Managerial instrument for didactic staff structure optimization for Distance Learning

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Abstract. Distance learning is a modern system for providing educational services and is relatively new in Romania, if related to the date of its emergence in Europe. More and more active working people are interested in this form of education, paying of course a special attention to its quality. It is quite difficult to appraise the quality of educational programs but several instruments and criteria have been developed over time. The present paper proposes an original mathematical instrument that is aiming at human resources, this type of resources being considered extremely important in case of providing educational service. The number of teachers is crucial for a distance learning program study, because the didactic staff must cover a number of didactic classes that take place on weekends. Concretely, this paper is focused on finding an algorithm that allows the didactic staff structure optimization. For accomplishing this objective, two managerial instruments were use. One of them is mathematical linear programing technique, that develops a mathematical model for didactic staff structure and the other one is *WinQSB* software package that tests the mathematical model.

1 Introduction

Distance learning is a modern system for providing educational services and is relatively new in Romania, if related to the date of its emergence in Europe. Over the last decade scientific and technological progress allowed a spectacular development of this form of education, as new communication tools were available for teachers as well as for students. As competition is continuously growing on educational market, people interested in distance education are of course paying a special attention to the quality of such programs. The quality standards elaborated by Romanian Agency for Quality Assurance (ARACIS) [1] are of course very important by they must be applied under the condition of resource optimization. The four categories of resources that are discussed in case of evaluation of the quality of any distance learning program study are: material resources, financial resources, human resources and informational resources. All these categories of resources have their importance and role, but when talking about the educational system human performance

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must be the core, because it directly influences the quality of didactic activities. The specialized literature is poor as regards the modalities of human resource optimization with a view to ensuring a high quality and efficient educational process. Usually, universities allocate human resources (didactic staff) to different didactic activities on the basis on human experience.

2 Distance learning in Romania

In Romania, the first distance learning study program was set up at the Academy of Economic Sciences of Bucharest in 1998. The Romanian distance learning system is a mixture between the American distance learning system that does not require the physical presence of the instructor, being based only on Internet communication tools [2] and European school that involves the physical presence of a teacher, of course combined with modern Internet communication tools [3]. In accordance with the founder of distance education in Romania, this is a modern form of education that supplies educational services for a wide variety of students from different fields. Distance learning is also helping students to learn how to learn in a modern environment supported by modern communication tools and is encouraging them to see the study activity as a continuous process [4]. In a general approach, distance education in Romania can be seen as a study system that makes available for students educational resources based on the following characteristics [4,5]: separation in time and space of students by the source that provides educational resources (the university that coordinates the distance learning study program); replacing the teaching activities (courses) by individual study; transmitting the learning resources by an environment specific for this form of education, which is the on-line electronic platform; student – teacher periodic meetings for deploying the applicative activities, such as seminars, laboratories, projects; access to a tutor for each student for coordinating the learning process and knowledge assimilation through evaluation tests; administrative assistance for every student, which is ensured by a special department that organizes the entire activity and the interface with teachers. The activities deployed within the Romanian distance learning system are: tutorial activities and homework, which are the equivalent of seminar classes of a traditional full time learning system, aided applicative activities, which are the equivalent of laboratories and project classes and individual studies, which are the equivalent of courses.

2.1 Distance learning resources

As specified before, distance learning must be based on four major categories of resources, as presented below [1, 5]. Table 1 identifies and briefly explains these categories of resources. The order of their appearance in the table does not take into consideration the importance of the resources. Each category of resources is as important as the others and they support each other. We cannot talk about a high quality distance learning without any of these categories. However, the present paper strongly highlights the importance of human resources, which are represented by didactic staff, because the human interaction is crucial for a well deployment of activities that take place in case of a distance learning study program.

Table 1. Distance learning resources.

