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Publication Efficiency in Science. Suggestions on Measures and their Application Using the Case of Poland and Nicolaus Copernicus University in Toruń

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Abstract

The article attempts to define the category of publication efficiency in science, and in this context to determine the strength of connections between financial outlays, the number of academic staff and the number of publications on the Web of Science at Nicolaus Copernicus University in Toruń. Reference data are established by the indexes compiled analogously at the Polish national level. The obtained results suggest a positive trend in publication efficiency at both the national and NCU levels. However, the differences between faculties and disciplines are significant. Moreover, analysis makes it possible to say that the developed measures constitute a good, synthetic source of information.

Keywords: *publication efficiency, fundings of science, parametric assessment, evaluation, WoS, Nicolaus Copernicus University in Toruń*

1. Introduction

Publication quality in world science is not homogeneously determined. Generally, assessment of publication quality may be based on two methods: parametric and qualitative (cf., Fenner, & Lin, 2015; Aagaard, 2015; Ernst, 2010). Theoretically, these two may be applied together as complementary methods; however, most often they are treated separately. Nowadays, the clearly apparent trend is

a turn towards creating lists which position scientific journals or publishers; a turn that is based on the mechanism of inheriting prestige (cf., Kulczycki, Korzeń, & Korytkowski, 2017; Drabek, 2017). The mechanism follows the assumption that articles in journals inherit the position of those journals and monographs inherit the prestige of their publishers. This means that there is a great trust in the work of the editorial staff and publishers, and therefore the peer review model is replaced by the periodic evaluation of journals and publishers.

Despite its numerous disadvantages (cf., Dobrovidova, 2016; Bagioli, 2016; Wróblewski, 2017; Kulczycki, 2017), assessing publication efficiency by using the mechanism of inheriting prestige gives relatively measurable results, which makes this method useful in the process of parameterization of scientific units and in the evaluation of the work of individual scholars (cf., Kreiner, 2016; Wróblewski, 2017).

Evaluation of scientific units (in Poland, the basic units which undergo the process of evaluation are mainly faculties) mostly depends on the parametric value of the best publications. The definition of a parametrically efficient publication is based on the analysis of *Rozporządzenie [Regulation]* (2016), according to which the most efficient group of publications is constituted by journals included in *the A list* of the Polish Journal Ranking, especially if their point value is 25 points or more. Generally speaking, each unit may submit to assessment three times as many publications as the average number of its academic workers during the parametric period (depending on the discipline, monographs may constitute maximum 40% of that, with each monograph worth 25 points). Therefore, articles in journals from lists A, B, and C must constitute minimum 60% of all the publications presented for assessment.

However, what exactly is publication efficiency? In the light of the aforementioned facts concerning the assessment of the quality of scientific publications, publication efficiency should be defined as the achievement of the most prestigious publishing results possible with the lowest financial outlays possible and with the minimum number of academic workers.

On the one hand, the problem discussed in the article is an attempt to define publication efficiency in science, and on the other hand, it is a practical analysis and evaluation of the efficiency levels at Nicolaus Copernicus University in Toruń (NCU). The analysis focuses on connections between the number of prestigious publications, the level of financial outlays and the number of academic workers at NCU. The indexes linking analogous variables at the national level have also been examined here, which made the comparative analysis possible.

2. Research Methodology

The conducted research assumes that the priority is assigned to publications from *the A list* (as can be concluded from the guidelines on parametric procedures), which means publications in journals with defined Impact Factor (IF). Thus, these are the publications which may be regarded as the most important measure of the publication efficiency achieved by Poland overall, individual universities or their faculties. Access to data which characterize research funds, the number of academic workers and the number of publications with IF at the national level as well as in reference to one of the 18 Polish universities make it possible to conduct both comparative analysis and the analysis of the trend over the period 2013–2016 (the parametric period determined in the Polish system of unit evaluation).

The university analysed here is NCU, which now has a wide-profile educational offer as it includes 14 faculties in Toruń and 3 in Bydgoszcz (Collegium Medicum – CM). The academic workers employed at NCU conduct research in six most important disciplines: social sciences, humanities, natural sciences, exact sciences, medicine, and arts.

