

**Dorota Kuchta**<sup>\*</sup>  
**Radosław Ryńca**<sup>\*\*</sup>  
**Yasmin Ziaecian**<sup>\*\*\*</sup>  
**Adam Grudziński**<sup>\*\*\*\*</sup>

## MULTICRITERIA ASSESSMENT OF THE ACADEMIC RESEARCH ACTIVITY

DOI: 10.22367/mcdm.2017.12.08

### Abstract

In this paper a network DEA approach to deal with efficiency assessment will be presented and applied to the assessment of performance of members of an academic faculty of Wrocław University of Science and Technology. The purpose of this study is to propose a solution to the problem of multicriteria assessment of faculty members at universities, discussing at the same time its advantages and disadvantages in the context of the higher educational system in Poland.

**Keywords:** efficiency, performance, Data Envelopment Analysis, research assessment.

### 1 Introduction

Data Envelopment Analysis (DEA) is a “data oriented” non-parametric approach for evaluating the performance of Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. DEA as a mathematical programming procedure computes a comparative ratio of outputs to inputs for each DMU,

---

<sup>\*</sup> Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław, Poland, e-mail: dorota.kuchta@pwr.edu.pl.

<sup>\*\*</sup> Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław, Poland, e-mail: radoslaw.rynca@pwr.edu.pl.

<sup>\*\*\*</sup> Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław, Poland, e-mail: yasmin.ziaecian@pwr.edu.pl.

<sup>\*\*\*\*</sup> Wrocław University of Science and Technology, Faculty of Computer Science and Management, Wrocław, Poland, e-mail: 015228420@student.pwr.edu.pl.

which is reported as the relative efficiency score. DEA has grown in a short period into a powerful, quantitative and analytical tool for measuring and evaluating efficiency and has been successfully applied in many contexts such as banks, schools, universities and other industries. The DMUs may be of various types: organizations, departments, projects, individuals... The reason why DEA is considered to be a good approach is that it requires minimal assumptions about how the inputs and outputs relate to each other. The result of its application is a relative efficiency of DMUs with respect to the given set of DMUs; therefore no global information is required, which is also an advantage (Charnes et al., 1978).

Originally, DEA dealt with one-stage production processes with no reference to the internal structure of the DMUs (with one set of inputs and one set of outputs only). But DEA can be also used to determine the efficiency of multi-stage processes, taking into account the internal structure of the DMUs, which indicates the flow of the intermediate inputs and outputs among the stages (Despotis et al., 2016).

The identification of the inputs and outputs for the assessment of DMUs is usually not easy, especially if we do not deal with a typical industry production process, where inputs are typical industrial resources and outputs, typical industrial products. The inputs should include all resources and other factors which impact the outputs. The outputs should reflect all useful outcomes which are important to the assessment of the DMUs or, in other words, the different criteria of the DMUs assessment.

Academic research is one of the most important activities in higher education and it consumes a large portion of state and business income (Athanasopoulos and Shale, 1997). It can be seen as an important element for determining the quality and performance of universities and other research institutions, as well as of employees of the individual university and research units. At the same time, there exists no generally accepted system of criteria of research activity assessment, either on the institutional or personal level (Woelert, 2015; Retzer and Jurasinski, 2009). That is why it is important to search for improvements and possible alternative solutions in this area.

The DEA model has already been used for the assessment of DMUs in the education and research context, for instance for educational and research organizations and units, research projects and individual researchers (Athanasopoulos and Shale, 1997; Meng et al., 2008; Despotis et al., 2015; Kuchta et al., 2016; Lee and Worthing, 2016). The inputs for the assessment of individual researchers include: the number of years of employment, salary, position etc., while for institutions: the number of academic staff and PhD students, wealth of the institution etc. Various outputs or evaluation criteria have been proposed in various national

systems of research evaluation (Meng et al., 2008; Hicks, 2012; Lee, 2011; Ghinolfi et al., 2014; Lee and Worthing, 2016). Those criteria include: the number and quality of publications and citations, important research awards granted, invited talks at important conferences, patent commercialization, cooperation with established companies, significant consultant reports, setting up national standards, participation in editorial boards or in organizing committees of meetings and conferences, obtaining external research funding, achievements in educating master's degree and PhD degree holders etc.

