National Science Systems and the Matthew Effect for Countries[1]

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Abstract

In this paper we continue our investigation of the micro-structure of the Matthew effect for countries (MEC). After the recent identification of a new type of scientific journal, the Matthew core journal (MCJ), we study the relations of MCJ to other types of core journals - publication, citation, and participation core journals. 144 MCJ out of 2712 SCI-journals in our sample account for half of the MEC.

A typology of the MCJ can be established. The exclusive role of the MCJ consists in carrying a high number of Matthew citations due to the competition of many countries for a high impact of their papers. The research fronts in science are "boiling" in the MCJ.

The 144 MCJ are sufficient to construct a country rank distribution that reflects world science performance.

1. Introduction: From world science structure investigations to the discovery of the Matthew effect for countries

Our introduction starts with two figures (Fig.1,2). These figures stand for a whole series of papers, the first - for our investigations of the world science structure, the second - for our discovery of the Matthew effect for countries. The first figure was first published in 1996 [2]. It is composed according to the approach of co-structure clustering [3]. We compared pair wise the national publication profiles, that is the shares in the life sciences (L), physics (P), chemistry (C), engineering (E) and mathematics (M) in the total number of publications of a certain country. As data base the *Science Citation Index* is used. Two countries can have a similar or a different publication profile and a distance measure can be introduced. In Figure 1 all countries with a very similar profile are linked by bold lines. The figure shows at the right side countries with a high percentage of life sciences in their science structure, while at the left side countries are assembled for which the percentage of the classical sciences - chemistry and physics - is dominating. When we tried to understand this map, we hypothetically postulated the existence of two worlds in science - a "right world" (in which life sciences are dominating and countries exhibit very similar research profiles) and a "left world" (in which countries have more diverse research profiles and physics and chemistry are dominating) according to this map. We studied separately their parameters and found distinct differences of the two worlds.

The two worlds in science are manifesting themselves also in the second figure. Here, the countries are ranked according to their Matthew index [4] which is positive for the right world countries and negative for the left world countries. The Matthew Index is a measure for the Matthew effect for countries. This effect was discovered in 1994 and we

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[1] This is revised and extended version of a paper presented at the Seventh International Conference on Scientometrics and Informetrics, 5-8 July 1999, Colima, Mexico. [1]

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gave a first account of its characteristics in 1995 at a conference in Antwerp [5]. We wrote: 'A minority of countries, expecting a high number of citations per scientific paper, is getting even more citations than expected, while the majority of countries, expecting only a low number of citations per scientific paper, is getting even less citations than expected.'

The term Matthew effect was coined by R. K. Merton in 1968 for a class of phenomena in science, characterized by a skewed distribution in the allocation of funds, citations, awards etc. [6] in analogy to the gospel parable of the entrusted talents (MATTHEW 25, 14—30). However, only a few of the hundreds of papers following the classical paper of Merton involved an attempt to measure the Matthew effect quantitatively. The Matthew effect for countries turned out to provide a useful indicator of each country's performance in science.

If one compares figure 1 and figure 2 one can see that countries which gain citations (Fig.2) are countries which have similar publication profiles, which are grouped together and which have a relatively high share of life sciences (Fig.1).