The data concerning publications by NCU academics were collected by using the Expertus system which includes bibliography of their scholarly achievements (gathered from 1st July 2017 to 16th July 2017). Thanks to the data it was possible to precisely pinpoint the works with IF (which is tantamount to the presence on *the A list*) for individual faculties and academics over the period 2013–2016. The data concerning financial outlays on NCU in total and split among individual faculties as well as the number of academic workers come from the reports published in the NCU Law Bulletin.

In the case of Polish universities, financial outlays on science include, among others, statutory subsidy, which has institutional character and is provided by the Ministry of Science and Higher Education, and grants, which are mostly awarded on the basis of competitions organized by the National Science Centre (the NCN) and The National Centre of Research and Development (the NCRD).

The analysis was also based on the data obtained from the Web of Science (WoS) database. Data collection process included searching for those articles in the WoS database which have at least one author affiliated to a Polish university or a scientific research unit (gathered from 20th to 21st July 2017). The tools provided by Clarivate Analytics were used to aggregate the data, which facilitated the process of determining the articles with IF affiliated in Poland over the period 2012–2015.

The Polish national data concerning the number of academics and the financial outlays on science come from the cyclical reports by the Central Statistical Office of Poland titled *Szkoły wyższe i ich finanse* [*Higher Education Institutions and their Finances*] from the years 2013–2016 (data for the period 2012–2015).

The collected data were analysed according to two main efficiency measures. Both of the measures had analogous structure for the national level and the NCU level (as a whole and for individual faculties):

- financial efficiency measure (financial efficiency), which conveys the relation between financial outlays on scientific activity and the number of published articles with IF, which makes it possible to determine the total cost of publishing one text that later appears in the reference database;
- personal efficiency measure (personal efficiency), which conveys the relation between the number of academics (academic teachers) and the number of published articles with IF.

The suggested efficiency measures are based on the assumption that the effects of scientific activity are in fact publications in international journals – included in the WoS data set as the basic reference data set and with established IF. Due to both the parameterization procedures and the prestige associated with this group of publications, they constitute the crowning achievement of scholars' careers. Referring to this particular group does not mean that other publications are regarded as irrelevant, but it only implies that the synthetic measure of the effects of scientific research is a publication in a journal with established IF, while less prestigious publications and speeches constitute a part of the path leading there.

Additionally, for individual NCU faculties the percentage of publications with IF against the total number of their publications has been determined, which shows the individual faculties' specificity of publication strategies and thus presents a diversity among the disciplines.

In regard to time span, the performed analysis also includes a trend analysis within the four-year period which includes the parameterization introduced in 2016. The national and NCU data were also used for comparative analysis (with the reservation that the Polish national data and the data for the selected higher education institution only partially cover the same time span since the Central Statistical Office has not published the data for the year 2016 yet (by July 2017).

3. Research Results

3.1. The situation in Poland

Trend analysis. The collected data make it possible to describe the trend in several dimensions. First of all, over the period 2012–2015 the number of academic teachers in Poland slightly decreased, which partially results from the actual decline in their number and it is partially connected with transformation to the model in which scholars occupy a single job position, for this measure in fact presents the number of positions (Table 1). In 2015, the number of academic teachers constituted 95.2% of the 2012 figure. A similar decrease (in 2015–95.8% of the amount from 2012) was noted in the subsidy on maintaining research potential, which constitutes one of the basic sources of funding scientific activity of higher education institutions (faculties). At the same time, the income from the research activity of Polish higher education institutions was growing (“statutory” subsidy on supporting research potential is a part of this category of income), and in 2015 it reached 113.6% of the amount from 2012. Even more dynamic was the increase in the number of scientific articles by authors with Polish affiliation, which were recorded in WoS – in this case the number of articles from 2015 constituted 127% of the figure from 2012.