Considering research activity assessment criteria without taking into account inputs, such as the number of years of experience for individual researchers or wealth of research institutions etc., may distort the results. Outputs do not come from nowhere, but are results of inputs and a "production" process. Thus the DEA method, which always tries to find inputs which influence the outputs, seems to be the right approach, not used at present at Polish universities. That is why the present paper proposes such an application.

The existing applications of the DEA model to research evaluation (Athanasopoulos and Shale, 1997; Meng et al., 2008; Despotis et al., 2015; Kuchta et al., 2016; Lee and Worthing, 2016) use either one-stage or two-stage models. One-stage models assume a single set of inputs and a single set of outputs and the solution of a single DEA model. A two-stage model may mean either:

- The formulation of two (or more) single-input and single-output DEA models (Meng et al., 2008): the first one for aggregated outputs, representing the main aspects of a research activity (e.g. publications – the aggregated output is the number of publications, grants – the aggregated output is the monetary value of grants completed, education of researchers – the aggregated output can be the total number of master's and PhD degree holders "produced" by a researcher or an institution) and the second one for a selected aspect of a research activity, taking into account not the aggregated output, but all individual outputs (e.g. for the aggregated aspect "publications" we can consider here the number of publications in various types of journals, in conference proceedings, monographs, citations etc.).
- The formulation of one DEA model reflecting the logical inner structure of inputs and outputs (some of which function as both outputs and inputs); two stages of the research process are considered (as in Figure 1, this is called "network DEA").
  - For example, in Lee and Worthing (2016), where the evaluation of research institutions is considered, the authors use two stages of the process. The first stage are "publications", with the number of academic staff and the institution's wealth as inputs and publication-related outputs, and the

second stage is “grant applications”, where the publication-related outputs from the first stage become the inputs, and the outputs are the number and value of grants obtained.

- Despotis et al. (2015) whose approach, explained in detail in Despotis et al. (2016), is adopted in this paper and presented in Figure 2, where individual researchers are evaluated, has as the first stage the “productivity” of a researcher (with inputs such as the time at the present position and salary and outputs related to publications since the appointment to the present position) and as the second one, the overall “impact/recognition” of the researcher. The latter represents “the impact that the research work of the individual has in academia and the recognition which the researcher has gained as a result of his work” (Despotis et al., 2015). In the second stage, inputs are equal to outputs from the first stage plus an external input (publications of the researcher before the appointment to the present position) and outputs are based on citations and other achievements, such as invited talks or important awards.

As mentioned above, we adopt the approach from Despotis et al. (2016), thus the network DEA, to an academic faculty at one of Polish universities. We discuss its practical advantages and disadvantages, as well as limitations imposed by both the Polish system of research evaluation and the information about researchers available at Polish universities, comparing the evaluation model and the results with those obtained for an academic faculty at a university in Greece (Despotis et al., 2015).

The paper proceeds as follows. First we present the network DEA method. Next, we apply the model to the selected academic faculty: the results of a pilot academic performance measurement are discussed. In the last section we draw conclusions.

## 2 The network DEA method

In this section, the network DEA approach is presented for two-stage processes. But before we proceed to the application of the network DEA, let us recall the basic DEA notion, that of efficiency (Charnes et al., 1978):

$$Efficiency = \frac{\text{weighted sum of inputs}}{\text{weighted sum of outputs}} \quad (1)$$

The idea of DEA is that each DMU, while being assessed, can choose its own weights for the weighted input and output sums, which are applied to all the DMUs, and allow the DMU being evaluated to obtain the maximal efficiency according to formula (1). The inputs are marked in Figure 1 with  $X$  and the out-

puts with  $Y$ . In the basic, one-stage DEA the internal structure of the DMUs, thus the two processes and  $Z$  inside the DMU in Figure 1 are not taken into account: the DMUs are treated as black boxes.

In Figure 1 we see, in fact, a two-stage process: the external inputs  $X$  enter the first stage of the process to produce the final output  $Y$  and the intermediate outputs-inputs  $Z$  are outputs for the first stage and inputs for the second stage.

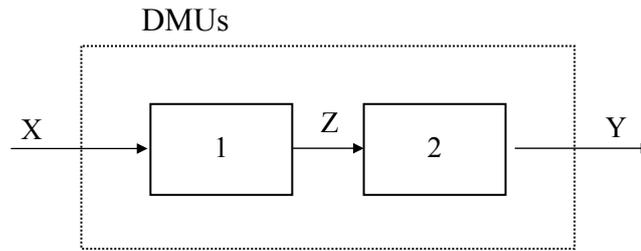


Figure 1. A two stage-process for network DEA

Source: Despotis et al. (2016).

