EFFICIENCY EVALUATION IN ACADEMIC UNITS APPLYING DATA ENVELOPMENT ANALYSIS
Initial State of Project

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Abstract: The aim of this paper is to present a procedure to look into the relative efficiency of university departments in order to make a good allocation of resources. This procedure uses a model based on Data Envelopment Analysis (DEA). DEA measures relative efficiency of a set of alternatives (decision making units – DMUs) that consume multiple inputs and produce multiple outputs. Results of the model will help to plan development of university departments in Facultad de Ingeniería of Universidad de Buenos Aires.

1 INTRODUCTION

In recent years, Facultad de Ingeniería (Engineering School) of University of Buenos Aires (FIUBA) has established a policy in order to encourage research activities mostly on new areas. As a result of this policy, several professors with full dedication were designated by open contest in some departments such as Industrial Engeneering.

In the case of Industrial Management Department (Departamento de Gestión Industrial), incorporation of professors has led to the formation of teacher-investigators groups that, even being still small, are allowing to start an interesting series of investigating activities. One of the mentioned cores is the Management Models Group (Grupo de Modelos de Gestión) which leads the working line presented on this paper.

The aim of this Group is to provide tools for decision making in order to analize, evaluate and solve real problems in operations, processes and management. The objective of this first project is the asessment of FIUBA's teaching departments to provide information for better allocation of resources. This information will be based on comparison of the teaching and research performance.

Nowadays, resource allocation in FIUBA has been implemented with intuitive, subjective procedures, not properly focused within a problem structure. Usually, not enough criteria were taken into account.

Therefore, changing the indexes used in productivity often leads to apparently inconsistent results. That is, according to an index, performance is well, but other index does not rate as well. Sometimes, results among different indexes can be complete opposites.

The idea of this paper consists in developing a mathematical model in which different indexes weights are the variables to calculate. In that way objectivity can be achieved because it would be possible to demonstrate that some of the evaluated units would not be able to achieve the best results even adopting the most favourable weights for them.

The starting point is the classical work of Charnes, Cooper and Rhodes (Charnes et al, 1978) in wich a new method for evaluating decision making units named Data Envelopment Analysis is proposed. Also the work of Banker, Charnes and Cooper (Banker et al, 1984) broadens the field of the first work.

In the present paper, we study factibility of application of those approaches plus other posterior works (Cooper et al, 2000), (Thanassoulis, 2001),

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(Ray, 2004) to academic departments of FIUBA, taking those departments as operative units and asessing, analyzing and evaluating their possible inputs and outputs.

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2 METHOD

2.1 Hypothesis

In order to achieve that, validity of a quantitative approach like DEA methodology will be experimented. This methodology bases in this essential hipothesis:

- Input and output measures for each university unit are known;
- Efficiency for each unit is presented as a weighted sum of the outputs defined divided by the weighted sum of the inputs defined;
- All efficiencies will be restricted to the (0, 1) range;
- Mathematical model proposed will production ougth to determine efficiency value for each unit by maximizing its efficiency and determining weights for inputs and outputs.

2.2 Information Used

The first plan is to use information that belongs to last years of management in FIUBA. In subsequent stages, when methodology would be validated, extension to other internal academic units and external units is planned.

One of the core aspects of the process will be the selection of units to be evaluated. We have used academic units as FIUBA Departments, Institutes, Schools, trying to be relatively similar in dimension and characteristics.

Once the units to be evaluated were identified we defined inputs and output, according to available information and apply some appropriate method for selecting variables, restricting its quantity in order to obtain a reasonable degree in discriminating efficiencies and taking into account (Cooper et al, 2000, 2007) refering compliance of >= max((m . s);3(m + s)) being m inputs and s outputs.

Other aspect that should be matter of analysis is DEA's classical assumption that efficiencies of units for every activity are equal. This assumption could not be true in case of academic units, where activities as teaching, research, extension may have different efficiencies. This situation would force rethinking the model to consider that fact.

2.3 Method

As mentioned early, a quantitative method based on DEA approach is used. Within this central idea, DEA method has a group of alternative models available, from which the basic are CCR models, owing their name to their authors: A. Charnes, W. W. Cooper and E. Rhodes (Charnes et al, 1978), who initially proposed them with a non linear optimization structure.