Table 1. Characteristics of Polish science with regard to the number of academic teachers, scientific activity funding, and scientific articles in the reference data set over the period 2012–2015

Year	Academic teachers	Income from the research activity of Polish higher education institutions (in thousand PLN)	Subsidy on supporting research potential (in thousand PLN)	Scientific articles by authors with Polish affiliation in WoS
2012	100 738	2 864 237	602 856.2	22 611
2013	98 497	2 876 209	547 799.7	23 857
2014	96 534	3 064 522	528 520.7	2 5114
2015	95 918.5	3 253 782	578 011.2	28 726

Source: the Central Statistical Office data.

Personal and financial efficiency. The efficiency measures widely vary depending on the category of funds for scientific activity which is used in order to determine the financial efficiency measure. However, they demonstrate an

analogous trend. If all the funds (which are found in the Central Statistical Office database) for scientific activity of Polish higher education institutions are to be taken into account, then the average cost of publishing an article with IF exceeded 100 thousand PLN. Yet, when considering only the subsidy on supporting research potential, it amounted to a bit over 20 thousand PLN (Table 2). At the same time, from the perspective of Polish science policy, both measures of financial efficiency had a positive decreasing trend, which, when comparing publishing success to all funds in 2015, resulted in financial efficiency that constituted 89% of the amount from 2012; if we consider only the subsidy on supporting research potential, then in 2015 it was 75% of the amount from 2012. Moreover, personal efficiency was characterized by a positive trend, and in 2015 it constituted 75% of the amount from 2012.

Table 2. Publication efficiency measures over the period 2012–2015
(all-Poland data)

Year	Financial efficiency (in thousand PLN)		Personal efficiency
	In relation to the total income from scientific activity	In relation to subsidy on support- ing research potential	
2012	126.67	26.66	4.46
2013	120.56	22.96	4.13
2014	122.02	21.04	3.84
2015	113.27	20.12	3.34

Source: Own study.

The publication efficiency measure makes it possible to estimate that publishing an article recorded in WoS requires funds amounting to 113 thousand PLN. It is necessary to say that this money is not the salaries of academics but only the funds which are qualified and accounted for as funds for scientific activity. Certainly, there are scholars who publish in renowned foreign journals which are present in the reference database without receiving funds for research (i.e., without grants from statutory funds, from the NCN, the NCRD, etc.). However, it is hard to estimate their number and present the degree to which the aforementioned estimation would have changed. The personal publication efficiency measure reveals the increasing “efficiency” of Polish scholars – in 2012 there were two articles recorded in WoS for every nine academics, but four years later, there were almost three.

3.2. NCU case study

Analysis of trends. Looking at the most important measure in this analysis, which is the number of articles published by NCU academics in WoS, a certain regularity may be observed. All the faculties which conduct research in the area of natural sciences, medicine, and exact sciences present rather an upward trend (Table 3). However, this is not the case with the faculties of humanities and social sciences, whose number of publications with IF is lower (although this cannot be said about the total number of their publications). At the same time, the number of academics at individual faculties has changed only slightly, and in many cases shows a decreasing tendency.

The leader in the number of articles with IF compared to the total number of publications is CM – especially the Faculty of Medicine. A similarly high level is represented by such faculties as the Faculty of Physics, Astronomy and Informatics, and the Faculty of Mathematics and Computer Science (Table 4). Although the rest of the faculties – humanities, social sciences, and fine arts – often have a significantly higher number of publications compared to the employed scholars than other faculties, their presence in WoS is occasional. Also, the faculties considerably differ in the cost of supporting research potential; the amounts for faculties of natural sciences, medicine, and exact sciences are definitely higher (often exceeding 1 million PLN) than for the faculties of humanities or social science. In perspective, large fluctuations of the sums are visible, and the strongest and explicitly growing trend is characteristic of the CM faculties.