In our model the two-stage process will be used (Figure 1).

Let us now specify the notation: assume  $n$  DMUs, indexed by  $j = 1, \dots, n$ , each using  $m$  external inputs and producing  $q$  outputs, of the same nature for all the DMUs. The values of the inputs for the  $j$ -th DMU and the first stage are denoted as  $X_j = \{x_{ij}, i = 1, \dots, m\}$  and the values of the outputs for the same DMU and the same stage, as  $Z_j = \{z_{pj}, p = 1, \dots, q\}$ . These outputs are used as inputs in the second stage, to produce  $s$  final outputs, whose values for the  $j$ -th DMU are denoted as  $Y_j = \{y_{rj}, r = 1, \dots, s\}$ .

Let  $j_0$  be a fixed index  $j = 1, \dots, n$ . The efficiencies of the first and second stages of the  $j_0$ -th DMU are as follows (this is a direct consequence of formula (1)):

$$e_{j_0}^1 = \frac{\varphi^{j_0} Z_{j_0}}{\eta^{j_0} X_{j_0}}, e_{j_0}^2 = \frac{\omega^{j_0} Y_{j_0}}{\varphi^{j_0} Z_{j_0}} \tag{2}$$

In formulae (2), weights  $\omega^{j_0} = (\omega_1^{j_0}, \dots, \omega_s^{j_0})$ ,  $\eta^{j_0} = (\eta_1^{j_0}, \dots, \eta_m^{j_0})$ ,  $\varphi^{j_0} = (\varphi_1^{j_0}, \dots, \varphi_q^{j_0})$  are used for inputs and outputs.  $Z_{j_0}$  occurs there in both functions, and in both cases has the same weights. The weights  $\omega^{j_0} = (\omega_1^{j_0}, \dots, \omega_s^{j_0})$ ,  $\eta^{j_0} = (\eta_1^{j_0}, \dots, \eta_m^{j_0})$ ,  $\varphi^{j_0} = (\varphi_1^{j_0}, \dots, \varphi_q^{j_0})$  are the values of the decision variables of mathematical programming problems (3), (4) and (5), where the efficiency of the  $j_0$ -th DMU form(s) the (maximized) objective functions.

We consider thus the following three ((3), (4) and (5)) mathematical programming problems with the  $j_0$ -th DMU in the main role:

$$\begin{aligned} \max e_{j_0}^1 &= \frac{\varphi^{j_0} Z_{j_0}}{\eta^{j_0} X_{j_0}} \\ \text{s.t.} \\ \varphi^{j_0} Z_j - \eta^{j_0} X_j &\leq 0, j = 1, \dots, n \\ \eta^{j_0} &\geq 0, \varphi^{j_0} \geq 0 \end{aligned} \quad (3)$$

The optimal value of the objective function of problem (3) is the ideal efficiency of the first stage (Figure 1) for the  $j_0$ -th DMU and is denoted by  $E_{j_0}^1$ .

$$\begin{aligned} \max e_{j_0}^2 &= \frac{\omega^{j_0} Y_{j_0}}{\varphi^{j_0} Z_{j_0}} \\ \text{s.t.} \\ \omega^{j_0} Y_j - \varphi^{j_0} Z_j &\leq 0, j = 1, \dots, n \\ \omega^{j_0} &\geq 0, \varphi^{j_0} \geq 0 \end{aligned} \quad (4)$$

Analogously to problem (3), the optimal value of the objective function of problem (4) is the ideal efficiency of the second stage (Figure 1) for the  $j_0$ -th DMU and is denoted by  $E_{j_0}^2$ .

The overall efficiency of the  $j_0$ -th DMU in the two-stage process from Figure 1 is defined (Despotis et al., 2016) using the solution of the following bicriteria problem:

$$\begin{aligned} \max e_{j_0}^1 &= \frac{\varphi^{j_0} Z_{j_0}}{\eta^{j_0} X_{j_0}} \\ \max e_{j_0}^2 &= \frac{\omega^{j_0} Y_{j_0}}{\varphi^{j_0} Z_{j_0}} \\ \text{s.t.} \\ \varphi^{j_0} Z_j - \eta^{j_0} X_j &\leq 0, j = 1, \dots, n \\ \omega^{j_0} Y_j - \varphi^{j_0} Z_j &\leq 0, j = 1, \dots, n \\ \eta^{j_0} &\geq 0, \varphi^{j_0} \geq 0, \omega^{j_0} \geq 0 \end{aligned} \quad (5)$$

