STUDY PROGRAM SELECTION BY AGGREGATED DEA-AHP MEASURE

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Abstract: *Upon the completion of the common first-year curriculum, under graduate university students may find it difficult to choose the most appropriate study program. This paper deals with a methodology that may help students select it on the basis of their first-year marks, i.e. their efficiency. We have used data on the students' marks from the official database at the Faculty of Organizational Sciences, University of Belgrade, to determine the weights of the first-year subjects in order to predict future students' success on each of the study programs, separately. The aggregated measure, as the combination of weights obtained by Data Envelopment Analysis (DEA) as an objective, and Analytical Hierarchical Process (AHP) as a subjective method is defined for determining the subject's weight. Furthermore, based on the weights assigned to subjects according to departments, we have selected subjects relevant for assessment of future students' success and recommended the appropriate study programs.*

1. INTRODUCTION

A great amount of characteristics could make confusion when selecting the best of available alternatives in practice. The significance of each of evaluated alternatives may vary to a great extent, if not clearly defined and it can make rating the alternatives a complicated problem. The main task is to determine a number of relevant characteristics (criteria) and significance for an object being evaluated. The difficulties above may be eliminated using the quantitative methods for determining the efficiency of particular activities. These methods are grouped into a set of objective or set of subjective methods, which depends on the influence of decision maker on the criteria weighting.

We have here made an attempt to make a selection of relevant criteria based on their weights, obtained by combining the results of one objective and one subjective approach. Data envelopment analysis (DEA) is an objective method for determining the relative efficiency of Decision Making Units -DMUs. The relative efficiency is calculated as a ratio of the weighted sum of outputs and weighted sum of inputs. At the same time, criteria weights (inputs and outputs) are variables in the model and they are obtained as its solution. When solving DEA models, the complete flexibility in the process of choosing weights is assumed, so it is possible that some criteria might be assigned as highly important only because of their appropriate values (very low for inputs or very high for outputs in comparison with other DMUs under evaluation). This may lead to misjudgment of the importance of the criteria that do not correspond to practical experience. In literature this problem is solved by the combination of the results of subjective and objective methods. The results of one subjective (AHP) and one objective (Entropy) method are aggregated in order to determine criteria weights in the case of performance evaluation of the university departments [1]. Good example of integration of DEA and multi-criteria method TOPSIS is given in [2]. The authors developed DEA-based optimization models to facilitate identifying parameter information regarding criterion weights and quantifying qualitative criteria in TOPSIS. The weight determination model that incorporates subjective information provided by the Analytic Hierarchy Process (AHP) and objective information to form Data Envelopment Analysis is given in [3].

In this paper, comparative analyses of DEA and AHP and their aggregation are carried out, according to the importance of the first-year study subjects for choosing an appropriate study program on the example of FOS (Faculty of Organizational Sciences). The importance (weights) of subjects is used for ranking study programs for a particular student, based on his/her success achieved in the subjects that are common for all first- year programs.

The statistical regression methods are applied for predicting students results based on their success in high school graduation or entrance exam ([4] and [5]). Also, statistical methods are used to determine the parameters for the assessment of whether the student will withdraw or continue his/her study based on the first- year's results [6]. The approach based on DEA for user-oriented ranking that is developed to help students select an appropriate college is shown in [7]. Multi - criteria AHP method is used in higher education for selection of candidates for teaching positions [8]. AHP method was applied to determine the complicity and priority of selection criteria. The selection of doctoral studies, depending on the objectives that the applicant wants to achieve in his/her career, was done using AHP [9]. Perspectives are set as a pseudo-level in the hierarchy and for each of them the ranking of doctoral studies is done, thus a student can choose based on their preferences. In the paper [10] authors have created the system of knowledge management that determines the minimum distance between existing and new cases and gives a recommendation to a student.

The paper consists of four sections. Apart from the introduction, theoretical basis of DEA and AHP is given. The methodology for selecting the study program based on the first-year marks is presented in the third section. The first part of this section is devoted to determining the subject weights and defining aggregated measure. Afterwards, the methodology is illustrated on hypothetical examples of selection based on all first- year subjects, and on a subset of relevant first- year subjects. In the fourth section, concluding remarks and further research directions are given.