Resource	Explanations
Material resources	They include proper spaces for deploying didactic activities, such as classrooms, rooms for seminars and projects, laboratories equipped with specific machine, tools and devices, Internet connected computer networks, multimedia software and hardware equipment and educational resources specific for distance learning education, such as: printed and CD courses written in distance learning technology, books, tutorials guides and others.
Financial resources	This category of resources must demonstrate that the university is capable of ensuring high quality educational services. The financial resources of a distance learning study program come from student's fee and they must fulfil certain conditions: they allow all the students to finalize studies and graduate; the financial policy of the institution clearly specifies all the expenditure and revenue; the financial resources take into consideration unpredictable situations that might appear. The fee paid by students is the value of all the services offered to students and must contain measurable elements.
Human resources	They are represented by the didactic staff involved in didactic activities; there are two categories of teachers: subject coordinators, whose role is to elaborate the educational resources and form the work team for a certain subject and tutors, who guide student during application classes, evaluate them by homework and ensure the interface among students, coordinators and educational resources.
Informational resources	The most important informational resources are represented by the educational resources and the electronic platform. The educational resources must be conceived in such a fashion that they replace the physical presence of an instructor in teaching – learning process. These resources must fulfil certain conditions, the most important are as follows: to be designed in accordance with the subject objectives; to present the competences gained by students after reading the didactic material; the material content must be divided into modules and study units and must be based on examples and auto appraising tests. The electronic platform is another important communication tool for students, subject coordinators and tutors and also, the educational resources are distributed by this platform. The electronic platform must be flexible and easy to adjust to requirements of the teaching – learning process and must make communication more efficient.

2.2 Quality management of distance learning in Romania

In order to ensuring the quality of educational process by distance learning system, the Romanian Agency for Quality Assurance in Higher Education (ARACIS) [1] have been elaborated specific standards, performance indicators and a certain methodology, regarding the accreditation of the distance learning study programs and periodical evaluation. Quality management is part of an integrated system that also contains: institutional capability and educational efficiency. The university coordinating distance learning study programs must have specific structures, policies, strategies and procedures for quality management and assurance of didactic activities [5]. The most important standards and performance indicators are [5]: existence of a set of rules regarding the initiation, approval, monitoring and periodical evaluation of study programs and activities; existence of certain procedures

for periodical evaluation of didactic staff; transparency of information regarding the activities deployed within a distance learning study program and regarding the certificates, diploma and qualifications awarded to graduates. An extremely important aspect of quality management in case of distance learning system refers to an optimal use of resources, the present paper proposing, as specified in the abstract, an original model for human resources optimization.

3 Aspects regarding linear programming

As mentioned before, quality of didactic activities deployed within distance learning programs strongly depends on resource use optimization. When talking about teaching – learning process, human resources, represented by didactic staff is crucial. A series of disciplines have been developed for resource optimization, the management science being one of them [6]. Management science is in fact an interdisciplinary science that is aiming at rational approach of the managerial process of decision making, based on scientific methodologies [6, 7]. Within this science, certain quantitative techniques and methods have been developed. The method used for building a managerial instrument that allows the optimization of teaching staff structure for distance education programs is linear programming method, which is a managerial and mathematical tool for optimizing a function dependent on one or more variables and taking into consideration certain restrictions [7-9,10]. Any linear programming problem is a quantitative approach of a phenomenon that is based on a mathematical model. The mathematical model is obtained as a result of a modelling process that allows passing from the real model to the mathematical model [11]. This model contains three components [6, 11, 12]:

• **Objective function**, which is aiming at maximization or minimization of an expression and is illustrated by the equations (1):

$$[\max] f = \sum c_i \cdot x_i \quad \text{or} \quad (1)$$

$$[\min] f = \sum c_i \cdot x_i$$

Where x_i represents the variables of the objective function and c_i represents the coefficients of the objective function's variables.

• **Restrictions**, which represent certain conditions that the variables of the mathematical model must fulfil and which indicate the range of values for the objective function. Generally, restrictions might be highlighted by equation system (2).

$$\begin{cases} a_{11} \cdot x_1 + a_{12} \cdot x_2 + \dots + a_{1n} \cdot x_n \leq b_1 \\ a_{21} \cdot x_1 + a_{22} \cdot x_2 + \dots + a_{2n} \cdot x_n \leq b_2 \\ \dots \\ a_{j1} \cdot x_1 + a_{j2} \cdot x_2 + \dots + a_{jn} \cdot x_n \leq b_j \\ a_{j+11} \cdot x_1 + a_{j+12} \cdot x_2 + \dots + a_{j+1n} \cdot x_n \leq b_{j+1} \\ \dots \\ a_{m1} \cdot x_1 + a_{m2} \cdot x_2 + \dots + a_{mn} \cdot x_n \leq b_m \end{cases} \quad (2)$$

- **Non negativity restriction**, which represent other conditions imposed on the mathematical model's variables and that can be represented by equation (3).

