Scientometrics, Vol. 20. No. 1 (1991) 37-54

SCIENTOMETRIC EVALUATION OF THE SCIENTIFIC PERFORMANCE AT THE FACULTY OF NATURAL SCIENCES, KOSSUTH LAJOS UNIVERSITY, DEBRECEN, HUNGARY‡,*

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(Received February 23, 1989)

The standard of research at different departments of the Faculty of Natural Sciences of Kossuth Lajos University has been assessed by a scientometric evaluation of the publication activities of the departments. The essence of our approach is the consideration of the number and quality of the papers published. For a measure of this quality we regarded the impact factor of the journal, in which a paper was published. The rather different range of the impact factors of different fields were taken into account during the evaluation. As a whole, no considerable difference was found between the publication activity (impact per number of researchers) of the research institutes of the Hungarian Academy of Sciences and the corresponding departments of our Faculty, although, significant differences occur in certain fields. Based on this study, changes in the publication strategies of the different departments were recommended.

Introduction

Scientometric evaluation of the quality of scientific performance has never been applied to universities in Hungary. One of the reasons was that although scientometrics has a long history, it was practically an unknown subject to Hungarian scientists until the late 70's. Since then the deliberate effort of the Information Science and Scientometrics Research Unit (ISSRU) of the Library of the Hungarian Academy of Sciences (LHAS) made scientometrics known to a broad community of Hungarian scientists. Nowadays its methods are widely applied.

In 1982 we carried out a scientometric evaluation at the Faculty of Natural Sciences of our University. We started off by sending out questionnaires to 314 faculty members. We asked them for a voluntary help in this study. In return we received only 126 (40%) forms filled out. The low percentage of response clearly indicates a kind of psychopathic reaction of some scientists in a situation when

‡ Dedicated to the memory of Michael J. Moravcsik

* The Hungarian version was published in Felsőoktatási Szemle, 7-8 (1984) 395-411.

 Elsevier, Amsterdam – Oxford – New York – Tokyo
Akadémiai Kiadó

him(her)self or rather his(her) own performance is tried to be measured by the very same exact manner like what he(she) applies in his(her) research.

We received statements with full of anger, like the followings: "Scientific performance cannot be measured" or "Science should not be measured but rather done.". These emotional reactions originate from a complete misunderstanding of both the aims and methods of scientometrics. People tend to forget that scientometrics analyses scientific performance by statistical methods on the base of publications only and applies first of all to large groups of scientists (a country, an Institute) and the least importantly to a single person. Many of these colleagues are concerned - perhaps with good reason - that judgement over their own performance will be limited to these kinds of investigations only. We have to spell out unequivocally that the result of even the most thorough and circumspect scientometric investigation could be only one but very important element in evaluating scientific performance. Measuring scientific performance is not like measuring length or temperature. The true merit of a scientific production is judged only by those who study or have studied science and in fact, the result cannot be expressed in terms of cold numbers only. However, a great number of scientometric investigations have proved that the conclusion drawn from the numerical results of the scientometric analysis are generally in a good agreement with the peer reviews.

In spite of the low percentage of the response, the collected data allowed us to draw general conclusions. 118 faculty members reported that at least one publication has been published in his career. These scientists represent a much greater impact on the scientific output of our Faculty that would simply follow from their ratio to the total number of faculty members. This statement is based on the following. By studying the bibliographies of our University published in the period between 1975 and 1981, it was found that 100 faculty members had not even a single publication. In fact, 90% of the faculty members who returned the questionnaire were listed also in the bibliographies. The remaining 10% had publications either after 1981 or had not at all. If we suppose that each of these 100 faculty members had at least one publication but this was not reported in the bibliographies because of some errors, the extra 100 publications would add only 4% more publications to the total number of publications (2626) represented by the scientifically active 118 faculty members who responded to our questionnaires. Comparing this number (118) to the total number of faculty members listed in the bibliographies (196), we found that about 60% of the scientifically active faculty members are represented by our study. Distribution of 88 non-responding but scientifically active faculty members was even among the different departments representing different disciplines. Therefore, we are convinced that the survey could provide characteristic data for our scientometric analysis.

Method of analysis

There are different methods in qualifying the scientific production of a given scientist, a group of scientists, an institute, or even a country.

The less informative results follow from simply counting the number of publications, regardless of where they were published and how many times they were cited by other authors.

A more accurate and perhaps the most frequently applied method is based on the *Science Citation Index* (*SCI*) published by the Institute for Scientific Information (ISI), Philadelphia, USA. The evaluation is based on the number of citations, therefore one needs to collect the citations quite tediously author by author, paper by paper. Although this method seems to be an objective one, there are also problems with it, especially when we apply to the most recent publications. References appear quite often after a two-three year lag period only. (History of science knows extreme examples when citation of a publication started only after decades.)