2. BACKGROUND

The aggregated measure as a combination of one objective and one subjective measure are used to determine the importance of the criteria. The DEA method is used for obtaining objective measures, while AHP method is used for obtaining subjective measures. The bases of these methods are given in this section.

2.1 DEA

DEA has been widely used for evaluating the relative performance of similar decision making units (DMUs) with multiple inputs and outputs. The original DEA model was given in [11], who tried to generalized single-input to single-output ratio definition of efficiency to ratio of sum of weighted outputs to sum of weighted inputs. Suppose that DMU_j ($j = 1,\dots,n$), within set of n units, uses inputs x_{ij} ($i = 1,\dots,m$) to produce outputs y_{rj} ($r = 1,\dots,s$), absolute efficiency measure [12] model is as follows:

$$E_j = \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i x_{ij} \quad (1)$$

where v_i ($i = 1,\dots,m$) are input multipliers and u_r ($r = 1,\dots,s$) are output multipliers (weights).

The above definition corresponds to a discrete multi-criteria decision making (MCDM) method. The determination of weights is a very sensitive and complicated process. The weights selected a priori, as in MCDM models, can significantly affect the results of the efficiency calculation. Following that idea, the authors of DEA model in [11] allowed each DMU to choose the most appropriate set of weights in order to become as efficient as possible in comparison with the other units in the observing set. Relative efficiency ratio is scaled between 0 and 1, and all efficient units have the same ratio equal to 1. The LP weighted form of the basic CCR model is as follows:

$$(\max)\ h_k = \sum_{r=1}^{s} u_r y_{rk} \quad (2)$$

st.

$$\sum_{i=1}^{m} v_i x_{ij} = 1 \quad (3)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0,\ \ j = 1,\dots,n \quad (4)$$

$$u_r \ge \varepsilon;\ \ r = 1,2,\dots,s, \qquad v_i \ge \varepsilon;\ \ i = 1,2,\dots,m, \quad (5)$$

The optimal values of efficiency scores h_k are obtained by solving the linear model (2)-(5) n- times (once for each DMU in order to compare it with other DMUs). As a solution of basic CCR DEA models, efficiency score h_k is 1 for all efficient units and lower than 1 for all inefficient units. All inefficient units are enveloped by production frontier, consisted of efficient DMUs, and for each of them an analyst could find benchmark (real–efficient or virtual-composite peer unit lying on efficiency frontier).

2.2 AHP

A subjective model which is widely used in decision-making is the analytic hierarchy process (AHP) introduced by [13]. Every problem is treated in terms of hierarchies - a system of stratified levels, each consisting of several elements. AHP views the problem as a system and decomposes it into elements. It involves pair-wise comparisons of decision variables (e.g., objectives, alternatives according to some attribute they share or a criterion they should meet. Preference is denoted by a vector of weights following an AHP scale of relative importance which is the basis for calculation of a relative weight for each decision variable. Furthermore, inconsistent comparisons are addressed by means of an internal procedure which detects inconsistencies according to an arbitrary consistency ratio of 10%. Remarks on AHP with review of basic axioms and ways of altering weights and rankings are given in detail in [14]. The procedure, however, is limited by the number of factors that can be compared. An individual cannot simultaneously compare more than nine objects without being confused [13].

A comprehensive overview of the AHP method and its application in different areas is given in [15]. The areas of applications are divided into several groups such as: selection, evaluation, planning and development, allocation, ranking and priority, decision making, and forecasting. In our case, AHP is used for evaluation and prioritization of subjects as alternatives. The results are used as the basis for recommendations for a study program selection.

3. CRITERIA WEIGHTINGS

There are four study programs at the Faculty of Organizational Sciences (FOS): Information systems (IT), Management (ME), Quality management (KV), and Operations management (OM). On completion of the first year, which has common subjects for all programs, students choose one of these programs. The aim of this work was to develop a methodology that could help every student to choose a program that would suit him/her best, i.e. where they will achieve highest efficiency. If a student fails to enroll the suitable program, the order in which the remaining study programs should be selected is determined.

Phases in the implementation of the proposed methodology are as follows:

I Gathering data on graduates (entry);
II Evaluation of the first year subjects;
III Selection and ranking of programs for a new student.

