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INTRODUCTION

This Proceedings comprises papers from the **International conference on Information technology and development of education** that is held in the National House of Mihajlo Pupin, Idvor on June 27th 2014.

The International conference on Information technology and development of education has had a goal to contribute to the development of education in Serbia and in the region, as well as, to gather experts in natural and technical sciences' teaching fields.

The expected scientific-skilled analysis of the accomplishment in the field of the contemporary information and communication technologies, as well as analysis of state, needs and tendencies in education all around the world and in our country have been realized.

The authors and the participants of the Conference have dealt with the following thematic areas:

- Theoretical and methodological questions of contemporary pedagogy
- Personalization and learning styles
- Social networks and their influence on education
- Children security and safety on the Internet
- Curriculum of contemporary teaching
- Methodical questions of natural and technical sciences subject teaching
- Lifelong learning and teachers' professional training
- E-learning
- Education management
- Development and influence of IT on teaching
- Information communication infrastructure in teaching process

All submitted papers have been reviewed by at least two independent members of the Science Committee.

The papers presented on the Conference and published in this Proceedings can be useful for teacher while learning and teaching in the fields of informatics, techniques and other teaching subjects and activities. Contribution to science and teaching development in this region and wider has been achieved in this way.

The Organizing Committee of the Conference

CONTENTS

QUALITY VALORIZATION OF UNIVERSITY STUDY PROGRAMS USING LINEAR PROGRAMMING APPLICATION

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Abstract - Measuring quality of education is one of the most important issues of the Universities management. The final result of the good quality evaluation gives precise guidelines of improvements and what should be done to increase efficiency in the high education productivity, whose target is to deliver knowledge and skills to students and future academic individuals as base of the society overall development. Of course, this production (knowledge as output) requires certain investments of resources (teachers, equipment, conditions), that can be treated as input. In such manner, measuring the output/input ratio, using specific LP technique known as Data Envelopment Analysis can give perspective of efficiency of the study process.

The application includes precise input/output model represented in all courses within the analyzed study program that collect all real input resources and all real output indicators done by complex survey. In such an environment, the result is represented in efficient and non-efficient courses within the study program. Through a comprehensive review of the results, discussion is done for the reasons of inefficiency. In addition, using DEA perception, concrete guidelines are proposed for management in order to optimize and increase efficiency to the non-efficient detected courses.

I. INTRODUCTION

Mathematical programming is an approach of selecting the best of the offered / possible alternatives to solve a particular problem (alternatives normally belong to a particular set). If a particular problem that is being analyzed is presented as a mathematical model reflecting certain real production function, the problem boils down to determining the optimum (minimum or maximum) value of the same. Linear programming which is a special case of mathematical optimization is an effective method that finds a huge application for solving optimization problems in the fields of industry, education, transportation, economy and etc. Application of LP involves pre modeling phase of the problem being analyzed and optimized, with its perception as part of the input / output system with inputs and outputs, represented by variables with their own characteristics, which have some specific linear constraints and ultimately through them, objective function can be represented mathematically (which is actually the subject of optimization, in the form of a linear equation). What is very important for correct application of LP is the generation of precise and clear reality reflecting mathematical model. In this context, LP is used as a powerful mathematical tool in the optimization process of the objective function, where it is meant to be a mathematical representation of the interdependence of the parameters that reflect the operation / production entity that is subject to analysis and optimization. and inequalities that reflect the reality. Nevertheless, some mathematical models have high complexity level and can not be solved through known mathematical optimization models. Then, not optimal, but “good enough” solution is the subject, using orientation and heuristic models [1].

A. LP and DEA

There are several important phases applied in this work (LP modeling):

1. Definition and problem formulation;
2. Model construction;
3. Model solvation;
4. Results and sensitivity analysis, and
5. Model evaluation and further implementation.