Financial and personal efficiency. Given the wide scope of research and the variety of scientific communication paths chosen by the NCU scholars, the answer to the question regarding their efficiency is ambiguous. However, if – according to the assumptions of this paper – we postulate that the key element used to calculate the efficiency measure is publication activity assessed on the basis of scientific articles with IF, it is possible to observe clear trends and, at the same time, differences between the faculties (Table 5). The most efficient are representatives of natural sciences, medicine, and exact sciences. The faculties which need the fewest academics (<1) to publish an article are the Faculty of Biology and Environmental Protection, the Faculty of Chemistry, and the Faculty of Physics, Astronomy and Informatics. Their texts are also relatively cheapest (below 10 thousand PLN). The last in this ranking is the Faculty of Theology, as for four years none of its scholars published an article with IF. Other faculties that appear inefficient according to this measurement method include the Faculty of Education Sciences, the Faculty

Table 3. Correlation of the number of academic workers employed at NUC with the total number of their scientific publications and scientific articles with IF divided by faculties over the period 2013–2016

Faculty	Employment (academic workers)					Scientific publications					Publications with IF (only scientific articles)					
	2013	2014	2015	2016	2013– 2016	2013	2014	2015	2016	2013– 2016	2013	2014	2015	2016	2013– 2016	
Time span	107	107	101	102		358	310	391	309	1368	79	87	108	130	404	
Faculty of Biology and Environmental Protection (FBEP)																
Faculty of Chemistry (FC)	95	89	92	92		395	397	457	421	1670	112	136	131	141	520	
Faculty of Earth Sciences (FES)	60	54	55	57		268	280	911	234	1693	13	16	22	35	86	
Faculty of Economic Sciences and Management (FESM)	108	108	108	109		346	433	352	410	1559	1	0	4	7	12	
Faculty of Education Sciences (FEoS)	55	58	52	51		260	288	251	272	1071	0	0	0	2	2	
Faculty of Fine Arts (FFA)	140	141	136	136		189	185	200	171	745	3	7	7	2	19	
Faculty of History (FHi)	132	123	122	119		680	780	703	636	2799	2	10	5	4	21	
Faculty of Humanities (FHU)	67	62	64	73		220	209	236	219	884	2	6	4	6	18	
Faculty of Languages (FL)	179	169	167	171		507	529	584	547	2167	2	2	3	4	11	
Faculty of Law and Administrations (FLA)	111	108	104	107		614	660	662	672	2608	0	2	1	0	3	
Faculty of Political Sciences and International Studies (FPSIS)	59	58	58	57		318	303	307	305	1233	0	1	3	1	4	
Faculty of Mathematics and Computer Science (FMCS)	81	77	82	83		190	132	153	102	577	71	53	80	53	257	
Faculty of Physics, Astronomy and Informatics (FPAl)	131	121	127	121		308	308	274	261	1151	149	168	160	159	636	
Faculty of Theology (FT)	35	34	33	33		170	230	271	204	875	0	0	0	0	0	
Faculty of Health Science (FHS)	278	269	282	276		730	647	1229	708	3314	51	64	71	106	292	
Faculty of Medicine (FM)	312	311	322	313		760	737	659	785	2941	133	135	146	129	543	
Faculty of Pharmacy (FP)	151	148	152	153		379	353	323	459	1514	50	63	70	102	285	

Source: Own study.

Table 4. The percentage of scientific articles with IF in all scientific articles by NCU academics plus the cost of supporting research potential according to faculties over the period years 2013–2016