In this study we took a third approach, the basis of which was worked out partially by the ISSRU of LHAS and developed further by us. This statistical method provides less accurate results when applied to one person, but serves well in comparing different groups of scientists. The method is based on the fact that the world-wide community of scientists always makes an informal grading of the scientific journals. This grading is then always applied by intuition when a decision is made on which journal the manuscript is going to be sent in based on the estimated quality of the paper. By the way, this is the best publications strategy that one should follow. Therefore, it is reasonable to assume that the value of a publication is generally measurable by the rank of the journal in which it was published. The rank of a journal is given by the value of the so called impact factor introduced by *Garfield.* 4000 journals are investigated by the ISI and their impact factors are published in the issues of the Journal Citation Reports every year. Impact factor is calculated by dividing the total number of citations for the papers published by a given journal in the year in question and a year before, with the total number of papers published by the same journal in the same period.

Although impact factor appears and intended to be an exact and objective (statistical) measure of the quality of a journal, its value also reflects the limitations of the ISI data base, the difference between countries, journals and disciplines in the way that publications are written and references are handled, therefore, one should be very careful in drawing conclusions. The impact factor approach is most reliable in the fields of physics and chemistry where the main body of publications is published in well-known international journals. It is obvious that the impact factors change year by year. In evaluating the scientific performance of our Faculty we chose the 1979's impact factors of journals, regardless of the real date of appearance. (If publication of a journal was stopped or different journals were created from a former one, the impact factor of the legal successor was taken into account.)

Definitions

Total impact (I_T) of an author is the sum of the impacts of his papers published in Hungarian (I_H) and in any world language (I_W) during his(her) career:

$$I_T = I_H + I_W \tag{1}$$

I_H and I_W are calculated according to Eqs (2) and (3):

$$I_H = \sum_i N_{H,i} f_i \tag{2}$$

$$I_W = \sum_j N_{W,j} f_j \tag{3}$$

where $N_{H,i}$ and $N_{W,j}$ are the numbers of publications published in a given journal in Hungarian (i) and world languages (j), respectively, while f_i and f_j are the impact factors of these journals.

Nowadays, publications are generally written by several authors. It is not correct therefore to attribute the full impact of a paper to every author separately. Instead, we calculated the *reduced impact of one author* by the following way. First we calculated, separately, journal by journal, the overall number of the authors of papers of a given faculty member. Dividing these numbers with the numbers of papers published by this author in the corresponding journals, the *average numbers of the authors* (A_i or A_j) are resulted. *Reduced impacts of one author* are calculated then by Eqs (4)-(6):

$$R_T = R_H + R_W \tag{4}$$

$$R_H = \sum_i N_{H,i} f_i / A_i \tag{5}$$

$$R_W = \sum_j N_{W,j} f_j / A_j \tag{6}$$

Different types of *average* impacts of papers published by one author can be calculated by dividing the values of impacts I_T, I_H and I_W with the numbers of the corresponding publications $N_H = \Sigma\ N_{H,i}$, $N_W = \Sigma\ N_{W,j}$, $N_T = N_H + N_W$. Since certain journals are not registered by the ISI or have zero impacts, it seems to be more correct to divide with the *reduced number of papers* $N_H^{\prime}$, $N_W^{\prime}$ and $N_T^{\prime}$. These are the numbers of papers that effectively contribute to the impacts of an author (total number of papers minus the number of papers published in journals with zero impacts). By dividing the impacts with the corresponding reduced numbers of papers we get the so called *effective average impacts*. A complete list of these characteristics together with their defining equations is given in Table 1.

Table 1

Type of average impact	Defining equation
average impact of all papers	$\bar{I}_T = I_T/N_T$
effective average impact of all papers	$\bar{I}_{T,E} = I_T/N_T^{\prime}$
average impact of papers in world languages	$\bar{I}_W = I_W/N_W$
effective average impact of papers in world languages	$\bar{I}_{W,E} = I_W/N_W^{\prime}$
average impact of Hungarian papers	$\bar{I}_H = I_H/N_H$
effective average impact of Hungarian papers	$\bar{I}_{H,E} = I_H/N_H^{\prime}$

Scientific performance can also be measured by the average value of the impact achieved in a year (I_y) that is calculated according to Eq.(7).

$$I_y = I_T/t \tag{7}$$

where *t* is the period (in years) that has been passed since the first publications of an author appeared (this period will be referred to as publication period). Reduced impact per year (R_y) is calculated in a similar way:

$$R_y = R_T/t \tag{8}$$

These quantities are much more characteristics than the average number of papers published in a year:

$$N_y = N_T/t \tag{9}$$

Results and discussion

In 1982 the Faculty of Natural Sciences at Kossuth Lajos University, Debrecen employed 314 teachers and researchers at five Faculties:

Biology:	53
Chemistry:	96
Geology:	25
Mathematics:	78
Physics:	62

Figure 1a shows a distribution of the faculty members (in percentages) according to age. The highest value belongs to the group of people with ages between 34 and 38. This is the group of scientists, the most members of which have already received the lower level scientific degree from the Hungarian Academy of Sciences. These people could lead research teams. However, a few of them can achieve this status, partly because of the lack of younger co-workers. In the next 5-10 years the ageing of our faculty is going to tend to a point where the future is at a serious risk. Evidently, the average age of a group can be kept constant either by continuous increase of the size or by an optimum mobility.

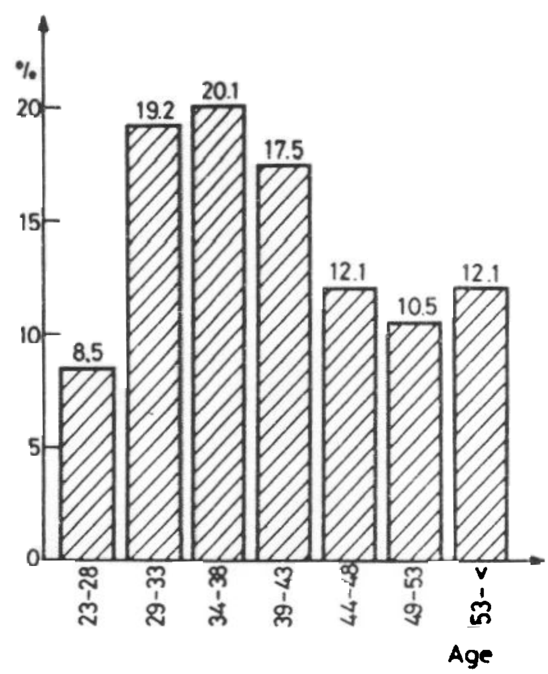

Fig. 1a. Distribution of 314 Faculty members according to age

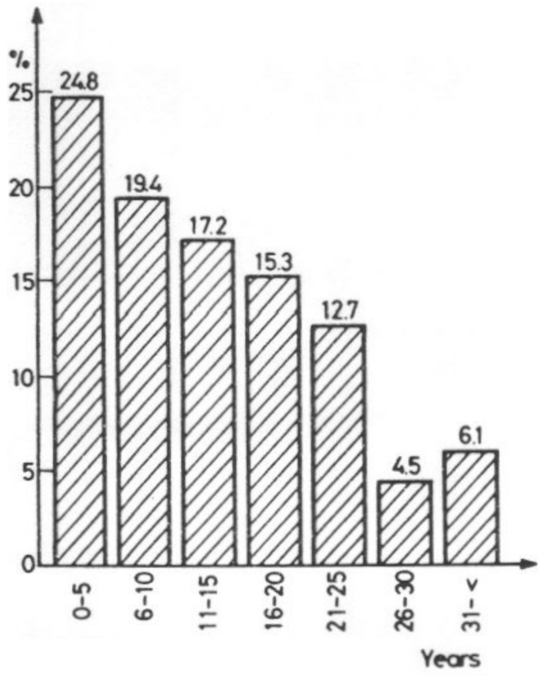

Fig. 1b. Distribution of 314 Faculty members according to the time of employment

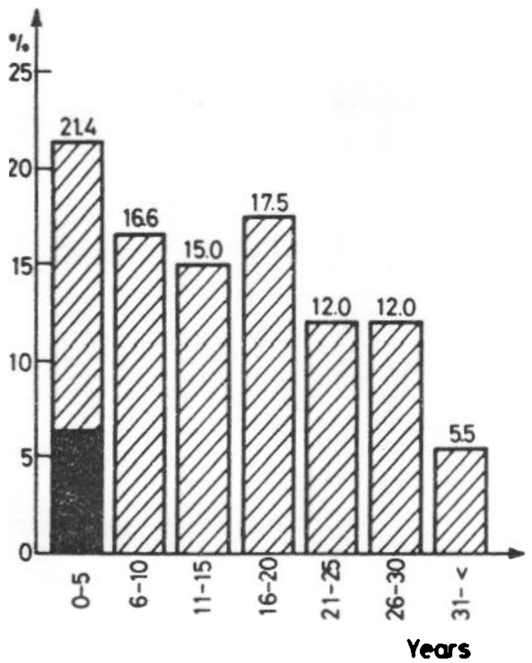

Fig. 1c. Distribution of 126 Faculty members who took part in our survey according to the publication period

Figure 1b shows the distribution of the faculty members according to their time of employment at the University. The optimum structure is almost reached, indicating certain mobility. We do not want to overestimate the benefits of mobility. There is an optimum level of it. A too fast change would result a too high percentage of novices and the present, good-standing quality of research and teaching would not be assured.