Of course, many approaches to the solution of the bicriteria problem (5) can be used. In Despotis et al. (2016) the distance of the solution of (5) from the ideal point  $(E_{j_0}^1, E_{j_0}^2)$  is minimized, using a selected distance measure. Details can be found in Despotis et al. (2016). The final solution, thus the overall efficiency of the  $j_0$ -th DMU, is calculated by means of a single-criterion problem (Despotis et al., 2016). The solution is a vector  $(e_{j_0}^1, e_{j_0}^2)$  representing the optimal solution of (5) following from the adopted assumptions, and the overall efficiency can be then expressed as the average or the product of the two values.

The model from Figure 1 can be also completed with an additional external input for Stage 2, denoted as  $L$ , which enters this stage together with the output of Stage 1 (as in Figure 2). Then the formula for  $e_{j_0}^2$  changes to:

$$e_{j_0}^2 = \frac{\omega^{j_0} Y_{j_0}}{\varphi^{j_0} Z_{j_0} + \mu^{j_0} L_{j_0}} \tag{6}$$

and models (4), (5) and the other ones mentioned above, change accordingly Despotis et al. (2016).

### 3 Assessing the research activity of individual researchers by means of network DEA

The first attempt to use the model from Despotis et al. (2016) for the assessment of the research activity of individual researchers is Despotis et al. (2015), where a Greek university is analyzed. We will use an academic faculty at a Polish university as another case.

#### 3.1 The case of a Greek university

In Despotis et al. (2015) the network DEA model from Despotis et al. (2016) was applied to the assessment of research activity of the researchers at an academic faculty of a university in Greece. As explained above, the network DEA model means that the process serving as the basis of the DMUs efficiency assessment is composed of two or more stages (Figure 1). In Despotis et al. (2015) the following model is used:

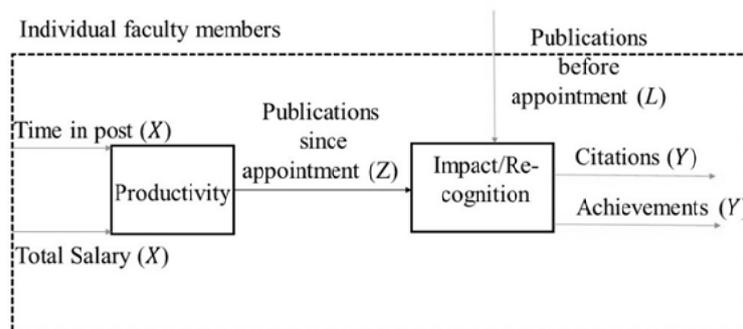


Figure 2. Academic research activity as a two-stage process

Source: Despotis et al. (2015).

The first stage represents the present (in the present position) productivity of researchers. The inputs in this stage are: time in the present position (such as full professor or associate professor) and the salary in the present position. Publications since appointment to the present position are the outputs of the first stage. The second stage represents the overall impact that the entire work of the researcher has had on science and the global recognition the researcher has gained in his/her entire academic career. In this stage the input consists of the output of the first stage and an external input, representing all the publications of the researcher before the appointment to the present position. Citations and important achievements (such as invited talks, important scholarly awards and positions etc.) are treated as final outputs. For the assessment of publications, the single-author equivalent (SAE) is used, which means that if, for example, a publication has three co-authors, each of them is assigned 1/3 of the publication.

The journals, and thus the publications in them, are either counted without any weighting (in one version of the model from Figure 2 in Despotis et al. (2015) or (in another version of the model from Figure 2 in the paper mentioned) classified in four quality classes (A+, A, B, C) according to the ERA2010 journal classification system<sup>1</sup> (www 1). A fifth class D is created for journals that are not indexed in ERA2010. The citations in both versions of the model were calculated as the number of units, without any weighting. The achievements (being editor-in-chief of a scholarly journal, associate editor or member of an editorial board, being invited as a keynote speaker to conferences, participating in organizing committees of conferences) were counted and weighted in a way which in Despotis et al. (2015) is not explained in detail.

The optimal values of the objective functions from the bicriteria model (5), representing the efficiencies of the researchers in Stages 1 and 2, were multiplied to form an overall efficiency of the researchers.