Faculty	The number of scientific articles with IF in all scientific articles (in%)						The cost of supporting research potential (statutory subsidy) (in thousand PLN)								
	2013	2014	2015	2016	2013–2016		2013	2014	2015	2016		2013	2014	2015	2016
FBEP	74.53	67.44	73.47	85.53	75.66		624.5	590.9	927.8	778.2		624.5	590.9	927.8	778.2
FC	79.43	83.95	78.92	87.04	82.41		1 006.3	891.9	1 102.5	1 157.6		1 006.3	891.9	1 102.5	1 157.6
FES	12.75	17.98	23.16	35.35	22.34		227.7	221.8	613.6	244.4		227.7	221.8	613.6	244.4
FESM	0.52	0.00	2.21	3.32	1.52		276.2	228.1	399.8	236.8		276.2	228.1	399.8	236.8
FEdS	0.00	0.00	0.00	2.53	0.61		149.2	179.2	217.5	324.9		149.2	179.2	217.5	324.9
FFA	8.33	12.73	13.21	6.90	10.98		259.4	459.6	1 080.2	860.0		259.4	459.6	1 080.2	860.0
FHi	1.09	5.65	3.13	3.57	3.32		381.8	451.1	261.1	600.6		381.8	451.1	261.1	600.6
FHu	2.53	9.38	3.96	7.50	5.56		458.1	503.1	312.2	478.8		458.1	503.1	312.2	478.8
FL	1.30	1.39	2.05	2.56	1.83		492.1	504.1	506.1	536.6		492.1	504.1	506.1	536.6
FLA	0.00	1.24	0.59	0.00	0.45		272.9	161.5	168.5	265.4		272.9	161.5	168.5	265.4
FPSJS	0.00	1.22	3.80	1.11	1.18		79.4	191.8	238.6	307.7		79.4	191.8	238.6	307.7
FMCS	77.17	89.83	93.02	88.33	86.53		892.9	414.4	373.0	339.7		892.9	414.4	373.0	339.7
FPAI	80.54	86.15	89.39	84.57	85.14		1430	1398.8	892.7	1143.2		1430	1398.8	892.7	1143.2
FT	0.00	0.00	0.00	0.00	0.00		61.8	36.9	134.6	121.2		61.8	36.9	134.6	121.2
FHS	20.00	21.84	21.85	28.65	23.49		472.1	587.9	774.1	1128.5		472.1	587.9	774.1	1128.5
FM	91.72	97.83	97.33	65.82	86.33		1457.2	2378.8	2756.2	3157.1		1457.2	2378.8	2756.2	3157.1
FP	15.34	19.38	23.97	34.81	23.06		622.9	884.3	1197.3	1516.2		622.9	884.3	1197.3	1516.2

Source: Own study.

of Political Sciences and International Studies, and the Faculty of Fine Arts, where in 2016 publishing one text with IF cost 430 thousand PLN.¹

Table 5. How much does one publication with IF cost at NCU?

Faculty	Financial efficiency (in thousand PLN)				Personal efficiency				
	Time span	2013	2014	2015	2016	2013	2014	2015	2016
FBEP		7.91	6.79	8.59	5.99	1.35	1.23	0.94	0.78
FC		8.98	6.56	8.42	8.21	0.85	0.65	0.70	0.65
FES		17.52	13.86	27.89	6.98	4.62	3.38	2.50	1.63
FESM		276.20	–	99.95	33.83	108.00	–	27.00	15.57
FEdS		–	–	–	162.45	–	–	–	25.50
FFA		86.47	65.66	154.31	430.00	46.67	20.14	19.43	68.00
FHi		190.90	45.11	52.22	150.15	66.00	12.30	24.40	29.75
FHu		229.05	83.85	78.05	79.80	33.50	10.33	16.00	12.17
FL		246.05	252.05	168.70	134.15	89.50	84.50	55.67	42.75
FLA		–	80.75	168.50	–	–	54.00	104.00	–
FPSIS		–	191.80	79.53	307.70	–	58.00	19.33	57.00
FMCS		12.58	7.82	4.66	6.41	1.14	1.45	1.03	1.57
FPAI		9.60	8.33	5.58	7.19	0.88	0.72	0.79	0.76
FT		–	–	–	–	–	–	–	–
FHS		9.26	9.19	10.90	10.65	5.45	4.20	3.97	2.60
FM		10.96	17.62	18.88	24.47	2.35	2.30	2.21	2.43
FP		12.46	14.04	17.10	14.86	3.02	2.35	2.17	1.50

– no publications with IF

Source: Own study.

In the context of the whole institution, it is possible to observe a positive trend – both of the defined efficiency measures were lower in 2016 than in 2013, with more visible change in personal efficiency (the measure value in 2016 constituted 71% of the measure value from 2013, while for financial efficiency the analogous comparison was 95.3%). At the same time, the personal efficiency measure has been clearly and consistently growing lower, whereas the financial efficiency measure has visibly fluctuated.

¹ Again, it should be emphasized that the criteria adopted in this paper are simplified and do not show the whole spectrum of activity of individual faculties.