$$x_i \geq 0, \quad i = 1 \dots n \quad (3)$$

3.1 Mathematical model based on linear programming for structure staff optimization in case of a distance learning program study

As mentioned in section 2 of the present paper, resource optimization is important for a distance learning program but this must be done under the conditions of taking into consideration the quality standards. As specified before, distance learning study programs must fulfil certain conditions and for that the teaching – learning process to achieve its goals, it must be deployed in an efficient way at all levels. Mainly, this might be ensured if the following conditions are fulfilled: all the specifications of the quality standards are met; all the specifications regarding developing the development of the payroll are met; taking into consideration certain economic indicators. The concrete mathematical model regarding structure staff optimization in case of a distance learning program study is developed taking into consideration the three components of a linear programming problem briefly described in section 3, as follows.

• Objective function

Having in mind that there are more variants for developing the payroll, by considering the quality standards, it is necessary the use of an additional criterion for determining an optimal form of didactic staff structure. This criterion might be considered as the objective function of the mathematical model. For developing this model, the following notations are considered: S_P^h , S_C^h , S_L^h , S_A^h represent the hourly salary of professors, associate professors, lecturers and professor assistant; n_{dh}^P , n_{dh}^C , n_{dh}^L , n_{dh}^A represent the number of didactic hours deployed by professors, associate professors, lecturers and professor assistants. Considering these notations, the objective function might be:

$$\text{Min} \left(n_{dh}^P \cdot S_P^h + n_{dh}^C \cdot S_C^h + n_{dh}^L \cdot S_L^h + n_{dh}^A \cdot S_A^h \right). \quad (4)$$

• Restrictions

The restrictions of the mathematical model refer to the most important quality standards and that can be measured and are further developed.

- The restrictions regarding the tutorial activities (AT), homework (TC) and aided applicative activities (AA). The didactic materials, considered as educational resources, destined to individual study can be elaborated by teachers entitled to deploy tutorial activities. In order to fulfil the quality standard, it is considered that this kind of activities can be deployed by professors and associate professors. The following notations are considered: N_P - the number of professors; N_C - the number of associate professors; N_L - the number of lecturers; N_A The restriction related to the right of elaborating the didactic materials, as educational resources. The educational resources destined to individual study of students can be elaborated only by didactic staff entitled to deploy teaching activities. Considering the following notations: N_P , N_C , N_L , N_A - the number of professors assistants involved in the entire distance learning study program; n_{d1} - total number of subjects having tutorial activities and homework; TC – medium number of homework activities per subject (it is considered that this kind of activities can be deployed by

lecturers and professor assistants); n_{d2} - total number of subjects having aided applicative activities. Considering these notations, these restrictions can be expressed as follows:

$$N_P + N_C \leq n_{d1}, \quad (5)$$

$$N_L + N_A \leq X, \quad (6)$$

where X will be further determined.

For determining the value of X the following notations are considered: H_P^{conv} , H_C^{conv} , H_L^{conv} , H_A^{conv} represent the maximum number of conventional didactic hours weekly deployed by a professor, associate professor, lecturer and professor assistant, considering full time learning; k_1 - the reducing coefficient of legal norms regarding distance learning in comparison with full time learning (for example $k_1 = 0.3$); mainly this coefficient has in mind the same quality level for both distance learning and full time learning, considering that the same didactic staff is involved in both learning systems; N - total number of study years for a distance learning study program; n_{sem}^{year} represents the number of semesters of a study year; n_{week}^{sem} represents the number of weeks of each semester; L_L , L_A - total number of didactic hours allowed for lecturers and professor assistants related to the entire study program. These numbers might be considered equal, being no significant differences between them. Therefore, the total number of didactic hours deployed by a lecturer for N study years is:

$$L_L = H_L^{conv} \cdot k_1 \cdot n_{sem}^{year} \cdot N \cdot n_{week}^{sem}, \quad (7)$$

or

$$L_L = H_L^{conv} \cdot k_1 \cdot K, \quad (8)$$

where:

$$K = n_{week}^{sem} \cdot n_{sem}^{year} \cdot N. \quad (8.a)$$

On the other hand the total number of didactic hours related to homework activities and aided applicative activities (N_{TC+AA}) for the entire study program can be expressed as follows:

$$N_{TC+AA} = 0,4 \cdot n_{d1} \cdot (AT + TC) + n_{d2} \cdot AA \cdot \frac{N_s}{25}, \quad (9)$$

considering that N_s is the total number of students of the study program and a group of students has 25 students.