The general mathematical representation of the problem which is the subject of optimization using mathematical programming is:

- Finding extreme value (maximizing or minimizing) of $f(X)$ (where $f(X)$ is the objective (target) function), and
- The restrictions: $g_i(X) \leq 0,\ i = 1, 2, \dots, m;\ X \geq 0$, where $X = (x_1, x_2, \dots x_n) \in R^n, f(X), g_i(X), i = 1, 2, \dots m$ are functions of real values vector X. If $f(X), g_i(X)$ are linear functions (linear equations and inequalities), then the problem can be solved with linear programming techniques. Otherwise, it is a problem that is subject to nonlinear programming (out of our scope).

More expanded, LP problem can be noted as follows:

- Objective function (minimize of maximize):

$$F(x_1, x_2, \dots x_n) = c_1 x_1 + c_2 x_2 + \dots + c_n x_n = z$$

- System of restrictive (in)equalities:

$$a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \leq b_1$$
$$a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n \leq b_2$$
$$\dots\dots\dots$$
$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \leq b_m$$
$$x_1, x_2, \dots x_n \geq 0$$

Here, $a_{ij}, i = 1, \dots, m; j = 1, \dots, n$ are called technological coefficients, $c_i, i = 1, \dots, n$ are called weight coefficients (or just weights) and the variables $x_1, x_2, \dots, x_n$ are called decisive variables. By definition, optimal solution is the solution that belongs to the set of allowed solutions that maximize (minimize) the objective function.

One concrete application of linear programming is implicitly presented in DEA technique (Data Envelopment Analysis). By the books, frontier analysis is designed for organization quality measurement and performance improvement, as main intention of the management. Frontier analysis uses DEA as powerful tool in this manner. It is nonparametric non-statistical multi-criteria method that allows handling heterogeneous data. Based on LP, it is used for measuring technological efficiency. DEA declares as effective those entities which produce a certain or more output parameters with fixed inputs or use the same or a smaller quantity of inputs to produce a certain output, compared with the other subjects within the same group being analyzed. Entities are called DMUs (Decision Making Units) and they have to be homogenous. All DMUs have same inputs and outputs in different quantities. DMU can be institution, bank, human, production line, vehicle, part of vehicle etc. Maybe one of the biggest DEA advantages is that inputs and outputs can be heterogeneous and completely independent in manner of quantity and perception.

B. DEA Equitations

Technical efficiency of a single DMU is defined as:

$$\theta = \frac{Output}{Input}$$

and is termed as pareto efficiency, if allocation of the resources (input and output) is such that better performances are not possible for the entity analyzed. Pareto efficient subject is the subject (entity) with best possible allocation of the resources. Here, it is impossible to improve the output (and increase the DMU's efficiency) without worsening the input.

In set of n DMUs with m inputs and s outputs of each DMU, the efficiency of k-th DMU is defined as:

$$\theta_k = \frac{u_1 y_{1k} + u_2 y_{2k} + \dots + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + \dots + v_m x_{mk}}$$

where $x_{1k}, x_{2k}, \dots, x_{mk}$ are the inputs of the k-th DMU, $y_{1k}, y_{2k}, \dots, y_{sk}$ are the outputs of the k-th DMU, $v_1, v_2, \dots, v_m$ are inputs' weight coefficients and $u_1, u_2, \dots, u_s$ are outputs' weight coefficients, with mathematical limitation (in connotation of the reality):

$$v_1, \dots, v_m \geq 0, u_1, \dots, u_s \geq 0.$$

From here, DEA CCR CRS is interpreted as follows [2]:

- Find $max\ (\theta_k = \frac{u_1 y_{1k} + u_2 y_{2k} + \dots + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + \dots + v_m x_{mk}})$,
- Having limitations:

$$\frac{u_1 y_{11} + u_2 y_{21} + \dots + u_s y_{s1}}{v_1 x_{11} + v_2 x_{21} + \dots + v_m x_{m1}} = \frac{\sum_{i=1}^{s} u_i y_{i1}}{\sum_{j=1}^{m} v_j x_{j1}} \leq 1$$
$$\dots$$
$$\frac{u_1 y_{1k} + u_2 y_{2k} + \dots + u_s y_{sk}}{v_1 x_{1k} + v_2 x_{2k} + \dots + v_m x_{mk}} = \frac{\sum_{i=1}^{s} u_i y_{ik}}{\sum_{j=1}^{m} v_j x_{jk}} \leq 1$$
$$\dots$$
$$\frac{u_1 y_{1n} + u_2 y_{2n} + \dots + u_s y_{sn}}{v_1 x_{1n} + v_2 x_{2n} + \dots + v_m x_{mn}} = \frac{\sum_{i=1}^{s} u_i y_{in}}{\sum_{j=1}^{m} v_j x_{jn}} \leq 1$$
$$v_1, \dots, v_m \geq 0, u_1, \dots, u_s \geq 0;$$
$$x_{ij} \geq 0, y_{rj} \geq 0; i = 1, \dots, m; r = 1, \dots, s; j = 1, \dots, n.$$

DEA finds such weights that maximizes each DMU's efficiency, no matter of the real input or output values and in correlation of all other DMUs. In this way, it forms frontier line consisted of best DMUs with efficiency = 1. All inefficient DMUs have efficiency below 1 and are called inefficient.

Often, as in this paper, the dual DEA CCR model is used. It is represented with following equations:

- Find $min\theta$
- Having limitations:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{i0}, \qquad i = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}, \qquad r = 1, \ldots, s$$

$$\lambda_j \geq 0, \qquad j = 1, \ldots, n$$

where index 0 represents each DMU that equitations are solved for (in order to maximize its efficiency – observed DMU), lambdas are weighted coefficients that are used to represent the so-called composite DMU for each real DMU that will be located as inefficient. The composite DMU for each inefficient real DMU is consisted as sum of the ERS (efficiency reference set – efficient DMUs used for interpretation of the composite DMU for the observed real DMU) multiplied with its lambda coefficients. If A and B and efficient DMUs (m inputs, s outputs) and belong to the ERS set of observed inefficient C DMU, its composite DMU C' can be interpreted as:

$$\lambda_A \begin{bmatrix} y_{1A} \\ \cdots \\ y_{sA} \\ x_{1A} \\ \cdots \\ x_{mA} \end{bmatrix} + \lambda_B \begin{bmatrix} y_{1B} \\ \cdots \\ y_{sB} \\ x_{1B} \\ \cdots \\ x_{mB} \end{bmatrix} = \begin{bmatrix} y_{Composite} \\ \cdots \\ y_{Composite} \\ x_{Composite} \\ \cdots \\ x_{Composite} \end{bmatrix}$$

DEA offers approach that is different from traditional optimization techniques, that analyze the profit / investment ratio and allows creation of "learning from the best" policy [3]

II. PROBLEM AND MODEL FORMULATION

The quality of a single process is reflected in the efficiency of the entity that is generator of that process. Having this approach in mind, the Universities can be perceived as generators of knowledge. More precise, the study programs and the courses within itself, through its theoretical and practical realization have function of production of knowledge and skills that should prepare the future academic person for the real sector. ECTS implementation should be implemented according to home legislative and with all procedures and steps for insuring study programs quality needs [4].

The model is based on forming the input of parameters whose increase will reduce the DMU's efficiency and output of parameters whose increase will increase the DMU's efficiency. The production of each course can be reflected of the type of the skills and knowledge delivered, as well as within the quality of the delivery (what did the student learned and the quality of the knowledge delivered). They form the output of the model. The input parameters are consisted of the resources spent for the realization of the study program, in terms of financial structure (gross salaries) for the teachers and assistants, financial structure for the equipment and inventory used and number of classes held. This builds the model:

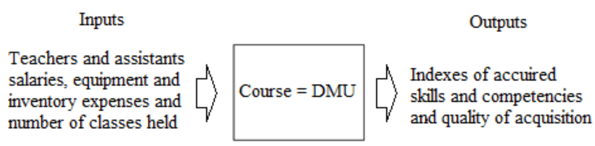

Figure 1. DEA Model

A. *Input and output definition and characteristics*

The model is applied on study program of informatics (Faculty of Informatics, generation 2007), at 24 courses from all the semesters. The selection of the courses is random, with no specific influence of observation.

