

MAKE OR BUY DECISIONS IN FACILITY MANAGEMENT: OPPORTUNITIES TO USE DATA ENVELOPMENT ANALYSIS (DEA)

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Abstract: *Since modern buildings are complex facilities, the facility managers have to outsource many activities to other specialized companies. In this context, decisions to make or to buy become of key importance to facility management companies. This present paper proposes an approach for making a reasonable decision to make or to buy based on the use of data envelopment analysis (DEA).*

Keywords: *Facility management, make or buy decisions, data envelopment analysis*

1. INTRODUCTION

According to the official website of the International Facility Management Association (IFMA) Facility Management is a multi-discipline profession to ensure functionality, comfort, safety and efficiency of the built environment through the integration of people, places, processes and technologies. For its part, ISO Standard ISO 41011: 2017 (ISO) defines Facility Management as an organizational function that integrates people, places and processes within the built environment to improve the quality of life of people and the productivity of the core business” (point 3.1.1). Again, the term „built environment” is defined as „a set of buildings, outdoor spaces (green areas), infrastructure and other facilities in a given area” (3.2.3).

With these comprehensive definitions, it is difficult to work, so it is convenient for practical purposes to define management primarily through its objective - improving the quality of life of people and improving the productivity of the organization’s core processes. As you can see, this is an activity that does not generate revenue directly, but only through its results it improves the flow of basic business processes. Therefore, improving the efficiency of Facility Management will be sought to improve the cost-to-target (result) ratio rather than cost-revenue. The notion of „efficiency” is also not always clearly defined, so it is good to use these international standards. ISO 9000: 2005 gives the content of the terms „efficiency” and „effectiveness”. According to this document, the effectiveness is the extent to which the planned activities are realized and the planned results are achieved (3.2.14), while efficiency is the relationship between the achieved result and the resources used (3.2.15). Considering that the objectives of Facility Management can be extremely varied (e.g. favorable temperature, air composition, degree of illumination, background noise level, etc.), it will be virtually impossible to formulate performance indicators. It will be necessary to use comparative effectiveness (different effectiveness variants) with minimization of input resources. Since the objects managed by Facility Management (parts of buildings, buildings, building complexes) are clearly differentiated, Data Envelopment Analysis (DEA) can successfully be used to investigate efficiency and comparative effectiveness.

This, in turn, can direct the company’s management to produce or purchase certain services and / or products.

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2. DEA AND MAKE-OR-BUY DECISION

The make-or-buy decisions are of strategic importance for a company. [1] A lot of research has been done in order to examine the issue. Our aim here is to present an indicator which shows that the outsourcing of certain activities should be considered seriously. However, in this process, the specific nature of facility management as a business should be borne in mind. Let us remember that in essence facility management involves the separation and control of all support processes within an organization by one center. The economic logic behind this is as follows:

1. As a rule, these processes take place in built environment and real estate includes a great part of company assets. Neglecting them can lead to problems with return on investment because of unjustifiably high costs.
2. The centralization of all support processes allows their optimization together with the optimization of core processes as well as their integration in the latter to a greater extent. The alternative involves different structural units that communicate badly with each other. In general, core processes and core competencies are in the focus of top management attention whereas support are neglected. At the same time, due to the direct connection of supporting processes with real estate, they incur a great amount of costs. A lot of these costs are not directly related to the company main activity. Therefore, if the support processes are managed for themselves and despite its key competencies, a company will spend money unjustifiably.

Here comes the question about core competencies and core processes in facility management. Until recently, the focus was on the technical elements of buildings and built environment. Nowadays, however, this focus is shifting increasingly to the people living in the environment: customers, employees, managers, visitors, etc. In other words, modern facility management provides certain facilities to people and creates prerequisites for the implementation of core processes at the optimal (in this case minimal) price. This requires the regulation of the main characteristics of the environment as well as a strict cost control.

Data envelopment analysis is a technique based on linear programming to measure the relative performance of a set of defined organizational units. Applied in the presence of a large number of input and output variables, which makes direct comparisons complex. [2] Classical performance measurement as the ratio between input and output variables is often inadequate due to the presence of multiple input and output measures corresponding to different resources, activities, environmental factors, and so on. An appropriate illustration of such a situation is a large retailing organization with multiple warehouses. The delivery rate for all warehouses needs to be optimized, but cost levels are not necessarily the same in all sites. It is possible that the value of the stock is different in the different stores as well as the cost of delivery and storage. The units being compared are the same as the structure of costs and results, but the specific quantities per unit of resource and / or result may vary a lot.