On the basis of aspects previously presented, the value of X from equation (6) is:

$$X = \frac{N_{TC+AA}}{H_L^{conv} \cdot k_1 \cdot K}. \quad (10)$$

The equation (6) becomes:

$$N_L + N_A \leq \frac{0.4 \cdot n_{d1} \cdot (AT + TC) + 0.04 \cdot n_{d2} \cdot AA \cdot N_s}{H_L^{conv} \cdot k_1 \cdot K} \quad (11)$$

- Restrictions regarding the legal norms related to the didactic degree of teachers. These restrictions can be expressed as follows:

$$\frac{n_{dh}^P}{K \cdot N_P} \leq H_P^{conv} \cdot k_1, \quad (12)$$

$$\frac{n_{dh}^C}{K \cdot N_C} \leq H_C^{conv} \cdot k_1, \quad (13)$$

$$\frac{n_{dh}^L}{K \cdot N_L} \leq H_L^{conv} \cdot k_1, \quad (14)$$

$$\frac{n_{dh}^A}{K \cdot N_A} \leq H_A^{conv} \cdot k_1. \quad (15)$$

These equations allow expressing the restrictions (5) and (11) in a different way:

$$\frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C \leq K \cdot k_1 \cdot n_{d1}, \quad (16)$$

$$n_{dh}^L + n_{dh}^A \leq 0.4 \cdot n_{d1} \cdot (AT + TC) + 0.04 \cdot n_{d2} \cdot AA \cdot N_s \quad (17)$$

- Restrictions regarding the maximum number of subjects allowed for one teacher. Considering that n_s is the total number of subjects of the study program, these restrictions can be expressed as follows:

$$\frac{n_s}{N_P + N_C + N_L + N_A} \geq 1, \quad (18)$$

$$\frac{n_s}{N_P + N_C + N_L + N_A} \leq 3. \quad (19)$$

Taking into consideration the equations (12) – (15), restrictions (18) and (19) become:

$$\frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C + \frac{1}{H_L^{conv}} \cdot n_{dh}^L + \frac{1}{H_A^{conv}} \cdot n_{dh}^A \leq K \cdot k_1 \cdot n_s, \quad (20)$$

$$\frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C + \frac{1}{H_L^{conv}} \cdot n_{dh}^L + \frac{1}{H_A^{conv}} \cdot n_{dh}^A \geq \frac{1}{3} \cdot n_s \cdot K \cdot k_1, \quad (21)$$

- Restrictions regarding the types of activities deployed considering the didactic degree can be expressed as follows:

For professors and associate professors:

$$n_{dh}^P + n_{dh}^C \geq AT \cdot n_{s1} \quad (22)$$

For lecturers and professor assistants it is obtained an equation identical to (17). As it can be observed, the ensemble of equations that contains the objective function (4) and the restrictions (16), (17), (20) – (22) forms the linear programming model (23):

$$\left\{ \begin{array}{l} \text{Min } (n_{dh}^P \cdot S_P^h + n_{dh}^C \cdot S_C^h + n_{dh}^L \cdot S_L^h + n_{dh}^A \cdot S_A^h) \\ \frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C \leq K \cdot k_1 \cdot n_{s1} \\ n_{dh}^L + n_{dh}^A \leq 0.4 \cdot n_{s1} \cdot (AT + TC) + 0.04 \cdot n_{s2} \cdot AA \cdot N_s \\ \frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C + \frac{1}{H_L^{conv}} \cdot n_{dh}^L + \frac{1}{H_A^{conv}} \cdot n_{dh}^A \leq K \cdot k_1 \cdot n_s \\ \frac{1}{H_P^{conv}} \cdot n_{dh}^P + \frac{1}{H_C^{conv}} \cdot n_{dh}^C + \frac{1}{H_L^{conv}} \cdot n_{dh}^L + \frac{1}{H_A^{conv}} \cdot n_{dh}^A \geq \frac{1}{3} \cdot K \cdot k_1 \cdot n_s \\ n_{dh}^P + n_{dh}^C \geq AT \cdot n_{s1} \\ n_{dh}^P, n_{dh}^C, n_{dh}^L, n_{dh}^A \geq 0. \end{array} \right. \quad (23)$$

This model considers that the variables that must be optimized are n_{dh}^P , n_{dh}^C , n_{dh}^L and n_{dh}^A .