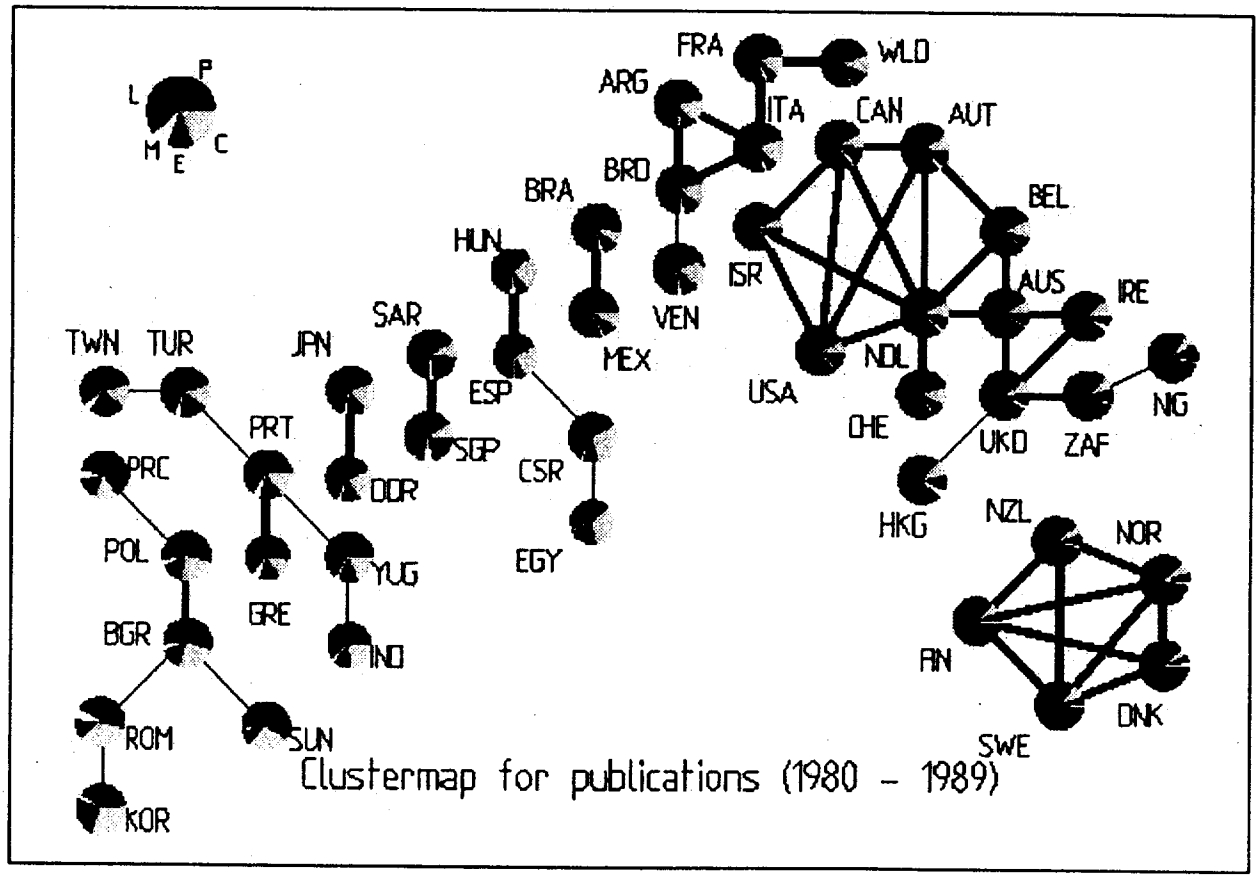

Figure 1: Our 'classical' cluster map

2. *The micro-structure of the Matthew effect for countries*

The Matthew effect for countries (MEC) is a small effect - only less than 10% of all citations are involved in it. The MEC consists in a systematic deviation of the number of actual citations from the number of expected citations. Firstly we confirmed, that the MEC is not an artifact, and we studied its order of magnitude, its field-dependency and its time-stability [7]. In the following we used data prepared by RASCI e.V. based on the *Science Citation Index* in the period of time from 1990-1994.