3.1 GATHERING ENTRY DATA

Data collection is the same as in [10]. The data used here were obtained from the Faculty of Organizational Sciences Students' Service database. The data on 847 graduates who enrolled FOS 2002 and 2006 were selected to be analyzed. For each student, we have collected information on 11 subjects' marks: Economics (EC), Mathematics1 (MA1), Management (MN), Fundamentals of Information Communication Technology (OIKT), Sociology or Psychology (S/P), Foreign Language 1 (SJ1), Mathematics 2 (MA2), Fundamentals of Organization (OO), Production systems (PS), Introduction to information Systems (UIS), Foreign Language 2 (SJ2). Belgrade University ranking system: 5 to 10, where 5 means fail and 10 means full mark. The Average mark (GPA) was used as a key performance that indicates students' success. These data were used in all approaches. Descriptive data statistics is given in Table 1.

Table 1 shows that study programs are not unified in terms of the number of students. Students usually choose to study one of the two major programs, IT with 38% and MN - 41.3%. Next on the list is program KV with 17%, while only 3.7% of students choose study program OM. Looking at the average marks in the first year and at the end of the studies it can be seen that students of all study programs tend to improve their results towards the end of studies.

Table 1 Descriptive statistics of entry data

Program	No. of students		Subjects											Average	
			EK	MA1	MN	OIKT	S/P	SJ1	MA2	OO	PS	UIS	SJ2	Marks in first year	Marks in the end
IT	322	Average	7.2	8.02	7.75	8.29	8.02	7.5	8.09	8.48	8.48	8.13	7.66	7.97	8.36
		SD	1.27	1.24	1.22	1.02	1.28	1.26	1.17	1.17	1.19	1.03	1.32	0.74	0.63
MN	350	Average	7.12	7.43	7.79	7.75	8.09	7.51	7.49	8.4	8.06	7.72	7.59	7.72	8.35
		SD	1.2	1.14	1.26	0.99	1.21	1.18	1.2	1.22	1.25	1.08	1.27	0.67	0.62
KV	144	Average	6.92	7.27	7.44	7.68	7.53	7.11	7.39	8.03	7.92	7.63	7.16	7.46	8.12
		SD	1.11	1.13	1.23	0.99	1.18	1.08	1.13	1.33	1.24	0.93	1.13	0.65	0.66
OM	31	Average	7.29	7.84	7.87	8.03	8.23	7.13	8.16	8.13	8.55	7.74	7.26	7.84	8.57
		SD	1.2	0.81	1.36	0.9	1.21	1.1	0.92	1.1	1.04	0.84	1.16	0.54	0.45

Based on the average marks per subject, we can distinguish three groups of subjects. The first group consists of subjects PS-OO, where students of all study programs achieve similar, high average marks. Another clearly distinctive group consists of subjects where students of all study programs achieve average low marks (EC, SJ1).

The third group consists of subjects where no apparent laws could apply to all study programs. Therefore, in-depth analyzes are performed for determining the impact of individual first-year subjects on a particular study program success using DEA and AHP methods.

3.2 SUBJECTS EVALUATION

In determining the priority of the first year subjects that are relevant for predicting future students' success, one objective (DEA) and one subjective (AHP) method are used. The final grade is obtained by aggregating the results of objective (DEA) and subjective methods (AHP).

Evaluation by DEA

The selection of the first-year subjects that are relevant for choosing a study program, is done based on average weights using DEA method. The value of weights can be reached in two steps. First, we evaluate the relative efficiency of each student. In doing so we determine such a weight for each subject that will show a student as efficient as possible, considering the results during studying, (average mark) compared with other students. In the next step, we determine the average weight for each of 11 first-year subjects.

For assessing the relative efficiency of each student, they are observed as units (DMU). The first-year subjects present 11 inputs, while average mark represents output. Considering the nature of input, information about first- year subject marks are transformed so that they present a deviation of full mark (10).

Since the aim of the analysis is to determine the weight of a subject, the input- oriented DEA model (2-5) is selected. Descriptive statistics of DEA results, which are obtained by using specialized software DEA - solver [16], divided into study programs according to students' affiliation, is given in Table 2.