Input is consisted of:

- Number of classes held, starting from the fact that classes load is often very important issue in terms of study program structuring as well as in forming groups of students and organizing the real implementation of the course - (1).
- Expenses that University had with equipment and inventory used for this study program. This is done by calculation of the degree of utilization, i.e. the ratio of annual depreciation of computer equipment and inventory used, in accordance with their gross purchase price and the legislation. Percentage of load / utilization in terms of number of students of the observed course and all students that used

the same equipment and inventory is considered – (2).

- Expenses that University had of hiring professors and assistants, no matter whether they are employed or external. Expenses are calculated in terms of gross salaries / expenses, with consideration of three months length (12 working weeks) of the semester (period of knowledge delivery) and the percentage of load in terms of number of students of the observed course and all students that the concrete person (teacher or assistant) covered during those three months. All increases and salary / expenses fluctuations are considered also – (3).

Two indexes represent the output:

- Index of the level of contribution of each course in skills, competencies and knowledge delivery, prescribed with the accreditation elaborate of the study program (IP-KKV). Massive survey was realized at representative sample of 28 (of total of 88 students graduated at the study program), that generated indexes' values – (4).
- Index of the quality of skills, competencies and knowledge delivered (IPKS-KKV) through the study program. This parameter, represented by the average grade of each course is calculated using the reporting module of the student information system of Goce Delcev University, fully automated for students' e-administration. – (5)

B. *Total input / output table*

With notation of the previous text, the numerical DEA model is represented with table 1:

TABLE 1. NUMERICAL DEA MODEL (ALL DMUs)

(1)	(2)	(3)	DMUs / Courses	(4)	(5)
24	28737,71	83066,86	English language 1	3,5714285715	9,0227
168	31190,88	122253,1	Electrical engineering	3,910742855	7,8181
252	28737,71	87609,05	Math 1	3,928571429	7,1705
168	31190,88	105634,6	Programing	4,267857143	6,8522
24	25154,8	79832,87	English language 2	3,571428572	8,8160
252	24766,98	101473,2	Linear algebra	3,875	7,5568
252	27093,87	101473,2	Math 2	3,982171427	7,0795
168	27093,87	107276,6	Objective programing	4,267857143	7
108	31979,06	36434,47	Probability and statistics	3,785714286	6,943181
96	31979,06	78218,35	Digital logic	4,285714286	7,1136
60	218481,7	51455,4	Operational systems	3,875	7,7045
96	218481,7	131314	Software processes	3,964285714	7,2954
96	218481,7	117407,6	Data structures and algorithms	4,25	6,9545
96	154104,2	187273,8	Computer architecture	3,678571429	7,1477
96	227342,5	62070,34	Data bases	4,321428572	7,318181
72	118954,8	65492	Internet programing	4,339285715	7,2386
72	12381,86	62527,75	Microprocessors	3,571428572	6,7954
72	13413,68	64872,67	Software analysis and modeling	3,928571429	7,125
48	128867,7	65273,13	Graphics and visualization	4,160714286	8,1704
72	128867,7	95668,31	Multimedia	3,982142857	7,6931
72	87132,91	64428,28	Visual programing	4,339285715	7,0568
72	7203,188	90306,62	Intelligent systems	4,142857143	7,6931
72	7536,731	67004,76	Distant learning systems	3,196428572	7,60227
72	7536,731	57935,99	Software projects management	3,821428571	7,0113

DEA technique takes all inputs and outputs of each course separately and tries to "optimize" it, i.e. to set its weight coefficients in such values to make it efficiency equals to 1, using linear programming / equations elaborated before. If it is not possible in this environment, their efficiency is calculated bellow 1. Courses not mentioned in the table 1 and all other influences and conditions are totally excluded. Whether there is need to include other factor, model needs to be changed and all calculations need to be done from the very beginning.