Obviously, there is a stronger correlation between the time of employment and the so called publication period. Figure 1c shows the distribution of the 126 faculty members, who responded to our questionnaire, according to their publication period. The lower part of the first column shows the percentage of faculty members who had no publication at all (6.4%).

Results of our survey are summarized in Table 2. It appears that 90% of the total impact were achieved by the publications that were published in world languages (60% of the publications). In fact, this impact was reached by only the two-third of the publications published in world languages, since 35% were published in journals not registered by the ISI.

Table 2

number of papers:	
total	2626
total but only in SCI registered journals	1455
in world languages	1585
in world languages but in SCI registered journals	1028
in Hungarian	1041
in Hungarian but in SCI registered journals	427
impact values:	
total	1302.89
papers in world languages	1170.90
papers in Hungarian	131.99
reduced, total	497.90
reduced, world language	447.56
reduced, Hungarian	50.34
average of average impacts:	
total	0.49
effective, total	0.89
papers in world languages	0.73
effective, world languages	1.13
Hungarian papers	0.12
effective, Hungarian	0.30
average of numbers of authors	2.62
average of numbers of papers per year	1.5
average of total impacts per year	0.68
average of total reduced impacts per year	0.26

This means that 90% of the total impact come from only 40% of all publications, which is in harmony with the statistical Bradford-law describing the dispersion of scientific publications.

Considering all publications one can calculate that 45% were published in journals not belonging to the ISI data base. This indicates that by our method almost every second paper published by the Departments of the Faculty of Natural Sciences of our University has not measurable impact. Looking at the publications written in world languages, this is true only to every third paper. In the case of papers published in Hungarian the following conclusion can be drawn: as an average, from every two and a half papers only one was published in journals listed by the ISI data base.

Taking into account the average number of papers per year, it follows that in one year one author publishes less than one paper (0.75) in journals with non-zero impact factors.

There are a lot of reasons of this rather disappointing situation. Few of them can easily be eliminated, while other ones seem almost unchangeable.

Publishing in Hungarian is obviously important to every Hungarian scientist. This way, one can inform the whole community of Hungarian scientists and engineers, not to mention the need to keep the freshness of the Hungarian scientific language. Furthermore, there are certain areas (like geology, mineralogy, biology, etc..) the results of which are important first of all, but not exclusively, to Hungarian scientists. So, there is no reason to be upset about the fact that 40% of publications were written in Hungarian. However, it should be obvious that the international interest in papers written in Hungarian is low. The impact factors of most of our domestic journals are small or even zero.

Publishing in world languages is a necessary condition that our results could reach the world-wide scientific community. It is rather disappointing therefore that only 65% of the papers written in world languages were published in journals with non-zero impact factors! This unfortunate habit is most characteristic of our mathematicians and biologists who often publish their results in world languages but mostly in our own University Journals. Obviously, the international impact of these papers cannot be judged by our method. It must also be considered that in mathematics the books and conference publications play a more important role than in other fields. Furthermore, mathematicians often publish in journals printed in the Soviet Union. The high-standard of these journals is beyond doubt, but this is not reflected in the values of the impact factors.

It is not easy to evaluate the scientific performance of our Faculty by the absolute values of the numbers alone shown in Table 2. Since there were no similar data available considering other universities in Hungary, we applied the results of the evaluation of the Research Institutes of the Hungarian Academy of Sciences as a reference. These data were published in Vol. 2 of the *Informatic and Scientometric Analysis Series of ISSRU.*

Average impacts of papers of different departments and institutes are listed in Table 3.

Table 3
Average impacts of all papers

Dept. of our Faculty		Inst. of Hung. Acad. Sci.	
Biology	0.645*	Biology	0.46
	0.275**	Botanics	0.03
Chemistry	0.629	KKKI	0.66
Geography	0.010	Geography	
Mathematics	0.065	Mathematics	0.12
Physics	0.428	ATOMKI	0.68
		KFKI	0.40

*: with Biochemistry Department.
**: without Biochemistry Department.

No significant difference can be observed. In general, the numbers represent the approximately same quality of research accomplishments.

Table 4
Averages of total impacts per year

Dept. of our Faculty			Inst. of Hung. Acad. Sci.	
	Method A	Method B		
Biology	0.014*	0.058*	Biology	0.294
	0.128*	0.257**	Botanics	0.026
Chemistry	0.258	0.313	KKKI	0.460
Geography	0.002	0.002	Geography	-
Mathematics	0.008	0.025	Mathematics	0.123
Physics	0.052	0.142	ATOMKI	0.289
			KFKI	0.064

*: without Biochemistry Department.
**: with Biochemistry Department.