However, all warehouses will strive to ensure a good level of service with the smallest possible amount of stored stocks and a low level of storage costs.

The example illustrated very well illustrates the complexity of the situation, but it should be noted that in the area of Facility Management things are not much different. In any building or part of a building that is run by the organization (e.g. a floor), there is a desire to have more space suitable for rent, while at the same time reducing the unusable areas. They are an infrastructure

for leased areas - they provide easy access, mobility convenience, and so on. At the same time, the cost of providing a good climate, cleaning, security and access, etc., can vary greatly from one building to another. This makes the task of determining the cost and / or resource efficiency of different buildings or parts of them very complex. The subjects considered in the Data Envelopment Analysis are called Decision Making Units (DMUs) [3]. The complexity of the task emerges immediately if we have, for example, over 10 decision-making units (DMUs) and each one works with two input and two output variables. In this case, the input quantities should be the total amount of the monthly costs in Euro and the number of man-hours, and the output shall be the level of rent achieved by property managers and the air purity coefficient. The latter is as higher as cleaner is the air in the room in accordance with the accepted criteria. The aim is to minimize input quantities and maximize output (with the proviso that this is not possible at the same time, of course). The task can be complicated even more because, in principle, neither the number of the DMUs nor the number of inputs nor the number of output quantities is limited. Such are the cases where DEA is appropriate.

Relative efficiency is measured to solve the problem with multiple difficult to measure inputs and outputs. A hypothetically effective DMU is being developed to be used as a tool for comparison with potentially ineffective DMUs [4]. Traditionally, comparative efficiency is measured using the formula:

$$\text{Efficiency} = (\text{Weighted Amount of Outputs}) / (\text{Weighted Amount of Inputs})$$

Taking into account that in our case the rent level is determined by factors external to the organization (the market situation) and the purity of the air cannot improve to infinity, we assume that the output quantities are set, and we will optimize the inputs, i.e., we will minimize them. In this case, it is more accurate to talk about comparative effectiveness.

In practice, the following terms have been adopted:

1. For the DMU number:

$$\text{DMU}_j, j = 1, 2, \dots, n.$$

2. For inputs:

x_{ij} , $i = 1, 2, \dots, m$. In this case m is the number of inputs.
For example, x_{35} means the third input of the fifth DMU.

3. For Outputs:

y_{rj} , $r = 1, 2, \dots, s$. In the case s is the number of outgoing dimensions (outs).
For example, y_{46} means the fourth output of the sixth DMU.

The values of all the variables mentioned are known in advance, and the models for comparative effectiveness and efficiency are described. The labels are by [5].

One of the main problems is to determine the weights weighing the input and output quantities. Since we are looking for a suitable convex combination of weights, the first and most important condition is that the sum of these weights is equal to one. For each DMU, we need to determine

weights that minimize its inputs (Inputs). This means we have to run the model as many times as the DMU count. The general look of the model we will use will look like this:

$$\theta^* = \min \tag{1}$$

subject to the following limitations:

$$\sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{io}, \quad i = 1, 2, \dots, m; \tag{2}$$

$$\sum_{j=1}^n \lambda_j y_{rj} \geq y_{ro}, \quad r = 1, 2, \dots, s; \tag{3}$$

$$\sum_{j=1}^n \lambda_j = 1 \tag{4}$$

$$\lambda_j \geq 0, \quad j = 1, 2, \dots, n. \tag{5}$$

Here γ_j is the aggregation of the unknown weights ($j = 1, 2, \dots, n$) corresponding to each DMU $_j$.

The convex combination requires the sum of all n lambda numbers to be equal to one.

The right side is one of the DMU counts to be assessed.

In the case of the shortened recording of the model it seems at first sight that it has three restrictive conditions. In fact, the number of restrictive conditions is $m + s + 1$, since the first restrictive condition is essentially m number of restrictive conditions for each input parameter. Accordingly, the second restrictive condition is in fact a restrictive condition, such as the number of outgoing quantities.