Table 6. The average publication efficiency of NCU academics over the period 2013–2016

Year	Financial efficiency (in thousand PLN)	Personal efficiency
2013	57.20	2.94
2014	51.64	2.57
2015	56.88	2.57
2016	54.53	2.09

Source: Own study.

3.3. Comparison: NCU vs. all-Poland data

When comparing NCU and the general situation in Poland, it is necessary to mention a similarity in the direction of changes in financial efficiency. Depending on the method applied to determine this efficiency, the financial efficiency of NCU may be higher or lower than the average one for Poland, which mostly results from the partial incompatibility of the data categories collected for NCU and those from the Central Statistical Office. In regard to all-Poland data, in both cases a slightly decreasing tendency may be noticed whereas due to the fluctuations of the measure, the observed trend shows a direction that is only slightly marked.

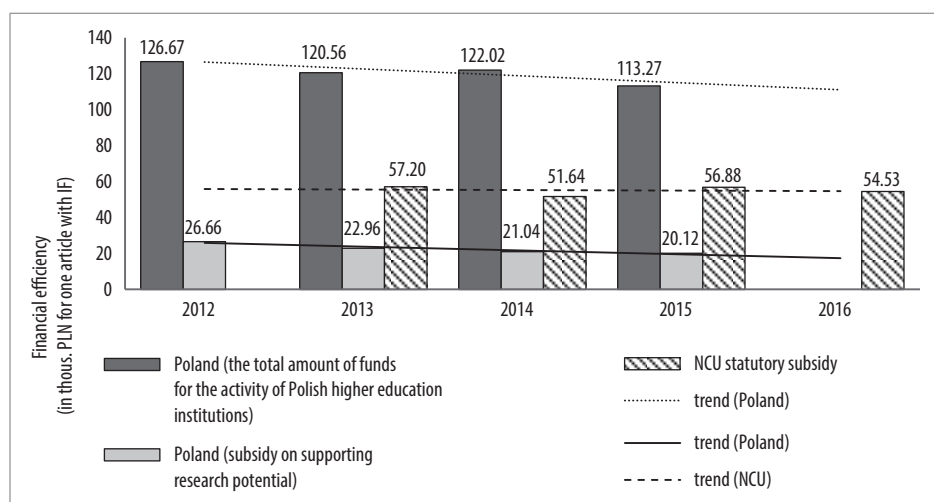


Figure 1. Financial efficiency

Source: Own study.

As for personal efficiency, both the all-Poland and NCU data show a less clear positive trend, i.e., a decreasing measure value, which means that (statistically) with time publishing one text with IF involves fewer and fewer scholars. Moreover, in comparison to the all-Poland data, this measure for NCU is clearly lower.

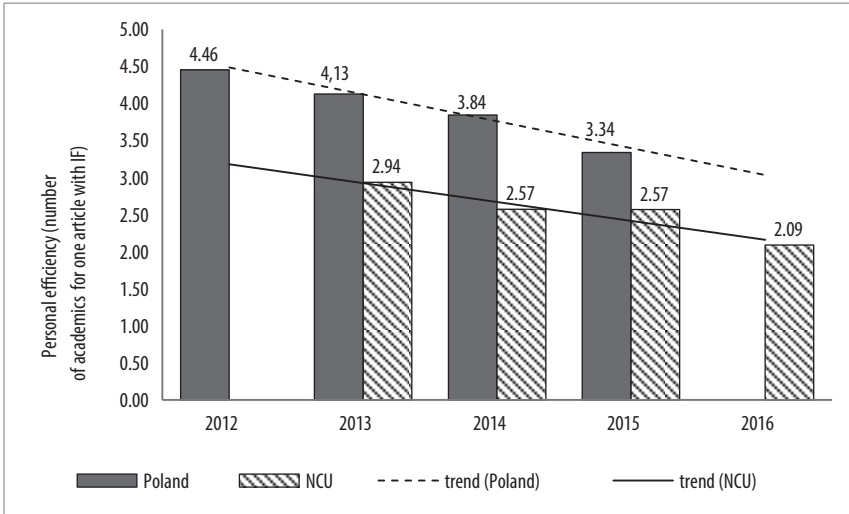


Figure 2. Personal efficiency
Source: Own study.