Averages of reduced impacts per year are compared in Table 4. Here, we had to apply different methods in the calculations.

In the case of the Institutes of the Hungarian Academy of Sciences this quantity was defined as follows:

$$\bar{R}_y = \frac{\text{Overall impact achieved in 5 year period}}{\text{5 x average number of employed researchers}}$$

In the case of the Departments of our Faculty we had to take into account that our survey did not include all faculty members. Two limiting values could be calculated. A lower limit of the average of reduced impacts per year can be given by supposing that those not taking part in the survey had no publication at all:

$$\bar{R}_y^A = \frac{\text{Sum of personal reduced impacts per year}}{\text{total number of faculty members}}$$

An upper limit of the average of reduced impacts per year can be given by supposing that those not taking part in the survey - but scientifically are active - would have the same value as the lower limit of the average of reduced impacts per year:

$$\bar{R}_y^B = \bar{R}_y^A \ \frac{\text{number of people in the bibliographies}}{\text{number of people in the survey}}$$

One should bear in mind that at the universities there is a considerable teaching load, consequently only the half or one-third of the worktime can be devoted to research. Therefore, the average values should be multiplied by a factor of 2 or 3 in order to make comparison between the Departments of our Faculty and the Institutes of the Hungarian Academy of Sciences. It is obvious that such a comparison is statistically valid only, therefore, it would be dangerous to draw far reaching conclusions.

Behind the average values there is a broad range of personal contributions. An average value is characteristic of a group if this value is also the maximum of a distribution curve. Therefore we investigated the distribution of the most characteristic quantities.

Figure 2a shows the distribution of the number of papers per year. The average (see Table 2) is 1.5. The maximum of the distribution curve is at about the same. The most productive group F is represented by a fairly high percentage. This group consists of the young members of scientifically active teams, besides department-heads and group-leaders.

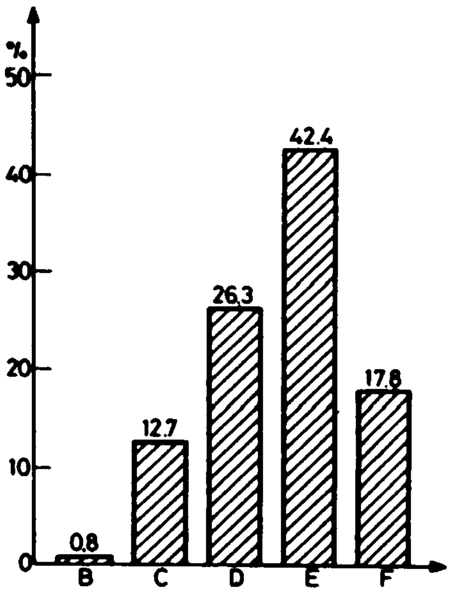

Fig. 2a. Distribution of 126 Faculty members according to the number of papers per year

Figure 2b shows the distribution of the reduced number of papers per year. It can be seen from this figure that 17% of our colleagues have never published a paper in a journal recorded by the ISI data base, and 12% publish less than one paper in a five year period. It is disappointing that almost one-third of our scientists are scientifically unproductive. Distribution among groups B and F does not show a maximum. It means that the average value (0.75, see Table 2.) is not characteristic.

Distributions of 126 faculty members according to the average impact and average effective impact of their papers written in Hungarian and in world languages are shown in Figs 3 and 4, respectively, while Fig. 5 shows the same measures but by considering all the papers. In these figures column A always indicates the percentages of authors who had no such publication, while column O indicates that although publication in this group has been published but no impact can be calculated.

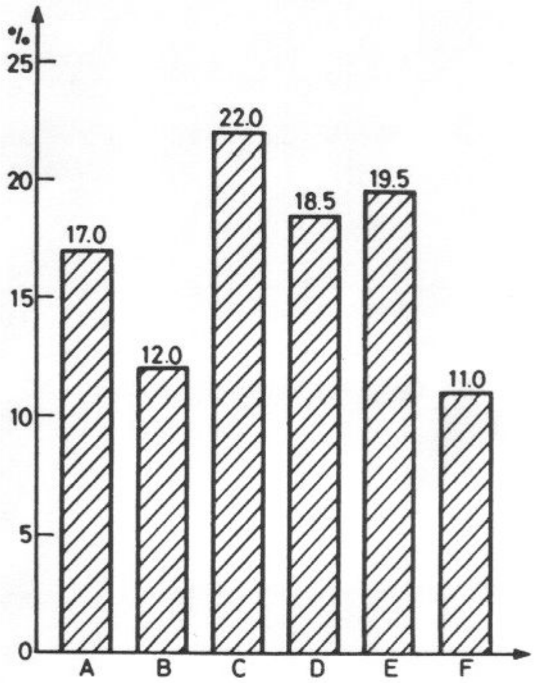

Fig. 2b. Distribution of 126 Faculty members according to the reduced number of papers per year. A: no publication in this category, B: less than one paper in five years (0-0.2), C: less than one paper in two years (0.2-0.5), D: less than one paper in one year (0.5-1.0), E: less than two papers in one year (1.0-2.0), F: more than two papers in one year (2.0-)