Table 2. Descriptive statistics of DEA results

Program	No. of students	Efficiency			
		Average	SD	Max	Min
IT	322	0.51	0.40	1	0.02
ME	350	0.46	0.40	0.99	0.02
KV	144	0.36	0.38	0.98	0.02
OM	31	0.52	0.40	0.96	0.04

Table 2 shows the average values related to efficiency, standard deviation, maximum and minimum values of the efficiency index by study programs. Measured by average efficiency, the OM students are the most successful ones, followed by IT, ME and KV. Approximately equal standard deviation values indicate that homogeneity of all students in all study programs is similar. Maximum efficiency index 1, in the IT study program, is given to the most successful student (with average mark 10) and he/she is the only efficient one and the reference for all other students.

As it is already mentioned, the relative efficiency is calculated as the ratio of weighted sum of outputs and the weighted sum of inputs (eq. 1). This analysis is not focused on determining the efficiency of the student, as is usually the case when applying DEA, but on the weights.

One of the DEA output is a matrix of weights for the inputs (outputs). As the ultimate goal of the research is evaluation of subjects which are inputs of DEA, we shall look at the matrix of inputs weights ($v_{ij}, i=1,...,11, j=1,...,n_k$) with dimensions $11\times n_k$, where n_k presents the number of students in observed study program (k=1,...,4). Based on weights, for every student we calculate average input weights for each study program as follows:

$$z_{ik} = \left(\sum_{j=1}^{n_k} v_{ij} \right) \Big/ n_k , i=1,...,11, k=1,...,4 .$$

Their normalized values are given in the table 3.

Evaluation by AHP

AHP is used for attribute weightings (determining the weight of subject) of the first- year study subjects, for each study programs. The hierarchy of problem in is set on two levels with a third, pseudo level, similar to [9]. The described main goal is on the first hierarchy level. As all subjects have different importance (weights) for different study programs (S_k, k=1,…,4), the main goal will be observed from different perspectives, that is, for each study program separately. As shown in Figure 1, the study programs are set as pseudo levels below the main goal.

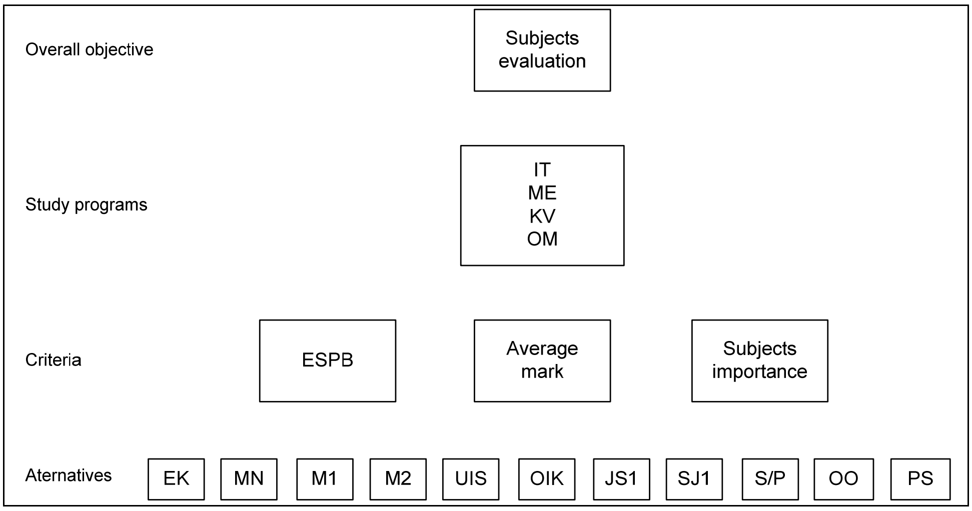

Fig. 1. Subject weighting hierarchy

The importance of subjects for each of the study program is determined on the third level criteria: two objective and one subjective criterion (C_l, l=1,2,3). The objective criteria are ECTS credits (ECTS) and the average mark. The value of ECTS credits is official information specified in the accreditation program. The values are taken from the Faculty's Student Service database. The subjective criterion is an expert evaluation of relevant subject importance for each study program (Subject importance). It is obvious that subjects are evaluated as set alternatives (A_i, i=1,…,11), for each study program separately.