Non-linear CCR DEA model has an objective function that maximizes efficiency E_o, where j = o means the generic S_j system subscript. In this paper, j is an academic or management unit for which weights u_r and v_i are to be determined. This weights u_r and v_i are applied in every S_j efficiency expression within ≤ 1 inequalities, trying to normalize its values, therefore forming the model restrictions, which are complemented with non-negativity conditions for the weights u_r and v_i. The model obtained has a non-linear structure.

$$\max Z = E_o = \frac{\sum_{r=1}^{s} y_{ro} * u_r}{\sum_{i=1}^{m} x_{io} * v_i}; \qquad o = 1,\dots,n \qquad (1)$$

Subject to:

$$\begin{aligned} &\frac{\sum_{r=1}^{s} y_{rj} * u_r}{\sum_{i=1}^{m} x_{ij} * v_i} \le 1; && j = 1,\dots,n \\ &u_r \ge 0; && r = 1,\dots,s \\ &v_i \ge 0; && i = 1,\dots,m \end{aligned} \qquad (2)$$

The process is repeated for each of the n S_j systems, leading to a series of n groups of weights u_r and v_i.

To determine efficiency of each functional unit, it is needed to solve n models, one for each unit. The basic model is a non-linear model, which can be solved with non-linear optimizers. However, this model can be taken to an equivalent linear form, with the inherent advantages of linear models. This is achieved fixing the objective function denominator as 1. In that way, the numerator itself will measure efficiency, passing denominators of the n restrictions to the second member and, then, the whole second member to the first member. The model obtained has a linear programming structure:

$$\max Z = \sum_{r=1}^{s} y_{ro} * u_r ; \qquad o = 1, \ldots, n \tag{3}$$

Subject to:

$$\begin{aligned} &\sum_{i=1}^{m} x_{io} * v_i = 1 \\ &-\sum_{i=1}^{m} x_{ij} * v_i + \sum_{r=1}^{s} y_{rj} * u_r \le 0; \qquad j = 1, \ldots, n \\ &u_r \ge 0; \qquad r = 1, \ldots, s \\ &v_i \ge 0; \qquad i = 1, \ldots, m \end{aligned} \tag{4}$$

As in the non-linear model, the process repeats in the same way for each of the n S_j systems, thus obtaining a series of n groups of weights u_r and v_i.

2.4 Preliminary Results

In Figure 1 is shown the preliminary results of our project:

	DMU	Score	Rank
1	Matemática	0,61	8
2	Física	0,55	10
3	Química	0,68	6
4	Estabilidad	0,61	7
5	Electrotecnia	0,44	15
6	Electrónica	0,43	16
7	Mecánica	0,55	9
8	Transporte	0,25	18
9	Hidráulica	0,46	13
10	Agrimensura	0,45	14
11	Economía	0,89	4
12	Industrias	0,87	5
13	Ingeniería Naval	0,38	17
14	Construcciones	0,52	11
15	Computación	1,00	1
16	Ing. Química	0,52	12
17	Ambiente y Trabajo	1,00	1
18	Idiomas	1,00	1

Figure 1: Preliminary Results

Further research might explore other DEA models, like BCC (Banker et al, 1984), AR (Cooper et al, 2000, 2007) and other models that may emerge from investigation.

Another aspect to define will be the software to use. This selection will depend on the dimension of the Linear Programming formulated model. Some of the specific decision analysis software are DEA Solver, Frontier Analysis, Warwick DEA.

3 CONCLUSIONS

The approach proposed is not the only tool being taken into account for decision making within planning and management of FIUBA's academic units, but is considered as a new contribution to be integrated to the collection of other proceedings and tools in use.

DEA methodology seems to be a suitable tool for efficiency analysis in education.

As a not less important sub-product, the investigation work already developed by the Management Models Group during this first stage and the work to develop during the project will allow gain experience in research activities that will not only benefit its members but also motivate other teachers and students to initiate them in similar activities, therefore responding to the policy promoted by the authorities of FIUBA.

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