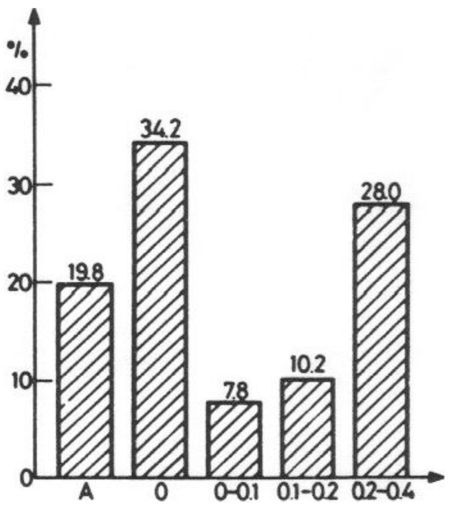

Fig. 3a. Distribution of 126 Faculty members according to the average impact of their papers written in Hungarian

Figures 3a and 3b show that almost one-third of the authors have received high values for the average impact (or effective impact) of the papers published in Hungarian. This follows from the fairly high ratio of chemists in our survey. *Magyar Kémiai Folyóirat* (Hungarian Chemistry Journal) is listed by the Journal Citation Reports with an impact factor of 0.332.

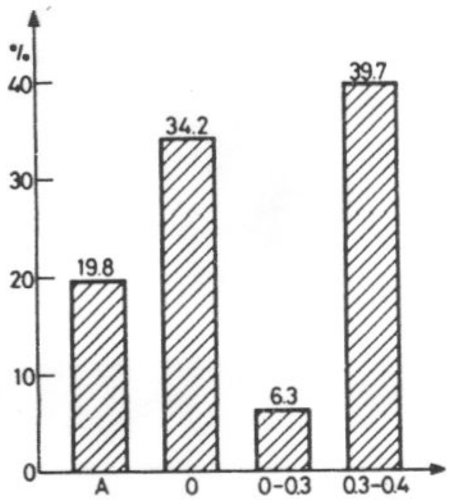

Fig. 3b. Distribution of 126 Faculty members according to the average effective impact of their papers written in Hungarian and published in *SCI* registered journals. A: no publication in this category, D: no impact of publications in this category can be shown

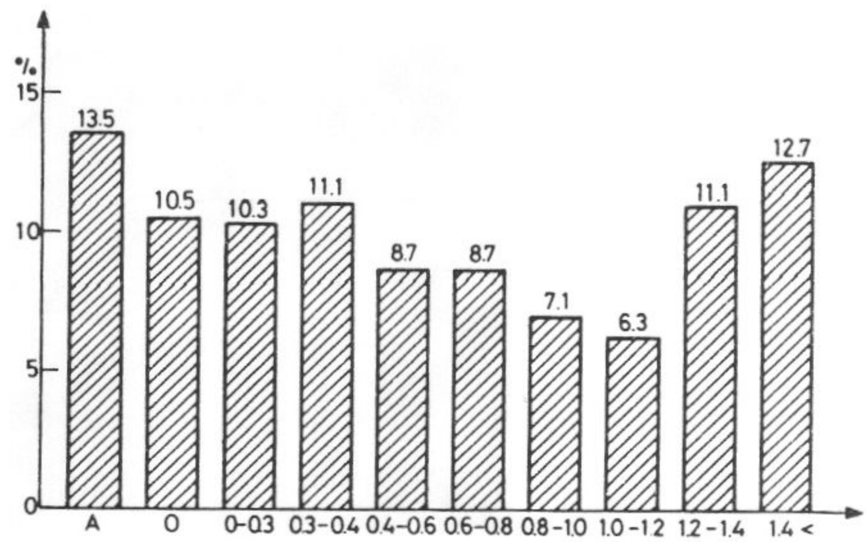

Fig. 4a. Distribution of 126 Faculty members according to the average impact of their papers written in world languages