In the first stage of evaluation, the comparisons matrix (pair-wise comparison matrix) is created for each study program, based on a subjective expert assessment. In the second phase we enter grades for each alternative, per each criterion. The final result of evaluation is weights of all alternatives (subjects) for each study program separately in relation to the set goal. Weights, which represent the synthesized importance of subjects in choosing study program process (w_{ik}, i=1,...,11, k = 1, ..., 4) are shown in Table 3.

Aggregated DEA-AHP measure

Flexibility in assigning weights when solving DEA model, as an objective approach, can lead to wrong estimates of individual units (students) under consideration. This is the result of neglecting certain inputs (outputs) that have too large (or too small) values in comparison with other units.

In addition, Table 2 shows that standard deviations of subject marks are different. This leads to the situation that DEA cannot make discrimination for subjects with a low standard deviation and that it assigns them very low weights.

On the other hand, when determining the importance of alternatives, AHP does not take into account the information about individual marks, but only the average values and subjective values of decision makers. Since in this research the importance of input (objects) is crucial, it is necessary to combine objective and subjective assessments. On the one hand, AHP corrects the impact of student marks in some subjects and includes a subjective evaluation of a decision maker and the importance of the subject from the ECTS perspective. On the other hand, the DEA grade brings about objectivity obtained solely only on the basis of empirical values.

The objective weights, determined by DEA and subjective weight w_{ik} determined by AHP, are combined into an aggregate weight ag_{ik} as follows:

$$ag_{ik} = z_{ik} w_{ik} \Big/ \sum_{i=1}^{11} z_{ik} w_{ik}, i = 1,...,11, k = 1,...,4 \qquad (6)$$

Their values are shown in Table 3.

Table 3. Weighs obtained by DEA, AHP and aggregated DEA-AHP measure

Study program	Method	Subjects										
		EK	MA1	MN	OIKT	S/P	SJ1	MA2	OO	PS	UIS	SJ2
IT	DEA	0.116	0.239	0.089	0.093	0.126	0.076	0.034	0.104	0.105	0.001	0.017
	AHP	0.071	0.109	0.085	0.125	0.075	0.038	0.111	0.104	0.103	0.129	0.050
	DEA-AHP	0.090	0.282	0.082	0.126	0.103	0.031	0.041	0.118	0.117	0.001	0.009
MN	DEA	0.118	0.051	0.192	0.062	0.235	0.062	0.040	0.129	0.074	0.014	0.023
	AHP	0.103	0.082	0.122	0.082	0.084	0.044	0.083	0.141	0.117	0.089	0.053
	DEA-AHP	0.121	0.042	0.235	0.051	0.197	0.027	0.033	0.182	0.087	0.012	0.012
KV	DEA	0.090	0.142	0.163	0.047	0.116	0.060	0.057	0.213	0.109	0.000	0.003
	AHP	0.087	0.082	0.122	0.082	0.084	0.044	0.083	0.141	0.133	0.089	0.053
	DEA-AHP	0.075	0.111	0.189	0.036	0.093	0.025	0.045	0.286	0.138	0.000	0.002
OM	DEA	0.066	0.008	0.344	0.123	0.273	0.005	0.060	0.005	0.115	0.000	0.000
	AHP	0.085	0.096	0.119	0.081	0.084	0.044	0.097	0.123	0.130	0.088	0.053
	DEA-AHP	0.055	0.008	0.402	0.098	0.225	0.002	0.057	0.007	0.146	0.000	0.000

The first thing that can be noticed by weights analysis from Table 3, is that the range of their values is smaller with AHP then with DEA method and that, unlike with DEA, using AHP method, none of the subject has been marked as insignificant.

Normalized weights, according to DEA method, presented in Table 3, show that S/P marks had influence on efficiency of students in all study programs, while subjects ME and OO had significance in determining the efficiency of the students in three out of four student programs. This shows that almost all first-year students have achieved good results from these subjects.

The students in IT program have shown good results in MA1. As it was expected this subject will have the biggest influence (0.239) in assessing capability of students to enroll the IT program. The same situation is with the subject of MN in OM study program whose weight is 0.34. But subjects OIKT and UIS, which are expected to be important to IT students, got small weights (below 0.1) which are the result of low standard deviations, that is, there are other subjects that make students more distinctive.