3.2 Application

For verifying the mathematical model expressed by equation system (23) it is used *Linear and Integer Programming* module of *WinQSB* software package. This module works on the basis on Simplex algorithm, which is supported by clear iterations and surely leads to the optimal solution [13, 14]. For using this module, three major steps were necessary: indicating general data, such as introducing the problem title, indicating if it is maximization or minimization problem and the number of constraints; introducing the mathematical model; solving the problem [15]. In order to introduce the mathematical model (23) in *WinQSB* software package, we consider the following elements: the hourly salary for a professor, associate professor, lecturer and professor assistant are: $S_P^h = 69$ lei/hour; $S_C^h = 48$ lei/hour, $S_L^h = 35$ lei/hour; $S_A^h = 27$ lei/hour; the number of conventional hours per week for every didactic degree are: $O_P^{conv} = 9$ hours/week, $O_C^{conv} = 10$ hours/week, $O_L^{conv} = 12$ hours/week, $O_A^{conv} = 13$ hours/week; total number of students for a new distance learning study program is 75; the total number of subjects for the entire study program is 50; the total number of subjects having tutorial and homework activities is 20 and the total number of subjects having aided applicative subjects is 50. Another aspect to be considered is that the study program has 4 study years, each year has two semesters and each semester has 14 weeks. For introducing the model (23) into *WinQSB* software package, the following notations are considered: x_1, x_2, x_3, x_4 – the number of didactic hours for a professor, associate professor, lecturer and assistant for the entire study program. Figure 1 presents the *WinQSB* mathematical model, where the numerical values of the coefficients of the objective function and constrains can be seen.

Variable	X1	X2	X3	X4	Direction	R.H.S.
Minimize	69	48	35	27		
C1	0.11	0.1			<=	672
C2			1	1	<=	3318
C3	0.11	0.1	0.083	0.076	<=	1882
C4	0.11	0.1	0.083	0.076	>=	627
C5	1	1			>=	210
C6	1				>=	0
C7		1			>=	0
C8			1		>=	0
C9				1	>=	0

Fig. 1. WinQSB mathematical model.

Appealing Solve the Problem function the software package displays a table containing the optimal solution. Considering the issue of human resource optimization in case of a distance learning study program, the optimal solution refers to the numbers of didactic hours necessary for each didactic degree. The optimal solution also indicates the value for the objective function, which in this case is the minimum of the salary costs for the entire study program. Figure 2 shows the optimal solution for the mathematical model (23).

Decision Variable	Solution Value	Unit Cost or Profit	Total Contribution	Reduced Cost
X1	0	69,00	0	16,20
X2	3.748,32	48,00	179.919,40	0
X3	0	35,00	0	4,64
X4	3.318,00	27,00	89.586,00	0

Fig.2. The optimal solution.

The optimal solution of the problem highlighted in Figure 2 refers to the total number of didactic hours necessary for every didactic degree for a distance learning study program, but considering the quality standards, elaborated by the Romanian Agency for Quality Assurance in Higher Education. As it can be seen from figure 2, the number of didactic hours for each didactic degree category is: 3716 hours for associate professors and 3360 hours for professor assistant. These values of the variables ensure the minimum value of the objective function that refers to the salary costs minimization. For determining the optimal number of teachers, by didactic degree, we must consider the number of conventional didactic hours for each didactic degree (H_C^{SP} - total numbers of conventional didactic hours for associate professors for the entire study program, H_A^{SP} - total number of conventional didactic hours for professor assistants for the entire study program) :

$$H_C^{SP} = H_C^{conv} \cdot K \cdot k_1 = 10 \cdot 112 \cdot 0.3 = 336 \text{ hours} \tag{24}$$

$$H_A^{SP} = H_A^{conv} \cdot K \cdot k_1 = 13 \cdot 112 \cdot 0.3 = 436.8 \text{ hours} \tag{25}$$

The total number of associate professors and professor assistants can be determined in the following way:

$$N_C = \frac{n_{dh}^C}{H_C^{SP}} = \frac{3748}{336} = 11.15 \cong 11 \text{ associate professors,} \quad (26)$$

$$N_A = \frac{n_{dh}^A}{H_A^{SP}} = \frac{3318}{436.8} = 7.59 \cong 8 \text{ professor assistants} \quad (27)$$

4 Conclusions

The present paper approached the issue of human resource optimization in case of a distance learning study program. In authors' opinion from the four categories of resources that support the didactic activities of a study program (material resources, financial resources, human resources and informational resources) human resources are considered crucial, because the deployment of the activities related to teaching – learning process involves people and people communication, by all means: face to face communication, e-mail communication, communication via virtual electronic platforms. The authors proposed an original instrument that allows the optimization of a distance learning study program from the point of view of human resources using as instruments linear mathematical programming, based on simplex algorithm and WinQSB software package.