The most important conclusions from the case analyzed in Despotis et al. (2015) are the following:

- the difference between the case where the publications are counted without any reference to journal quality and the case where the journals, and thus publications, are classified according to the ERA system, is important: researchers with comparable efficiencies in the first case may have very different efficiencies in the second case;
- DEA delivers a better model for the evaluation of individual researchers than the conventional system of questionnaires, commonly used at universities at present;

---

<sup>1</sup> ERA: Excellence in Research in Australia.

- although DEA is a promising method for the evaluation of researchers, it is still unclear which model should be chosen; the following questions need to be answered:
  - are the stages in Figure 2 defined correctly, i.e., so that they reflect the needs of the evaluation of researchers?
  - are the inputs and outputs defined correctly?
  - how to weight publications and citations, how to quantify achievements etc.?The ERA system is just a proposal, and so are the quantifications of all the inputs and outputs used in Despotis et al. (2015).

### **3.2 The case of a selected academic faculty of a Polish university**

The aim of the present paper is to test the approach from Despotis et al. (2015) in another context: at an academic faculty of a Polish university. The system presently used there for the assessment of researchers is based on questionnaires; information about the outputs in Figure 2 is requested, but without a distinction of stages, with the relevant information limited to the last 2-4 years. No information about inputs is used, at least formally. The journals are classified according to points assigned as explained below.

We adopted the model from Despotis et al. (2015) with the following problems and changes:

- We did not take the Australian ERA system for journal classification, but a system which is often used in Poland (www 2), based on a so-called “ministry list”, elaborated and constantly updated by the Polish Ministry of Higher Education. Each paper in a journal included in this list is assigned a certain number of points (which may change from one year to another). The “ministry list” is composed of three parts:
  - A: journals with an impact factor and available in the JCR database (20 to 50 points);
  - B: journals that do not have an impact factor (0.25 to 10 points);
  - C: journals available in the European Reference Index for the Humanities (ERIH) database (12/16/20 points).
- We did not create any D class for journals not on the “ministry list”. These journals were not taken into account; nor were book chapters or publications in conference proceedings not on the “ministry list”. Of course, this decision may have influenced the results considerably. However, an initial study of the faculty in question has shown that it was publications in journals from the “ministry list” which really differentiated among the individual researchers.

- The information about achievements was not easily available. We had no access to the corresponding data. Therefore, we estimated the achievements on the basis of interviews and the incomplete knowledge we had of the persons in question, thus the results may be inaccurate in this regard. Additional input in the second stage was not considered.

As in Despotis et al. (2015), two versions of the model from Figure 2 are considered: one with all the publications from the “ministry list” treated equally (model M1) and another one with the number of points (according to the “ministry list” version from the year of the paper’s publication) taken into account as weights (model M2).

The salary was not the actual one, to which we did not have access, but the average salary for the given position. Of course, both in Greece and in Poland, the researchers in question have also teaching duties, hence only a part of their salary is spent on research activities, but the exact percentage is impossible to determine with the Activity Based Cost approach, which is used only in selected English-speaking countries and in Scandinavia (Cropper and Cook, 2000).

Tables 1, 2 and 3 show the descriptive statistics of the data for the two models. Table 1 shows the years in the positions and the salaries; these data are used by both models.

Table 1: Descriptive statistics (part 1) of the data for Models M1 and M2

	<b>Total Salary (in ten thousands)</b>	<b>Time in Position (years)</b>
<b>Min</b>	2,78	0,49
<b>Max</b>	10,93	44,02
<b>Average</b>	5,44	21,91
<b>St. Dev.</b>	1,69	14,62

Table 2 shows the rest of the data for Model M1 and the output data shared by both models.

Table 2: Descriptive statistics (part 2) of the data for Model M1 (publications) and for both models (citations and achievements)

	<b>Publications (SAE)</b>	<b>Citations</b>	<b>Achievements</b>
<b>Min</b>	0	0	7
<b>Max</b>	59,67	409	34
<b>Average</b>	9,02	19,75	8
<b>St. Dev.</b>	12,29	77,73	7

Table 3 shows the data on publications for Model M2.

Table 3: Descriptive statistics (part 2) of the data on the publications for Model M2

	Publications (SAE)		
	A	B	C
Min	0,00	0,00	0,00
Max	4,33	40,08	5,25
Average	0,35	6,04	0,28
St. Dev.	1,02	7,64	1,00

It can be noticed that the number of publications in classes A and C is much smaller than that in class B. The results in almost all the categories are rather diversified, which is shown by the standard deviations and the differences between the maximal and minimal values.