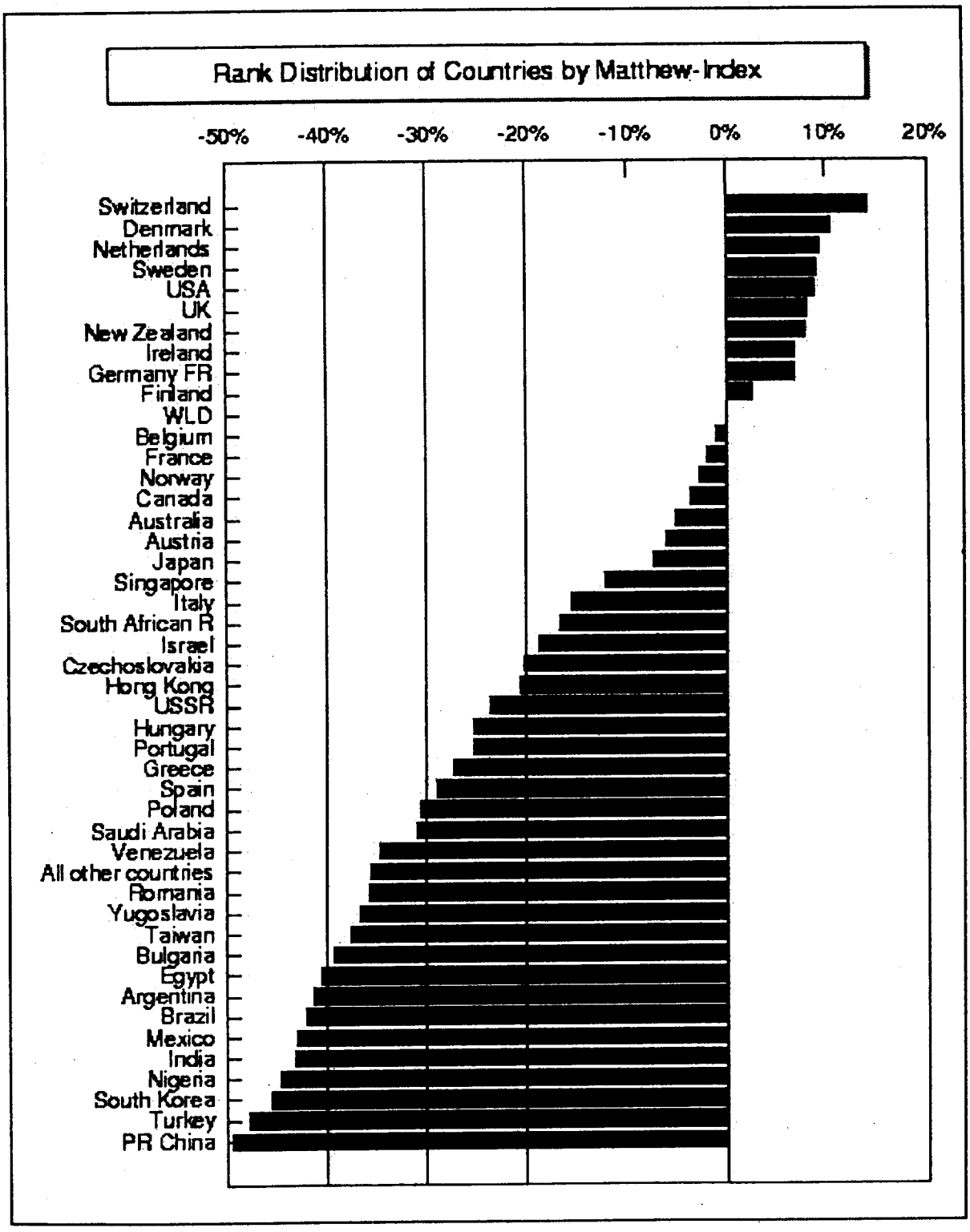

Figure 2: Our `classical' rank distribution

The rank distribution of figure 2 - a distribution at the macro-level of science - can be well reproduced in all investigations. Our interpretation is now, that this rank distribution is indicating how effectively a country is using its 'scientific talent' [9] in the international scientific community - the Matthew index is an indicator of national science quality.

However, the interpretation of a macro-phenomenon is not yet its explanation. It becomes necessary to study the micro-structure of the MEC.

While figure 2 provides an overall picture of national impact factors it is important to observe that the picture is different for each journal one studies. As an example (see figure 3) we take the journal NATURE, that has a high number of papers, cites, and participating countries. In this journal, publications from different countries receive a different number of citations, and according to figure 3 countries have different national impact factors (citations per publications). The journal impact factor itself represents an average. If we take this journal impact factor as an expectation of citations for a certain paper, then some countries lose citations compared with this average and some gain citations. Loss and gain of citations in a journal are balanced because of the definition of the journal impact factor. The amount of citations for all papers in a journal is unequally distributed among the participating countries. In this sense we speak of a "re-distribution" of citations among the countries. We observe that in a given journal a certain number of citations is 're-distributed' from the low impact countries to the countries with a higher national impact factor.

Further, we take the number of citations for all articles from a certain country as an indicator of visibility and/or quality of the research done in this country. In other words, if all papers in the journal were of equal quality, the distribution would be more or less flat with every country's impact equal to the journal impact. But you find always a non-uniform distribution. When you go from journal to journal, say in alphabetical order, you cannot predict whether a country in a given journal will belong to the 'winner' countries or to the 'loser' countries. This will be decided entirely by the world community of authors citing the papers of that journal.