The optimization problem approached by the present paper is aiming at deploying a high quality educational process but also taking into consideration a high economic efficiency. The mathematical model proposed is in fact a frame model that highlights an original approach of the issue discussed. Depending on the concrete conditions existing in universities, the mathematical model presented can be corrected / completed with new constraints.

As it is known, every university from Romania takes advantage of a certain degree of university autonomy or independence, meaning that all universities apply the quality standards elaborated by the Romanian Agency for Quality Assurance in Higher Education using the internal norms. The managerial instrument elaborated as a result of researches made by the authors of this paper takes into consideration, of course the quality standard but also specific conditions and norms of the university where the authors deploy their activity, which is Transilvania University of Brasov. As specified before, this mathematical model is a general and also a frame model that can be successfully applied by any university or institution providing higher educational services, in case of full time study programs as well as in case of distance learning study programs.

The managerial instrument that allows the optimization of the didactic staff structure can be, no doubt, further developed. Some changes or improvements that can be added refer to modifying certain restrictions or adding some new restrictions, as the quality standards or the internal conditions from universities changes or even considering different objective functions. The objective function that stands on the basis of the mathematical model developed within this paper refers to the minimization of the salary costs of the didactic staff involved in distance learning teaching activities. Of course, costs are very important but not always the efficiency of certain activities means as lowest costs as possible. In case of didactic staff structure optimization, other optimization criteria might be considered. Such criteria could be: maximization of student's number, minimization of the costs involved in educational resource distribution, minimization of the number of face to face activities, or even minimization of the number of teachers. These aspects represent potential starting points in further researches of the authors of the present paper, in the field of higher education optimization.

References

1. The Romanian Agency for Quality Assurance in Higher Education – Quality Evaluation Activities Guide for University Study Programs and for Higher Education Institutions, 2015., available at: http://www.aracis.ro/fileadmin/ARACIS/Legislatie_-_Proceduri/Part_I_-_STUDY_PROGRAMMES_ACCREDITATION.pdf
2. J. Holden, Ph. Westfall, *An Instruction Media Selection Guide for Distance Learning – Implication for Blended Learning*, (USDLA, 2010).
3. H. Fry, Katteridge, S. Marshall, *A Handbook for Teaching / Learning in Higher Education. Enhancing Academy Practice*.(Fourth Edition. Routledge Taylor / Francis 2015)
4. <http://www.idifr.ase.ro/despre-id>, accessed on June 27, 2016.
5. http://www.aracis.ro/fileadmin/ARACIS/Legislatie_-_Proceduri/Partea_a_V-a_-_Ghid_evaluare-ID.pdf accessed on June 27, 2016.
6. D.R. Anderson, D.J. Sweeney, T.A. Williams, J.D. Camm, J.J. Cochran, M.J. Fry, J.W. Oklmann, *An Introduction to Management Science, Quantitative Approaches to Decision Making*, (Cengage Learning, 2015).
7. B. Rander, R. Stair, M. Hanna, *Quantitative Analysis for Management*, (Global Edition, Pearson, 2014).
8. W.L. Winston, C.S. Albright, *Practical Management Science*, (Cengage Learning, 2015).
9. D. Lixandroi, *Decision Modelling in Economics*(Economica Publishing House, 2014).
10. C. Ratiu-Suciu, *Modelling and Simulation of Economic Processes* (Economica Publishing House, 2009).
11. V. Marascu-Klein, *Modelling and simulation of Production systems*, (Lux Libris, 1997).
12. J. Chaouachi, M. S. Ghorbel, *Linear Programming*, (ISTE Press LTD – Elsevier Inc, (2016).
13. F.A. Ficken, *The Simplex Method of Linear Programming*, (Dover, 2015).
14. P.-Q. Pan, *Linear Programming Computation*, (Springer, 2013).
15. Y.L. Chang, *WinQSB*, (John Wiley & Sons, Inc, 2003).