Model (5) was solved. Figures 1 and 2 present the distribution of efficiencies of the researchers in the first stage of models M1 and M2.

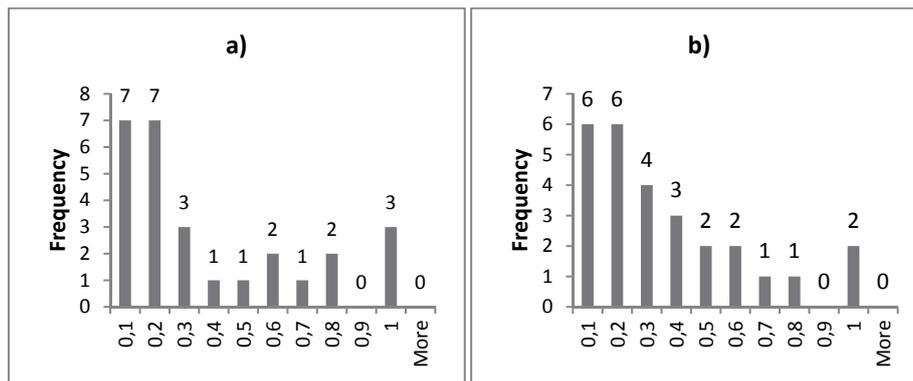


Figure 3. The distribution of productivities (efficiencies of the first stage, Figure 2) of researchers from the selected faculty of a Polish university for model M1 (a), all publications treated equally) and for model M2 (b), publications weighted according to journal quality)

A decrease in the productivity scores (Stage 1 in Figure 2) can be observed by comparing Figure 3a) (model M1, all publications treated equally) and 3b) (model M2, with the quality of publications taken into account). In the case of model M1 (Figure 3a)), the productivity of five researchers is over 0.7, in the other case (M2) only three researchers reach such a high productivity. This result can be visualized using the example presented in Table 4.

Table 4: Two selected researchers and their selected characteristics

	X	Y
Years in position	31.8	18.5
Total income in position (tens of thousands)	417.0	108.1
Publications after appointment (SAE total)	59.7	35.6
A (in SAE units)	2.1	0
B (in SAE units)	40.1	1
C (in SAE units)	5.3	0
Citations	409.0	1
Achievements	9	9
M1 – Productivity (Stage 1)	0.97	1
M2 – Productivity (Stage 1)	1	0.04

The two researchers can be regarded as similar with respect to the outputs, if the quality of journals is not taken into account. The mere fact of taking the quality of journals into account changes the assessment of the productivity of researcher B completely and the difference between the two researchers is visible.

Next we consider the second stage.

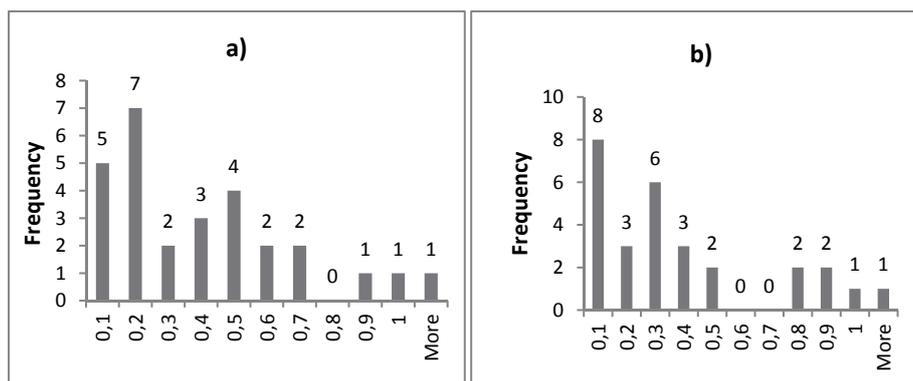


Figure 4. The distribution of impact/recognition (efficiencies of the second stage, Figure 2) of researchers from the selected faculty of a Polish university for model M1 (a), all publications treated equally) and for model M2 (b), publications weighted according to journal quality)

In the second stage of the model from Figure 2 the difference between not taking (Figure 4a)) and taking (Figure 4b)) journal quality into account has a lower influence on the results than in the first stage. It was probably because citations and achievements have a predominant impact on the results. It has to be kept in mind, however, that the citations were not weighed in either model and they come from journals of various quality and, as it was mentioned above, the

information about achievements is here biased to a high degree. Hence, if the citations were weighted as the publications in Model M2 had been and if more exact information about achievement were available, the results in the two models in the second stage may have differed in a similar way they do in stage 1.