III. Results and Discussion

With processing of the input and output parameters in DEA software solution (there are many available open source applications that can be used for this purpose / here is used Open Source DEA Application), results give picture of efficient and inefficient courses:

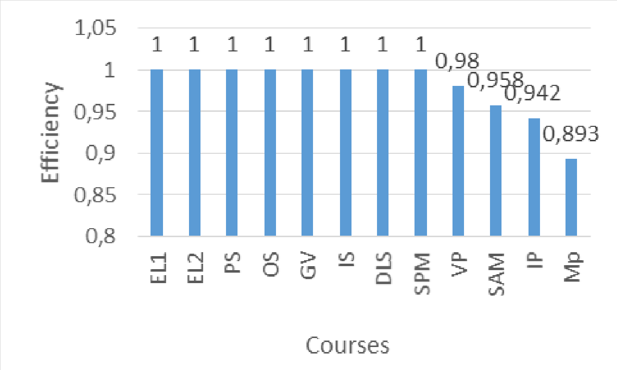

Figure 2. Efficiency of courses (part 1)

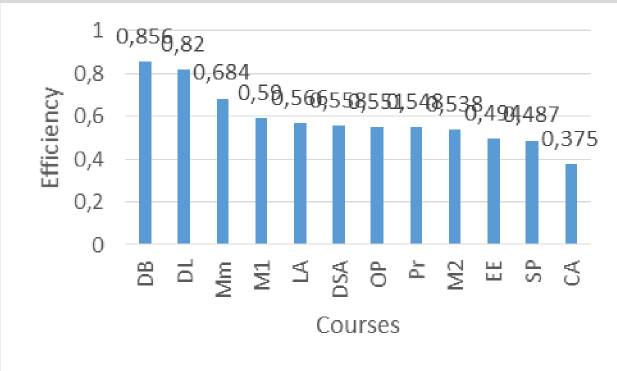

Figure 3. Efficiency of courses (part 2)

Courses with efficiency = 1 are noted as relativly efficient courses and are set of representative courses for the courses with efficiency bellow 1, noted as inefficient courses. Most efficient courses are used in most of the cases of composite courses. Table 2 shows number of use of every efficient course (consisting Efficiency Reference Set – ERS) in creating composite courses.

TABLE 2. ERS COURSES (DMUS)

ERS Courses	Number of times used
English language 1	0
English language 2	6
Probability and statistics	12
Operating systems	2
Graphics and visualization	10
Intelligent systems	0
Distance learning management	0
Software projects management	16

Three courses are used most often in creating composite units: Software projects management, Probability and statistics and Graphics and visualization. This means that they form the "best" part of the frontier, or that they have the best resource allocation in this conditions and constellations. Worst resource allocation has the course Computer Architecture, with worst (biggest possible) input constellation and worst (smallest possible) output constellation.

Table 3 illustrates the composite units for each inefficient course. DEA propagates that, in order to make inefficient DMUs efficient, changes have to be made that will cause for each inefficient course to became as closer it is possible as its composite DMU / course, that lays on the frontier (set of best possible courses, virtual or real). For constant output, every composite entity is consisted as sum of the multiplications of lambdas and inputs of the ERS entities, qualified as efficient.

Further analysis can be made, in order to present clear picture to the University management and propose changes for efficiency increase. Figure 4 pictures the ratio between expenses for teacher and assistants and the efficiency. It illustrates that the efficient courses are located in lower right corner of the diagram, and the most inefficient courses are located in the upper left corner of the diagram. Exactly the course Computer Architecture is located as most inefficient, especially in terms of teachers and assistants expenses. Given this fact, in opposite, the course Probability and statistics is located as most efficient course. This type of ratio can be shown for all inputs and outputs of the model applied. The difference is in case of the outputs ratio – the best DMUs will be located in the upper right corner and the worst will be located in the lower left corner.