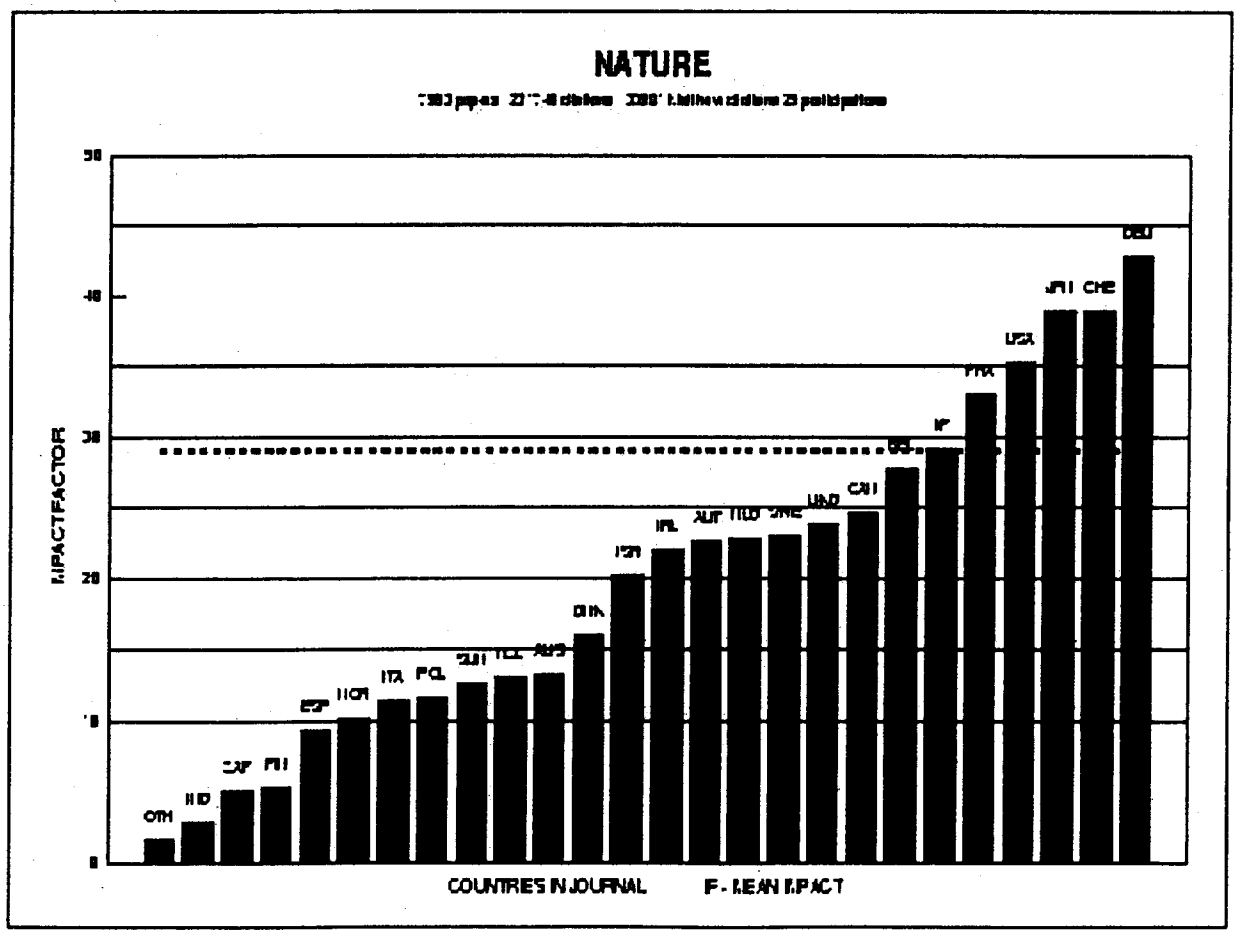

Figure 3: The non-uniformity of country impacts in a journal

3. Matthew citations and the Matthew core journal

Each journal has its own number of redistributed citations. For instance, the journal NATURE has 33901, the journal ANALYTICA CHIMICA ACTA has 1134. We call the re-distributed citations 'Matthew citations', because they turn out to be the 'atoms' of the Matthew effect for countries.