The overall efficiencies of the researchers are presented in Figure 5a) (model M1) and b) (model M2).

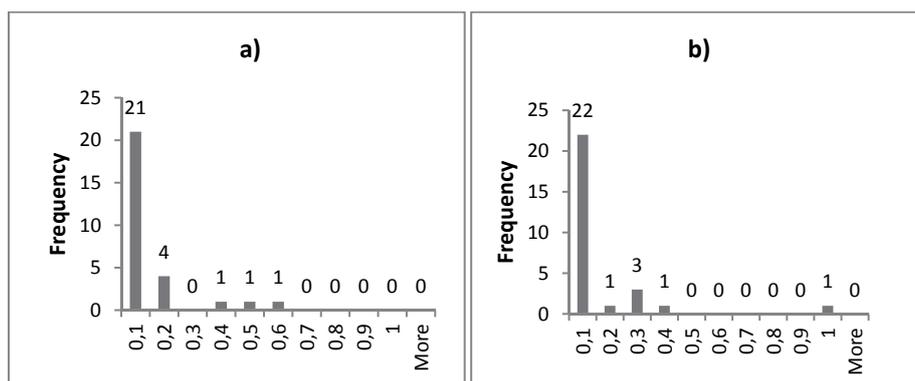


Figure 5. The overall efficiencies for both stages (Figure 2), calculated as a product, of researchers from the selected faculty at a Polish university for model M1 (a), all publications treated equally) and for model M2 (b), publication weighted according to journal quality)

As in Despotis (2015), the overall efficiency is calculated as the product of the values of both objective functions of the solution of problem (5). As a result, it is always relatively small and thus does not differentiate sufficiently among researchers. However, there is one researcher with the overall efficiency equal to 1 in model M2, hence he/she can be regarded as one who really distinguishes himself. Of course, in the analyzed case there is still the problem of insufficiently complete or exact data.

#### 4 Conclusions

In our paper, a general network DEA approach to deal with efficiency assessment in a two-stage process has been presented, with multi-objective programming as the modeling framework. The proposed approach has been applied to an academic faculty of Wroclaw University of Science and Technology with 28 members. Research productivity is evaluated in the first stage, while the second stage represents the impact/recognition of individual researchers. Time in Position and Salary are the inputs of stage 1 and publications are its output. In stage 2,

publications are the input, while achievements and citations are final outputs. Two versions of the model are considered: one with publications weighted equally and another one which takes into account their different quality.

It is important to underline the fact that the choice of criteria (outputs) we and other authors applying DEA use in assessing research activity is widely criticized (Retzer and Jurasinski, 2009; Vanclay, 2011; Woelert, 2015). First, it is emphasized that they are mainly quantitative and as such do not always reflect the actual value and output of a researcher or a research institution. Second, it has been shown that researchers, research institutions and academic journals have been adapting to the indicators so that higher values of the indicators do not correspond to a higher quality of research (Retzer and Jurasinski, 2009). There are attempts to include more qualitative and soft criteria in research evaluation (Retzer and Jurasinski, 2009), but this has not yet been incorporated into any DEA-based model. This step still needs to be done: DEA models will be useful only if the inputs and outputs used will correctly reflect the dependencies which exist in reality and the criteria which really do determine the quality of researchers.

Also, the network DEA model used in this paper has assumed a certain internal structure and stages in building up the output of the researchers. But the model is not ideal. First of all, the recognition of a researcher is a complex notion and it can be built up in another way than it was assumed in Despotis et al. (2015). In particular, non-quantitative data play here an important role, which is omitted in our model. The other problem is the multiplicative formula for the aggregated efficiency. In Despotis et al. (2015) and in our paper it gives, in most cases, very low values, hence the question arises whether it correctly differentiates among the researchers. Also, we can ask whether the input in the second stage (all the publications of the researcher being evaluated) is correct and what happens if he/she had very good publications in a remote past – is the model motivating in this case? Another question is how to separate the correct salary value corresponding to research activities, since the teaching load is very different in various institutions and countries.