On the other hand, as AHP includes expert evaluation of a subject importance as one of the criteria, subjects OIKT and UIS got highest weights (0.129 and 0.125). The same situation refers to the subject OO in the study program OM. Thus, using DEA method, this subject was given a small value of weighting, while with AHP, where the expert importance grade is high, it was declared as the second most important (0123). This can be also seen by looking at subjects ranks in Table 4. By looking at the values in the same table, similar analysis can be made for study programs MN and KV.

Table 4 Subject ranges obtained by the DEA, AHP and aggregate grade DEA- AHP

Study program	Method	Subjects										
		EK	MA1	MN	OIKT	S/P	SJ1	MA2	OO	PS	UIS	SJ2
IT	DEA	3	1	7	6	2	8	9	5	4	11	10
	AHP	9	4	7	2	8	11	3	5	6	1	10
	DEA-AHP	6	1	7	2	5	9	8	3	4	11	10
MN	DEA	4	8	2	6	1	6	9	3	5	11	10
	AHP	4	8	2	8	6	11	7	1	3	5	10
	DEA-AHP	4	7	1	6	2	9	8	3	5	10	10
KV	DEA	6	3	2	9	4	7	8	1	5	11	10
	AHP	5	8	3	8	6	11	7	1	2	4	10
	DEA-AHP	6	4	2	8	5	9	7	1	3	11	10
OM	DEA	5	7	1	3	2	8	6	8	4	10	10
	AHP	7	5	3	9	8	11	4	2	1	6	10
	DEA-AHP	6	7	1	4	2	9	5	8	3	10	10

Since the aggregated measure is a normalized product of two measures, the objective measure of DEA will have the greater impact on its value because of its wider range of weight values. AHP was able to correct results only for subjects where DEA method has not assigned extremely small weights. For example, in the Table 4 we can see that subject OIKT in the study program IT, got the same rank both with aggregate measure (DEA-AHP) and AHP method, while the subject UIS, in the same study program, was ranked as the least in important using both aggregated measure and DEA method. This result was expected considering the values of corresponding weights in Table 3.

3.3 STUDY PROGRAM SELECTION

Normalized weights of DEA-AHP in Table 3 can be used for predicting future students' success, after completion of the first year of study, resulting in the recommendation which study program they should select. Students' success is estimated by aggregate weight.

Implementation steps:

1. Collect new student's first- year marks;
2. Evaluate study programs based on the aggregated importance of weights by the method of sum of weights:

$$O_k = (\sum_{i=1}^{11} ag_{ik} \cdot subject's\_mark_i),\ k = 1,...,4\ ;$$

3. Determine which study program would suit the student best: ($\max_k O_k$).

As shown, step 2 can be implemented taking into consideration weights of all subjects, or by selecting the relevant ones. The aggregated method selected for weights causes that a subject can be relevant only if it does not get extremely low weight from any of the measures. In a selection process two approaches were used:

Approach 1. The subjects, which have sum of aggregate weights greater than the given threshold, are considered relevant. The selection of these subjects is based on the values in Table 3.

Approach 2. The first $t \leq 11$ subjects ranked are considered relevant (for example 5).The selection of these subjects is based on values in Table 4.

The selected subjects, according each study program are shown in Table 5.

Table 5 Selected subjects:

	Approach 1	Approach 2
IT	MA1, OIKT, OO, PS	MA1, OIKT, OO, PS, S/P
MN	MN, S/P, OO	MN, S/P, OO, EK, PS
KV	OO, MN, PS	OO, MN, PS, MA1, S/P
OM	MN, S/P	MN, S/P, PS, OIKT, MA2

The suggested methodology is illustrated by the group of 12 hypothetic students whose all first- year subjects marks are known. For each student all study programs are ranked based on aggregate weight values based on all subjects or the ones that are selected by approach 1 or Approach 2. The student records and their results are shown in table 6.