A citation is a citation. It makes no sense to ask whether a certain reference will become a Matthew citation. The number of Matthew citations in a journal can only be calculated through the comparison of expected with observed citations for each country.

The distribution of the Matthew citations over the journals is extremely skew. Only 144 journals out of 2712 in our sample account for half of all Matthew citations, and therefore, for half of the MEC. We call these 144 journals 'Matthew core journals' - a type of scientific journal which never before had been described.

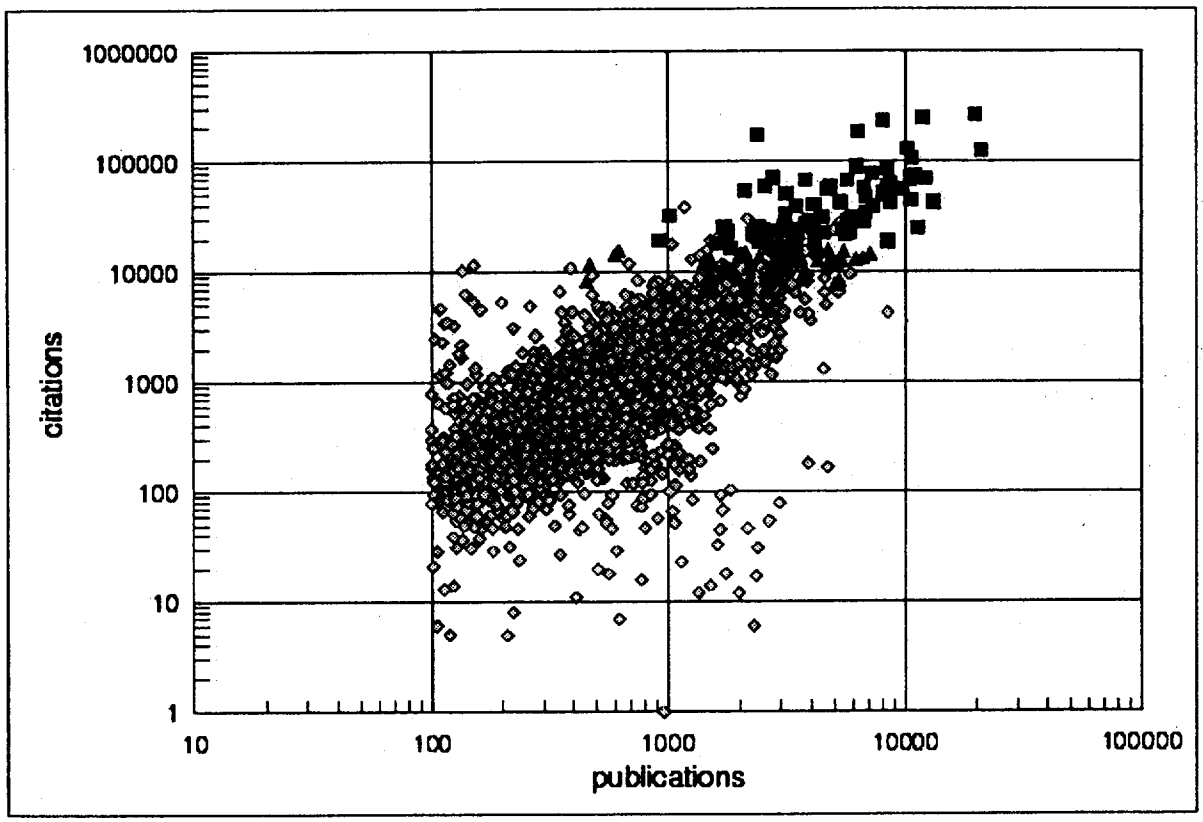

Figure 4: Citations vs. publications in 2712 journals

E. Garfield and others have frequently noted concentration effects in scientific communication ('a few account for the whole') [8]. Identifying Matthew core journals is an additional confirmation of this fundamental phenomenon.

In a recent paper [1] one can see numerous figures (like figure 4) with clouds of journals that are arranged according to parameters like publications, citations, Matthew citations, and participations (number of participating countries). The Matthew core journals are highlighted in these clouds (black quads), and they are always in a special position. For instance, Matthew core journals (MCJ) are in general located in regions of high publication and citation numbers (figure 4), but the opposite is not always true: a journal with a high number of papers and/or cites must not necessarily be a MCJ. The same holds for

journals with high participation of countries, and for journals with high impact factors. Recently the list of the MCJ has been published [4].