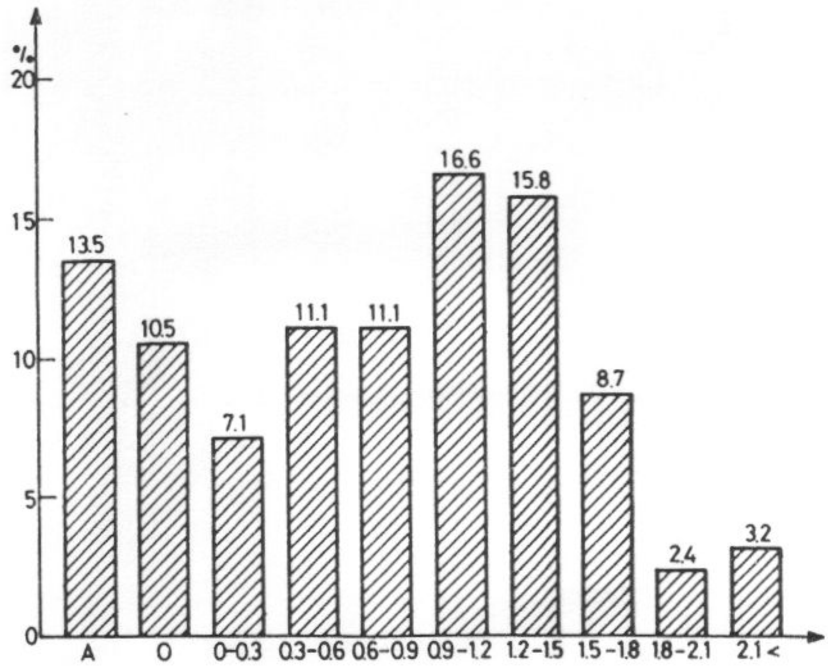

Fig. 4b. Distribution of 126 Faculty members according to the average effective impact of their papers written in world languages and published in *SCI* registered journals. A: no publication in this category, D: no impact of publications in this category can be shown

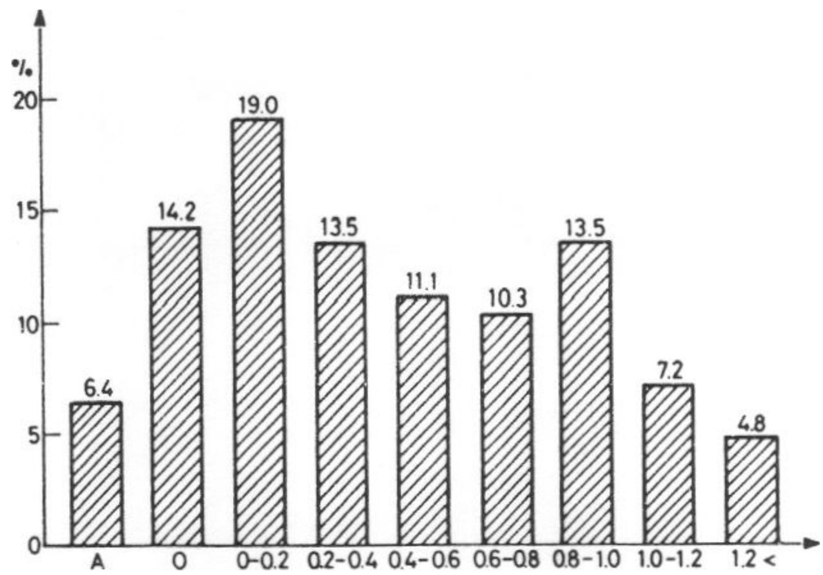

Fig. 5a. Distribution of 126 Faculty members according to the average total impact

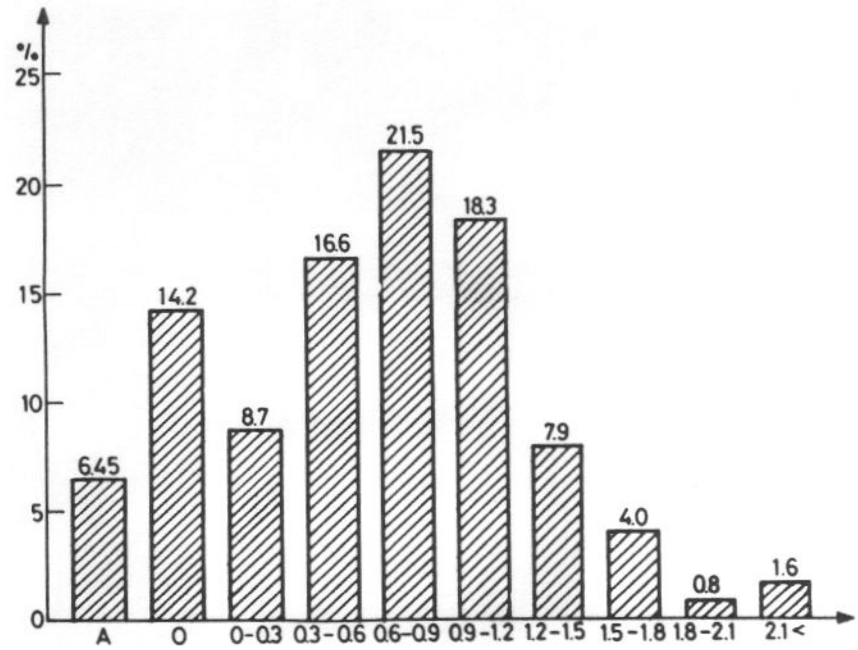

Fig. 5b. Distribution of 126 Faculty members according to the average effective total impact. A: no publication in this category, D: no impact of publications in this category can be shown