The model can also be saved as follows:

$$\theta^* = \min \theta \tag{6}$$

subject to the following limitations:

$$\lambda_1 x_{i1} + \lambda_2 x_{i2} + \dots + \lambda_o x_{io} + \dots + \lambda_n x_{in} \leq \theta x_{io} \quad i = 1, 2, \dots, m; \tag{7}$$

$$\lambda_1 y_{r1} + \lambda_2 y_{r2} + \dots + \lambda_o y_{ro} + \dots + \lambda_n y_{rn} \geq y_{ro} \quad r = 1, 2, \dots, s; \tag{8}$$

$$\lambda_1 + \lambda_2 + \dots + \lambda_o + \dots + \lambda_n = 1 \tag{9}$$

$$\lambda_j \geq 0 \quad j = 1, 2, \dots, n. \tag{10}$$

Accordingly, in its most developed form, the model will look like this:

$$\theta^* = \min \theta \tag{11}$$

subject to the following limitations:

$$\lambda_1 x_{11} + \lambda_2 x_{12} + \dots + \lambda_o x_{1o} + \dots + \lambda_n x_{1n} \leq \theta x_{1o} \text{ (first input)} \tag{12}$$

$$\lambda_1 x_{21} + \lambda_2 x_{22} + \dots + \lambda_o x_{2o} + \dots + \lambda_n x_{2n} \leq \theta x_{2o} \text{ (second input)} \quad (13)$$

...

$$\lambda_1 x_{m1} + \lambda_2 x_{m2} + \dots + \lambda_o x_{mo} + \dots + \lambda_n x_{mn} \leq \theta x_{mo} \text{ (m-th input, the last)} \quad (14)$$

$$\lambda_1 y_{11} + \lambda_2 y_{12} + \dots + \lambda_o y_{1o} + \dots + \lambda_n y_{1n} \geq y_{1o} \text{ (first output)} \quad (15)$$

$$\lambda_1 y_{21} + \lambda_2 y_{22} + \dots + \lambda_o y_{2o} + \dots + \lambda_n y_{2n} \geq y_{2o} \text{ (second output)} \quad (16)$$

...

$$\lambda_1 y_{s1} + \lambda_2 y_{s2} + \dots + \lambda_o y_{so} + \dots + \lambda_n y_{sn} \geq y_{so} \text{ (s-th output, the last)} \quad (17)$$

$$\lambda_1 + \lambda_2 + \dots + \lambda_o + \dots + \lambda_n = 1 \quad (18)$$

$$\lambda_j \geq 0 \quad j = 1, 2, \dots, n. \quad (19)$$

θ is the desired variable and represents the effectiveness of DMU_o - one of the DMUs we are currently assessing. The right side represents the assessed DMU (one of n). The left side is the possible convex combinations of observed values of incoming and outgoing dimensions (inputs and outputs).

Competitiveness is seen as the ability of a company to disclose, create, maintain, and exploit competitive advantages. On the other hand, competitive advantages are additional value for customers, for which the company makes lower costs than its competitors. The disclosure of the company's relatively efficient and effective DMU will allow positive management experience to be applied wherever the results are not yet at the required level. The expected result is to increase the overall competitiveness of the company [6].

Once we determine which DMUs do not work effectively, we need to analyze the business processes in them. This analysis is carried out with the idea of deciding whether certain business processes are better suited to be executed by the company's staff or outsourced. Thus, performance analysis through DEA can be used as the first step in determining which DMUs need business process analysis and then a decision to produce or buy.

3. NUMERICAL EXAMPLE

The examined dependencies could be illustrated by a suitable numerical example. Before we proceed, we need to make a clarification. There are two main types of efficiency - allocative and technical. The allocative is related to the prices of the inputs and the possibilities of replacing an Input with another. In turn, the technical is concerned with achieving optimal results with limited resources [7]. In our case, we cannot analyze the prices of the Inputs, so we use the concept of technical efficiency. Calculations and visualizations were performed with the package "Benchmarking" in R.

The rented area of the first four buildings is between four and six thousand square meters, for buildings with numbers five, six and seven is between nine thousand and eleven thousand square meters, and for buildings with numbers seven, eight and nine the rented area is between forty-eight and fifty thousand square meters.

The indicators we are looking at are as follows: Input 1 - Staff costs; Input 2 - Expenditure on external services; Output - revenue from rented areas. The initial data is given in Table 1.