In order to find out the role that MCJ might play in scientific communication, we have investigated the relations between Matthew core journals at the one hand, and publication, citation and participation core journals, at the other. The result is a typology of the MCJ, which will be described in the next section.

4. Typology of the Matthew core journals

Correspondingly, the sets of publication or citation or participation core journals account for half of all papers or cites or participation's in the whole sample. Usually the cores are a very small percentage of the entire set. The data for our sample are given in figure 5.

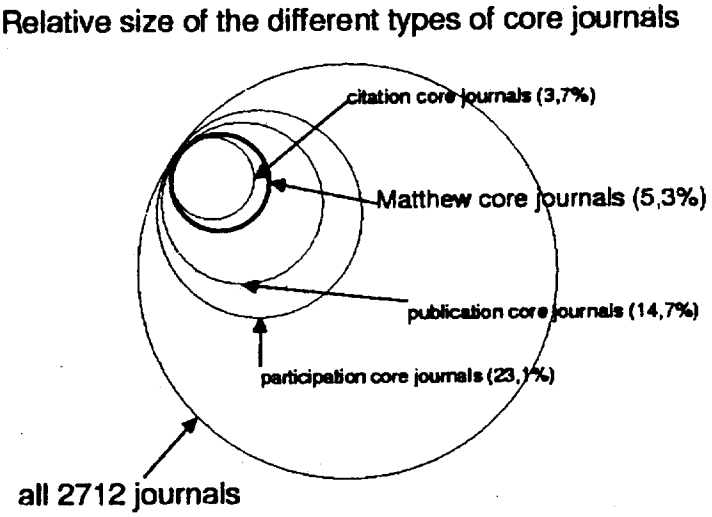

Figure 5

As far as the four types of core journals partly overlap, there remain about 2000 journals in the sample that are neither Matthew, nor publication nor citation, nor participation core journals.

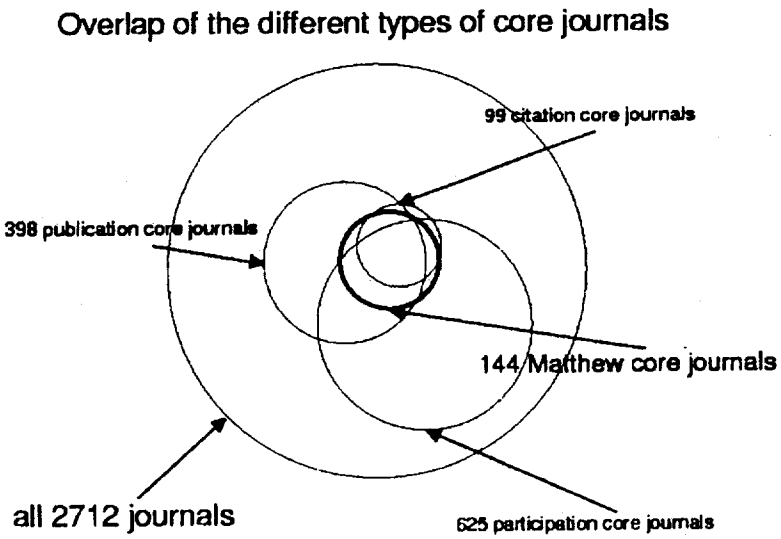

Figure 6

The overlap of Matthew core journals and citation core journals is shown in figure 7. Among the 144 MCJ 84 are also citation core journals, 60 are not; among the 99 citation core journals 15 are not MCJ.