4. Discussion

The presented data lead to several conclusions of different generality levels. First of all, in regard to trends, both at the all-Poland and NCU level there are positive tendencies that are demonstrated by the decreasing values of the financial and personal efficiency measures, which reflects an increase in publication efficiency. Taking into account the relatively strong emphasis placed on publishing in journals with defined IF as well as the variety of publication practices characteristic of individual disciplines (where social sciences and humanities except psychology previously have had no established custom of publishing articles in WoS), the results may be interpreted as a reflection of tendencies desired by regulatory institutions (mainly the MSHE), and thus as an expression of efficiency of the applied means of influence. At the same time, the presence of social sciences and humanities in journals with WoS remains marginal despite the observed increase,

as all publications from these disciplines constitute about 4% of publications by authors with Polish affiliation recorded in WoS (in 2015), which is still twice more than in 2004 (cf., Jeran, & Piechowiak-Lamparska, 2016).

The NCU faculties are characterized by considerable diversity resulting from the differences in publishing practices followed by individual disciplines as well as from their different quality. The faculties may be divided into three basic groups:

1. Faculties which have good financial and personal efficiency measures and at the same time are characterised by positive trends – these faculties include the Faculty of Biology and Environmental Protection, the Faculty of Chemistry, and the Faculty of Physics, Astronomy and Informatics, as well as all the CM faculties, the Faculty of Mathematics and Computer Science, and the Faculty of Earth Sciences;
2. Faculties which are characterised by a positive trend; however, the defined personal efficiency measures are very high, which shows that the articles with IF coming from these faculties have only several authors. These faculties are: the Faculty of Languages, the Faculty of Humanities, and the Faculty of Economic Sciences and Management;
3. Faculties where publications with IF are rare and present only in some of the years analysed here. These faculties include: the Faculty of History, the Faculty of Education Sciences, the Faculty of Political Sciences and International Studies, the Faculty of Fine Arts, and the Faculty of Theology.

On the basis of the performed analysis it is possible to show strong and weak points of the suggested measures. The strong points include their synthetic character, ease of interpretation, and the possibility of describing and assessing trends in an explicit manner. However, there is a problem with data comparability – the categories of financing used by the Central Statistical Office and the higher education institutions are not fully convergent. Yet, if the comparison of data is limited to one of these institutions, the financial efficiency measure adopted in order to compare and characterise individual faculties is appropriate and the usefulness of its application raises no doubt.

5. Conclusions

The general trend shows that the effects of system influence which are in conformity with principles are being achieved. However, it is not clear whether they are sufficiently supported and how many scholars are able to translate the requirements of the long-term strategy into operational activities. What is needed

are coherent systems dedicated to the improvement of publication efficiency – adequate support for individual higher education institutions and scholars in order to increase their chances to publish in WoS indexed journals. The results also show differences, which probably result from the specificity of disciplines which do not follow the practice of publishing in WoS (since monographs are more valued there, or there are no journals dedicated to these disciplines in WoS).

The actions taken by the NCU authorities may serve here as an example of implementing such a system. The most important rector scholarships are awarded for all publications in scientific journals that have the MHES scoring equal to or higher than the threshold established for each group of faculties (social sciences, exact and natural sciences, medicine, humanities, arts) (*Uchwała Nr 217 Senatu NCU, [the NCU Senate Resolution No. 217]*). Moreover, the deans of individual faculties can give special bonuses for publication achievements, which are awarded for publications in scientific journals with the highest number of points, also in accordance with the threshold established for each faculty.

The suggested efficiency measures are a good synthetic picture of the situation although the full comparability requires investigation whether the data on financing may be collected with better category convergence. Nevertheless, the issue of publication efficiency and the applied measures are undoubtedly worth discussing. Perhaps WoS is not the most prestigious publication place for all disciplines. However, it is difficult to define to what extent the government should intervene in science and to what extent scientific research should be free to develop in a natural way.

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