Distributions of the average impacts and the average effective impacts of papers published in world languages show no characteristic maxima (Figs 4a and 4b). 13.5% percentages of researchers did not publish in SCI recorded journals. This value is lower than in the case of papers published in Hungarian. The average effective impact shows a normal distribution with a maximum at about 0.9-1.5 (not taking into account columns A and O). This is a relatively good value. This means that in one year at least one reference can be found to every paper published in an SCI registered journal by each of our faculty member. The same conclusion can be drawn from Figs 5a and 5b. It is promising that more than 10% of the authors have average effective total impact above 2.0

Distribution of the values of the average impact per year (Fig. 6a) shows that statistically more than half of the authors can achieve a relatively good value (above 0.4) for a longer period. The maximum of the distribution of the average reduced impacts per year (Fig. 6b) can be found at about 0.2, which is less than the mean value (0.263) given in Table 2.

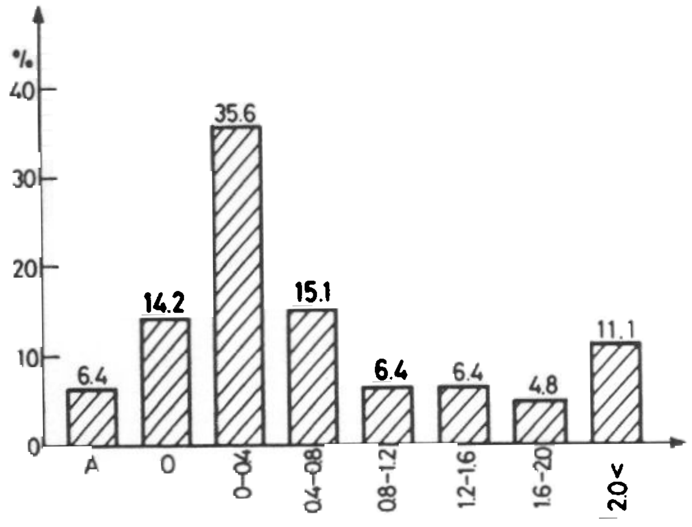

Fig. 6a. Distribution of 126 Faculty members according to the total impact per year

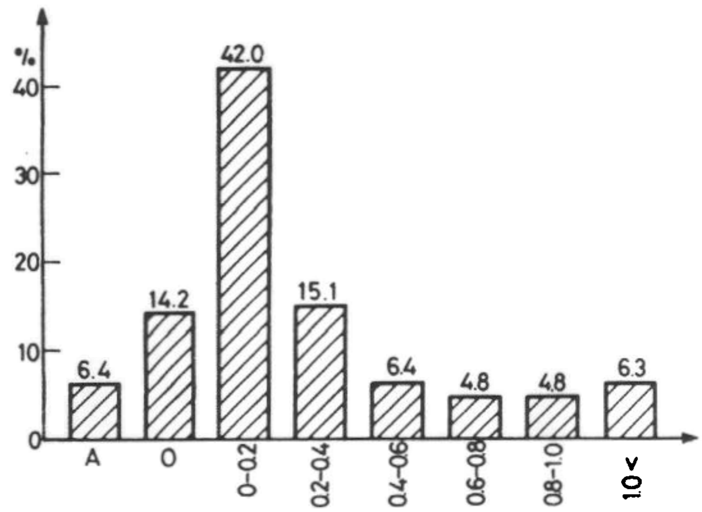

Fig. 6b. Distribution of 126 Faculty members according to the reduced total impact per year. A: no publication in this category, D: no impact of publications in this category can be shown

Conclusions

According to the results of this survey, the following conclusions can be drawn that could be important to similar universities in Hungary:

1) The average age of the faculty can be kept at about an optimum value by only a well-planned strategy of mobility.

2) Ratio of the novices has to be increased.

3) Formal requirements should be called into effect in order to prevent the high percentages of scientifically unproductive faculty members.

4) Publication in Hungarian is important even with the present ratio. Nevertheless, the authors should choose journals with higher impacts.

5) We think that publications in university journals should be avoided. This statement does not refer to the humanities.

6) There should be an increase in the number of well-organized scientific teams even if the number of projects is decreased.