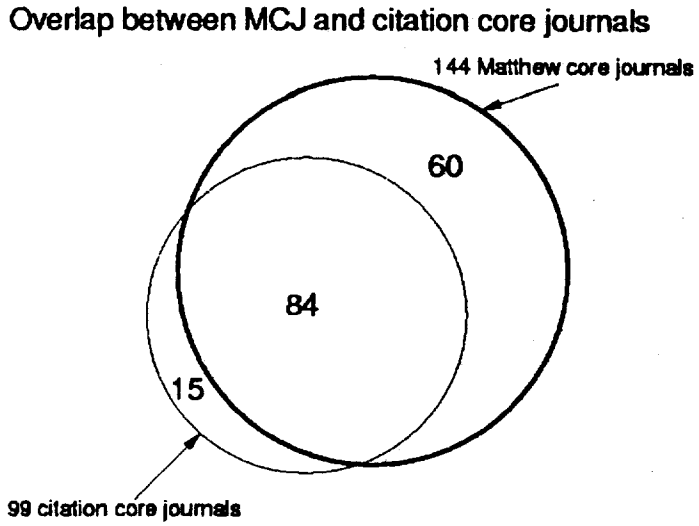

Figure 7

You can hardly see graphically what is going on inside the circle of the MCJ in figure 7. We investigated these relations and found at least seven different categories of MCJ, see figure 8. They are significant in different ways.

Typology of the Matthew core journals

Type						Number of MCJ
						of this type
A		PUB	CIT	PART		73
B		NOTPUB	NOTCIT	NOTPART		6
C		PUB	CIT	NOTPART		9
D		PUB	NOTCIT	PART		47
E		PUB	NOTCIT	NOTPART		5
F		NOTPUB	CIT	NOTPART		2
G		NOTPUB	NOTCIT	PART		2

PUB / NOTPUB: The Matthew core journal is / is not a publication core journal
CIT / NOTCIT: The Matthew core journal is / is not a citation core journal
PART / NOTPART: The Matthew core journal is / is not a participation core journal

Figure 8

For each journal we ask whether it is also a member of other sets of core journals. As far as there are three indicators each with two possible values (to be and not to be a member of an other core), we expect eight typical combinations. The table in figure 8 should be read in the following way: to type A belong those MCJ which are also publication core journals (PUB), citation core journals (CIT), and participation core journals (PART). Only seven of the eight possible combinations are found. They are differently

loaded by MCJ. The most heavily loaded types, A and D, are correlated with the scientific fields represented by the corresponding MCJ.

Type A, PUB CIT PART, core journal in all aspects, contains half of all MCJ, predominantly in the life sciences. All are possessing high impact factors ('average' = 8.8).

Type D, PUB NOTCIT PART, MCJ being not citation core journals, contains one third of all MCJ, here we have more physics journals than life sciences journals, the impact factors are lower ('average' = 3.8).

Interesting is type B, NOTPUB NOTCIT NOTPART, 6 journals being MCJ only - having not too many papers, citations, and participations.

5. Conclusion

5.1 The exclusive role of the Matthew core journals

Matthew core journals seem to play an independent role in the system of scientific communication.

What is the most striking feature of the MCJ? That they all possess a high number of Matthew citations? That is their definition! Why do they not completely coincide with the publication, citation or participation types of core journals? What does that mean - to possess a high number of Matthew citations?

It means, the research fronts in science are 'boiling' in them; many countries are competing in them; countries are giving their apparently 'best' scientific work to these journals hoping to capture a surplus of citations over expected citations but also taking the risk of not achieving the expected impact. MCJ are the most important journals in scientific communication from these aspects.

There are 16 journals with 'ANNUAL ...' in their title, many of them with high impact factors. But these journals are not MCJ, they are review journals, highly visible and cited, but countries are not competing in them, the number of Matthew citations is low.

Another example. There are 82 journals with 'INTERNATIONAL...' in their title, on the average with medium impact factors. Only one journal, the INTERNATIONAL JOURNAL OF CANCER, is a MCJ. So, alone the title of a journal is not capable to attract sufficient papers to make that journal 'boil' from science.

There are 61 journals with 'AMERICAN...' in their title. A minority of them, the AMERICAN JOURNAL OF CLINICAL PATHOLOGY, AMERICAN JOURNAL OF PHYSIOLOGY, AMERICAN JOURNAL OF PSYCHIATRY, AMERICAN REVIEW OF RESPIRATORY DISEASE, have such a high reputation, that they can attract papers from all over the world for competition in the research front areas.

5.2 A 'Dow Jones Index' for national scientific wealth

Another feature underlines the unique role of the MCJ. When the Matthew effect is concentrated in only 144 MCJ - why not try to make a ranking not on the basis of all 2712, but on the basis of these journals?