Table 1: Initial Data

<i>DMU</i>	<i>INPUT 1 (x1)</i>	<i>INPUT 2 (x2)</i>	<i>OUTPUT (y)</i>
Building01	1400	650	2450
Building02	1400	700	2600
Building03	1400	655	2450
Building04	1400	720	3000
Building05	2750	1200	4800
Building06	2750	1300	5500
Building07	2750	1250	5000
Building08	4900	5600	25000
Building09	4900	5300	21000
Building10	4900	5400	23000

Table 2: Optimization results (Technical Efficiency)

<i>DMU</i>	<i>EFFICIENCY RATIO</i>
b1	1
b2	1
b3	1
b4	1
b5	0,932727273
b6	0,98041958
b7	0,930909091
b8	1
b9	0,889193825
b10	0,954882155

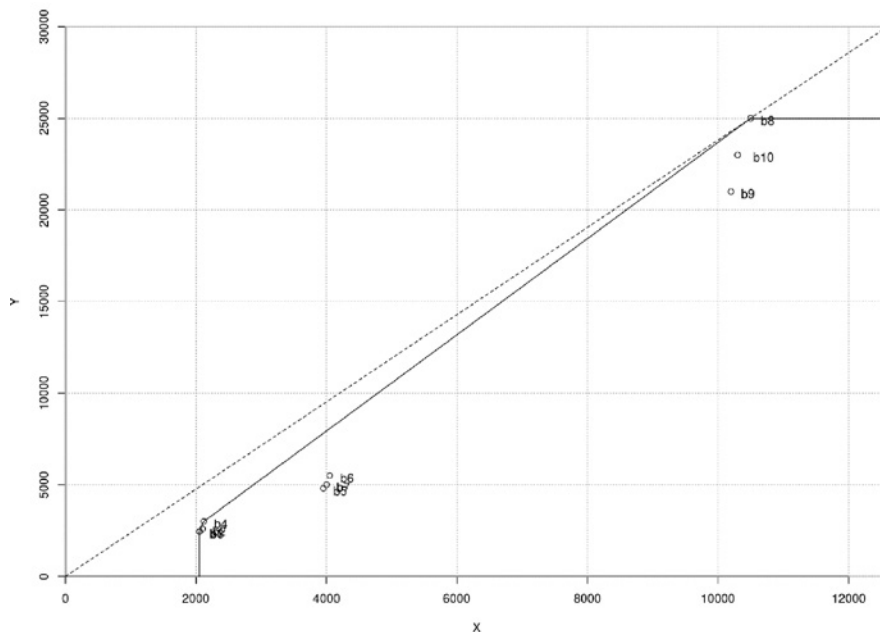


Figure 1: Efficiency frontier (Variable Return of Scale)

The optimization results are presented in Table 2. It is clear that five DMUs work optimally, and the other five do not. In addition, effective DMUs are among the buildings with the largest and smallest rentable area, and the group of buildings with average rental space are ineffective.

The visualization of the optimization process is presented in Figure 1. Due to the large difference in the rented area for different buildings, a variable return of scale procedure is used.

4. CONCLUSION

The visualization of the results clearly shows how the analyzed objects are grouped in three groups according to the amount of the rented area. The group of objects with rented area between nine and eleven thousand square meters is farthest from the efficiency frontier. These are Building 5, Building 6 and Building 7 – DMUs b5, b6 and b7. Additionally, visualization allows us to compare the performance of objects under consideration with the help of vectors. By drawing a vector that starts from the beginning of the coordinate system and ends at the point indicating the corresponding DMU, we would have a vector visualization of the effectiveness of this DMU. The orthogonal projection of the vector on the ordinate axis will correspond to the absolute volume of the output. Therefore, the larger (i.e., closer to 90 degrees) the angle between the vector and the ordinate axis, the more effective the DMU will be. These considerations confirm the fact that DMUs b5, b6 and b7 are the most ineffective.

Estimated values for DMU performance allow us to formulate certain hypotheses. Business processes in DMUs b5, b6 and b7 are most likely inadequate. The balance between the activities carried out by own staff and the outsourced activities is violated. Business processes in the listed DMDs need to be reviewed and new make-or-buy decisions have to be made.

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