TABLE 3 COMPOSITES OF INEFFICIENT DMUS

Composites	ERS					
	EL2	PS	OS	GV	SPM	
Inefficient course						Production levels
EE	0,0865 14754	0,2302 96305	0	0	0,7782 29001	
M1	0	0,3755 90319	0	0	0,6559 57254	
Pr	0	0,3258 30999	0	0,0093 57358	0,7838 48429	
LA	0	0,2402 52428	0	0	0,8398 84745	
M2	0	0,2745 388	0	0	0,7700 90534	
OP	0	0,2658 67267	0	0	0,8534 39903	
DL	0	0,0559 3835	0	0,1357 79195	0,9182 45408	
SP	0,0806 24363	0	0	0,8047 43829	0,0858 40258	

DSA	0	0,0476 4483	0	0,9306 4462	0,0516 78035	
CA	0,5322 10613	0	0	0,3386 2454	0,0965 34391	
DB	0	0,3085 39831	0,8137 76755	0	0	
IP	0	0,2737 56379	0,0101 98233	0,7843 37473	0	
Mp	0,1055 63595	0,0492 5189	0	0,0074 17073	0,7790 54684	
SAM	0,0976 14486	0	0	0,0276 00157	0,9067 58254	
Mm	0,1429 15191	0	0	0,6441 93784	0,2071 01916	
VP	0	0,1897 35113	0	0,5980 11357	0,2964 46308	
	Lambdas (production levels)					

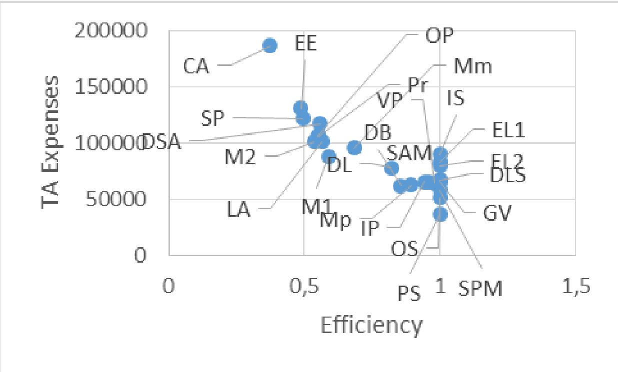

Figure 4. TA Expenses / Efficiency ratio diagram

IV. CONCLUSION AND OPTIMISATION SUGGESTIONS

Within this research, there is a factual quantification of the level of contribution and the quality of the acquired knowledge of one hand. Practically, we locate all items (in terms of courses) that invested more than necessary (and find its composite unit). In such manner, for efficiency increase, follow needs to be done:

- Reduce the cost of engagement of teaching and associate staff, as may be realized by increasing the effectiveness of the teachers and assistants that are is least burdened (and most "expensive"), by reducing the amount of gross financial structure / salaries and benefits for the teachers and assistants, consider the possibility of involvement of part-time teaching staff hired for a fee which in sum would be less than that spent on ineffective courses etc.
- Reduce costs for equipment and inventory, that for example can be realized through the purchase of inventory (computer tables and chairs) and / or computer equipment (computer units, projectors) in lower purchase price (though the trend is to reduce the cost IT equipment), by increasing the number of students who use the same computer (for example, two students per computer or summarized increasing availability of computers in the same number of students), increasing the rate of depreciation in terms of full time depreciation of material goods etc.
- Reduce the number of hours realized through reduction and convergence of study materiel in fewer hours, joining classes for lectures and exercises, reducing the number of groups of students (increasing the capacity of groups) and intervention within the study programs regarding the defined funds for hours for lectures, tutorials and student / practical activity.

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