In figure 9 we display the rank number of the countries for the two cases

- all 2712 journals (squares)
- only 144 Matthew core journals (rhombs)

The MCJ based ranking sufficiently reproduces the original rank distribution obtained at the macro-level (cf. Fig.2), right and left countries remain in their region, there occur no dramatic jumps from right to left or vice versa. If one chooses 144 journals randomly to make the same ranking procedure one would observe greater fluctuations compared with the set of Matthew Core Journals.

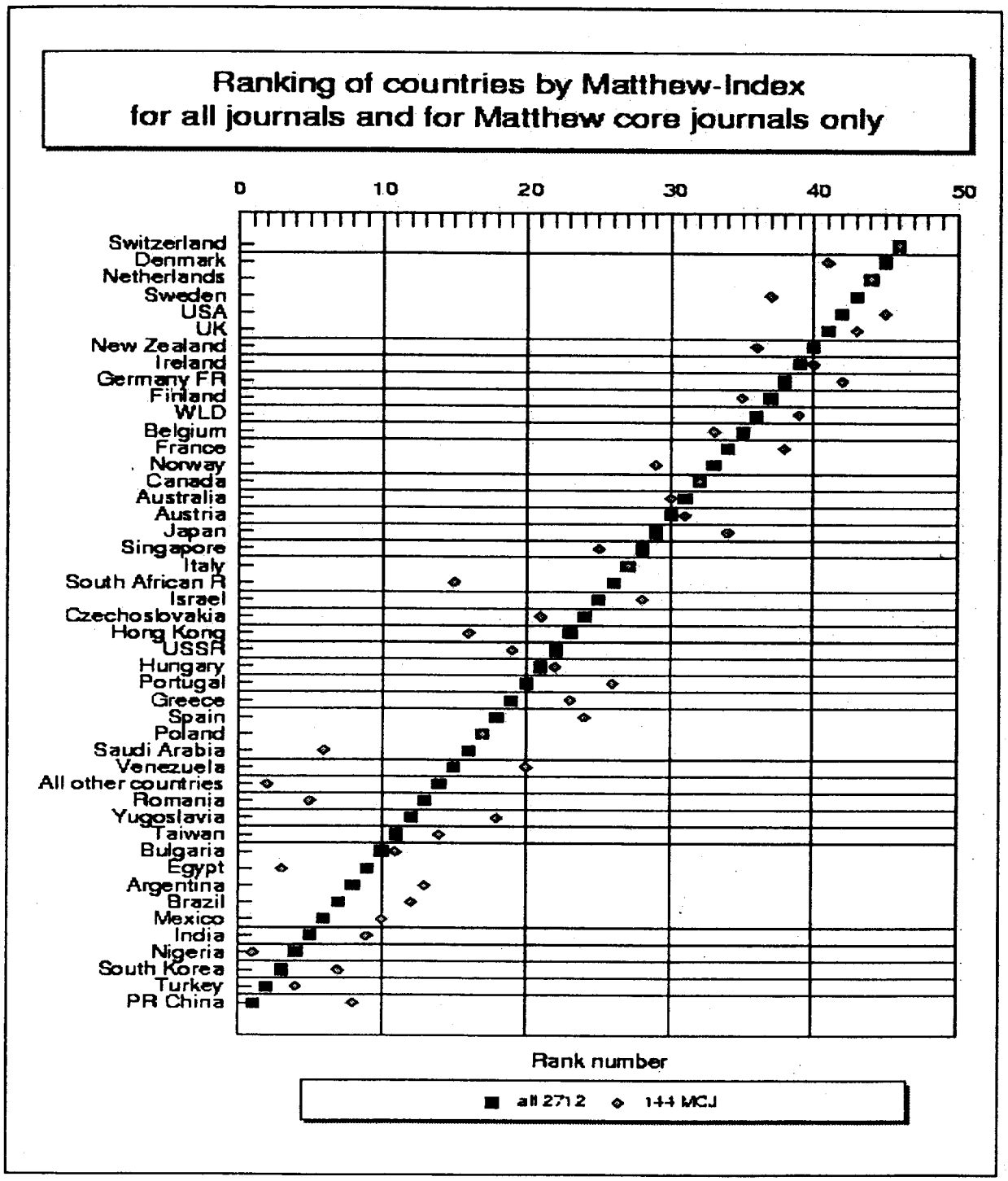

Figure 9: Country ranking for Matthew core journals

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