Table 6 Study programs recommendation

Student	Average mark 1st year	All subjects	Approach 1	Approach 2
1	8.18	ME - KV - OM – IT	KV - ME - OM – IT	ME - KV - OM – IT
2	6.82	KV - ME - IT – OM	KV - ME - IT – OM	KV - IT - ME – OM
3	10.00	*OM - KV - ME – IT*	*OM - KV - ME – IT*	*OM - KV - ME – IT*
4	7.64	OM - KV - ME – IT	OM - ME - KV – IT	OM - ME - KV – IT
5	6.82	IT - OM - ME – KV	IT - OM - ME – KV	IT - OM - KV – ME
6	9.82	OM - KV - IT – ME	*OM - KV - ME – IT*	*OM - KV - IT* – ME
7	7.45	KV - ME - IT – OM	KV - ME - IT – OM	KV - ME - IT – OM
8	6.27	KV - *ME - IT* – OM	KV - IT - ME – OM	KV - IT - ME – OM
9	9.18	IT - KV - ME – OM	IT - KV - ME – OM	IT - KV - ME – OM
10	7.55	KV - ME - IT – OM	KV - IT - ME – OM	KV - ME - IT – OM
11	6.91	IT - OM - KV – ME	IT - KV - *OM – ME*	IT - OM - KV – ME
12	9.27	OM - ME - KV – IT	*OM - KV - ME* – IT	OM - ME - KV – IT

Based on results from Table 6, students get recommendations which study program he/she should select as their first choice based on their first-year success. If a student is not able to study the recommended study program, in Table 6, he/she can find the order in which they should select alternative study programs.

In the second column, we can find the sequence of study programs when all subjects are considered while grading, in the third one – programs that are chosen according to Approach 1 and in forth the programs selected according to Approach 2.

The Italics point that the programs are of the same rank. It can be noticed that student No.3 could choose any of the programs because since his/her average mark is 10.00. This example shows that, in most cases, the same study program is selected as the first choice using any of the approaches for subject reduction, or evaluating all subjects.

We can find deviation only in student No.1 when the grade is calculated according to Approach 1. For student No. 6 the ranking was not made by any of the approaches –when the subject number is reduced. In the case of student No. 12 there was no ranking according to Approach 1. From Table 5 we can see that the fewest number of subjects was included when using this Approach.

The analysis has shown that the number of subjects can be reduced only in the case of one selected study program. When ranking study programs, the deviation is 25% in relation when all subjects are ranked. This result shows that we need to be very careful when selecting reduction criteria. The list of relevant subjects can be selected on the basis of multi-criteria simulation. Also, the reliability of results obtained with a narrowed list of criteria (subjects) can be increased if the aggregate measure is created based on the results of more subjective and objective methods.

Many students do not opt out of personal interest only, but also for other reasons. The final decision can be made out based on: obtained prediction, students' academic experience, motivation and expectation regarding future career. They can also change professional vocation during career [17].

4. CONCLUSION

Most students select study programs based on personal preferences related to the subjects the study program includes and career qualification. However, if the study program is to be selected after the first-year of study, we can predict students' success based on the first-year grades evaluation and help them select the most appropriate study program. That was the first goal of this research.

In this paper, the prediction of success in each of the four study program is based on the weights assigned to the first- year subjects. First, we have estimated 847 students efficiency using DEA. Subject weights were calculated as the average weight assigned to each subject. Then, using AHP the subjects were evaluated as alternatives based on three criteria: ECTS, average mark, and an expert evaluation of a subject importance to different study programs. Subject weighs were identified as synthesized weight alternatives. Finally, we got weights obtained by aggregate measure which combines the objective DEA and subjective AHP measures. In that way we have reduced the subjectivity of information obtained using AHP, and we have reduced DEA flexibility in assigning weight only on empirical data basis.

The second goal was to investigate whether it is necessary to take into consideration all first- year subjects or a set of selected relevant subject is enough. In selecting relevant subjects we have used two approaches: the sum of selected subject weights should exceed a given threshold and a given number of first ranked subjects. On a hypothetical example, it is shown, that if the threshold is properly chosen, the reduced number of subjects gives the same study program as the first choice , as well as when all subjects are taken into consideration. However, the complete sequence of all study programs is different.

Therefore, if it is necessary to reduce the list of criteria, the approach to the reduction is very important. Reliability of results obtained by the reduced set of criteria can be enhanced using a number of methods whose weights will be included in aggregated measure.

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