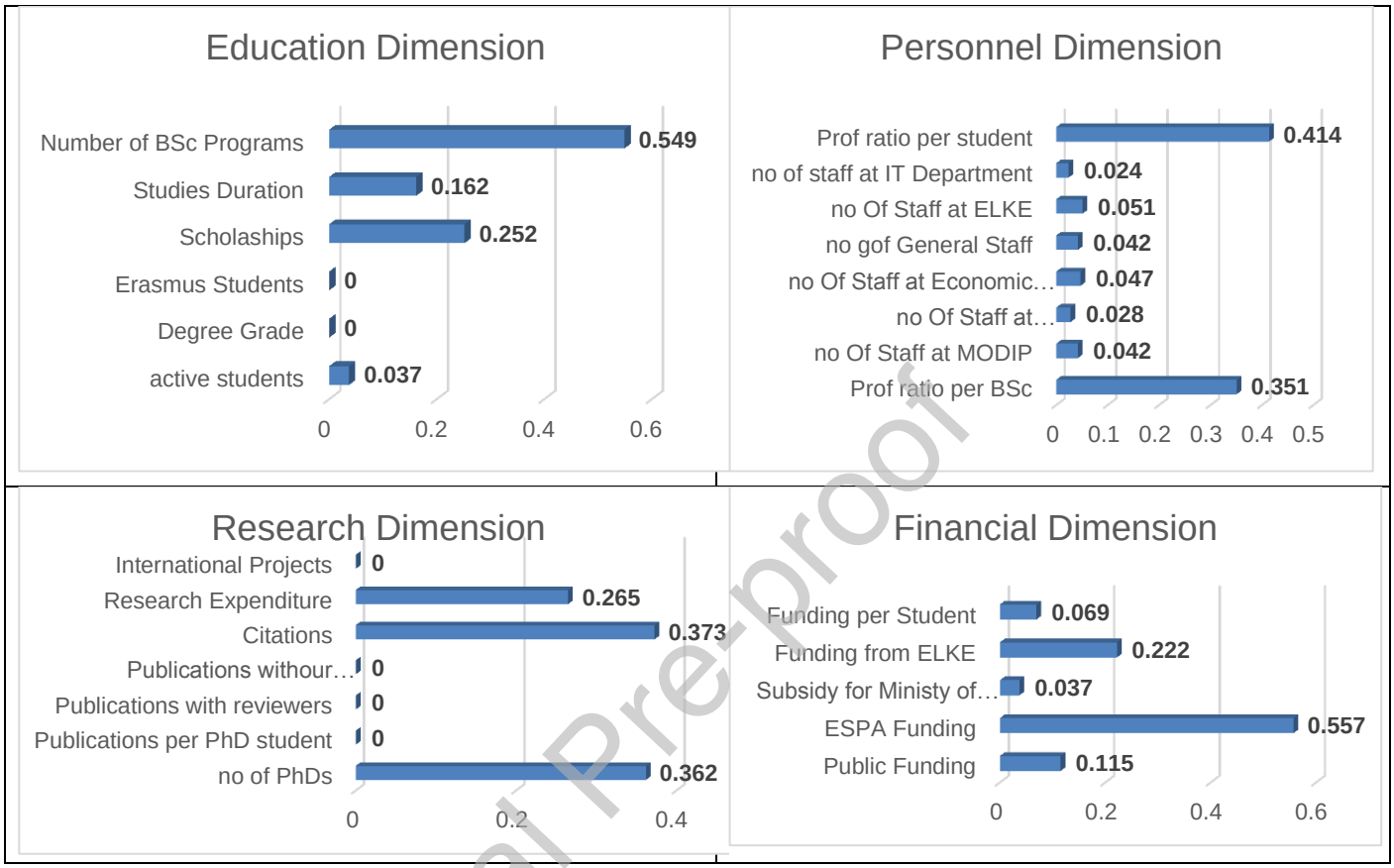

Table 3: Performance Scores of KPIs for each BSC perspective