The last important problem is the availability of data. In the case of the selected Polish university many important data are simply not available. Although publications are documented by library services and the corresponding information is available, citations are not classified according to any categories. This is not logical: if the weight of a publication depends on journal quality, so should the weight of a citation. And information about salary and achievements are sensitive data, which is protected and not available for scientific analysis of any kind. A coding method should be designed which would allow to store these data

and make them available in a legally acceptable form. The Greek university is much smaller and made its data available in a legal form.

Also, there is the issue of the possible inclusion of publications in journals which are not on any “list”, of chapters in monographs or publications in conference proceedings. There are important contributions among them, which are valued very low – the second model in Despotis et al. (2015) or not at all (our model). This question still awaits an answer.

Of course, much more cases should be considered before a final recommendation can be made for universities on how to evaluate researchers or for governments on how to evaluate research institutions. However, it seems that DEA is, on the whole, a correct approach and it should replace the present system of researchers evaluation (and research institutions evaluations) which does not take inputs into account. Output cannot be analyzed disregarding the input, which is clearly shown by the example in Table 4 (the two researchers there differ strongly in experience and salary, which has to be taken into account in their analysis). But the question should be answered how to choose and measure inputs and outputs in individual stages and globally.

## References

- Athanassopoulos A.D., Shale E. (1997), *Assessing the Comparative Efficiency of Higher Education Institutions in the UK by the Means of Data Envelopment Analysis*, *Educ. Econ*, 5, 117-134.
- Charnes A., Cooper W.W., Rhodes E. (1978), *Measuring the Efficiency of Decision Making Units*, *European Journal of Operational Research*, 2, 429-444.
- Cropper P., Cook R. (2000), *Activity-Based Costing in Universities – Five Years On*, *Public Money & Management*, 20, 61-68.
- Despotis D.K., Koronakos G., Sotiros D. (2015), *A Multi-objective Programming Approach to Network DEA with an Application to the Assessment of the Academic Research Activity*, *Procedia Computer Science*, 55, 370-379.
- Despotis D.K., Sotiros D., Koronakos G. (2016), *A Network DEA Approach for Series Multi-stage Processes*, *Omega*, 61, 35-48.
- Ghinolfi D., El Baz H.G., Borgonovini E., Radwan A., Laurence O., Sayed H.A., De Simone P., Abdelwadoud M., Stefani A., Botros S.S., Filippini F. (2014), *A Model for Southern Mediterranean Research Institute Self-assessment: A SWOT Analysis-based Approach to Promote Capacity Building at Theodor Bilharz Research Institute in Cairo (Egypt)*, *Arab Journal of Gastroenterology*, 15(3-4), 92-97.
- Hicks D. (2012), *Performance-based University Research Funding Systems*, *Research Policy*, 41(2), 251-261.
- Kuchta D., Skorupka D., Duchaczek D., Kowacka M. (2016), *Modified, Stakeholders Perspective Based DEA Approach in IT and R&D Project Ranking*, *ICEIS 2016: Proceedings of the 18th International Conference on Enterprise Information Systems*, Rome, Italy, 25-28 April 2016, S. Hammoudi (ed.), 2, 158-165.

- Lee B.L. (2011), *Efficiency of Research Performance of Australian Universities: A Reappraisal Using a Bootstrap Truncated Regression Approach*, *Economic Analysis and Policy*, 41(3), 195-203.
- Lee B.L., Worthington A.C. (2016), *A Network DEA Quantity and Quality-orientated Production Model: An Application to Australian University Research Services*, *Omega*, 60, 26-33.
- Meng W., Zhang D., Qi L., Liu W. (2008), *Two-level DEA Approaches in Research Evaluation*, *Omega*, 36, 6, 950-957.
- Retzer V., Jurasinski G. (2009), *Towards Objectivity in Research Evaluation Using Bibliometric Indicators – A Protocol for Incorporating Complexity*, *Basic and Applied Ecology*, 10(5), 393-400.
- Vanclay J.K. (2011), *An Evaluation of the Australian Research Council's Journal Ranking*, *Journal of Informetrics*, 5(2), 265-274.
- Woelert P. (2015), *The 'Logic of Escalation' in Performance Measurement: An Analysis of the Dynamics of a Research Evaluation System*, *Policy and Society*, 34(1), 75-85.
- (www 1) <http://guides.library.unisa.edu.au/c.php?g=169983&p=1119054> (access: 13.05.2017).
- (www 2) <http://www.bg.pw.edu.pl/index.php/en/indicators-for-journals-evaluation#the-polish-ministry-of-science-and-higher-education-scores> (access: 17.05.2017).