Ten years Matthew effect for countries[1]

Manfred Bonitz
Dresden/Germany

The task of this paper

Actually the Matthew effect for countries (MEC) was discovered at Holy Eve 1994. Since then more than 30 papers of mine - many of them together with Andrea Scharnhorst and Eberhard Bruckner - appeared in journals or were read at conferences of international and national scientific societies.[2] It is not the task of this paper to present a bibliometric analysis of those paper's impact, nor to give any detailed historical description of the surprising findings following the discovery, I'd rather try to unfold - from the heightened standpoint of our days - a new summary of the Matthew phenomenon, because I am convinced it will not lose its fascination and importance in the years to come.

A saying older than the Bible

When modern people hear the term "Matthew effect" they associate it in most cases with the wide-spread understanding that "the rich are getting richer and the poor poorer". It seems that this saying is much older than the Bible,[3] and that even the well-known sentence in the biblical parable of the entrusted talents: *"For unto everyone that hath shall be given, and he shall have abundance: but from him that has not shall be taken away even that which he has "* [ST. MATTHEW 25:29] is most preferably treated in that above way "the rich are getting richer and the poor poorer". After having read in a newspaper of my country exactly this treatment even by a very respected personality of our protestant church, I have given up my hope that in a near future the Christian part of mankind will change its meaning about the semantics of the parable of the entrusted talents.[4] And as far as we cannot now correct the writers of the Bible and must fight without any hope for success against that convenient misunderstanding, we rather can explain, how wonderfully our scientific findings coincide with the very essence of the biblical parable, namely: *For unto everyone that properly uses the talents given him by the Lord will enlarge them: but everyone that digested his entrusted talents into the earth will lose them forever*. This is a wonderful metaphor concerning all of us, our institutions, and the scientific nations we belong to. And it was present at all steps after the discovery of the MEC at that Holy Eve 1994.

The MEC and its multiplicity of implications

Ranking the scientific nations by the so-called Matthew Index - an indicator constructed on the basis of the countries' observed and expected citations - we see that a minority of the countries (not necessarily the largest ones) possesses positive values of the indicator, while the majority of the countries possesses negative values. In other words: *the right countries (with positive values) are getting more citations than expected, while the left countries (with negative values) are getting less citations than they might expect.* Obviously, the more right the position of a country, the more effectively it is doing its science. *The implication for science policy is to look and to learn what the right neighbor is doing better.*

Another implication concerns the huge number of scientific journals in which the micro-processes are proceeding that constitute eventually the macro-phenomenon of the MEC. The system of scientific communication behaves like a gas, where all molecules at the micro-level are constituting the pressure of the gas at the macro-level. A scientific journal is not only characterized by its number of citations per paper (the impact factor), but also by its number of

so-called Matthew citations. Indeed, *Matthew citations are the "atoms " of all Matthew phenomena in the system of scientific communication* (while their number is bound to the level of aggregation - papers, authors, institutions, countries - we are working at). When we are working at the aggregation level of countries (MEC) as we mostly have done, we see at this macro-level a ranking of countries according to their Matthew Index, and at the micro-level in each journal a

ranking of countries according to their number of Matthew citations, or better, according to their national impact factor. As in the macro-distribution (MEC) we can distinguish also in the micro-distribution of each journal left and right countries: the left countries possess together as many "negative Matthew citations" as the right countries are possessing together "positive Matthew citations". We explain this fact a bit later. *The number of Matthew citations is a characteristic indicator of each journal.* Ranking of journals by this indicator leads to a very skewed distribution: only 144 journals out of 2700 are possessing half of all Matthew citations. We coined the name "Matthew core journals" for these journals. *The Matthew core journals are by some reasons more important than the impact factor top-ranked journals.*

Further implications of the Matthew citations are: the surprising possibility to establish a more than metaphoric *neighborhood of science and economics,* and their promising *evaluation potential* — not only for countries, but also for all other items of aggregation: papers, authors, and institutions (we will speak about them somewhat later).

Garfield's impact factor is the key

Measurability and reproducibility are important features of an effect like the MEC. Therefore we are finding much more effects with such properties in the natural than in the social sciences. An effect occurs, when an observed phenomenon is compared with a situation or model of expectation. In our case, the expected situation happens to be created by using Garfield's journal impact factors.

In the never-ending discussions around the journal impact factors it is mostly forgotten that the impact factor is merely an expectation value for the "average" paper of the journal. However, as far as average papers do not exist in reality, there will be always (positive or negative) deviations from the impact factor: the number of citations really received by a paper minus the number of citations "forecasted" by the impact factor. A paper being "better" ("worse") than average has a positive (negative) deviation. There is a name for the deviations: *Matthew citations.* Every paper has its own number of (positive or negative) Matthew citations. The number of the positive Matthew citations in a journal is (as a mathematical consequence from the averaging procedure leading to the impact factor) equal to the number of the negative ones. Thus not only every journal has its own characteristic indicator: number of Matthew citations (in the positive or in the negative pool), even has every paper its own number of Matthew citations - in the case of uncitedness this number is the negative value of the journal impact factor. *Matthew citations never would exist without the existence of the impact factor.* They are additive which makes them suitable for evaluation processes - two papers of one author with +5.7 and -2.3 Mathew citations respectively "enrich" this author by +3.4 Matthew citations.

Science and Economics: essential neighbors

One of the most striking surprises in our investigations was the eye-opening similarity between the principal graph of a scientific journal (national impact factors versus countries in journal) on the one hand, and the principal graph of an economic market with so-called perfect competition (product price of firms versus firms on market) on the other. What is the meaning of this similarity? We know that science and economics are not so easily comparable. Scientific information, for instance, is not a commodity being sold and bought, and citations are not a currency.

When in classical economics the "invisible hand of the market" (Adam Smith) is establishing the mean price for a certain product - isn't there too in scientific communication an "invisible hand of the scientific community" establishing (by citing the papers) the impact factor of a journal? And doesn't competition exist in economics as well as in science - for the best price of a product on the one hand, and for being first in presenting a significant scientific result, on the other?

We came, therefore, to the conclusion, that *the scientific journals can be treated as markets for the competition in science.* The competition is proceeding within the journals, not between them. Moreover, we think to have found a measure for the strength of the competition within a journal: its number of Matthew citations. *The Matthew core journals are thus the journals with the highest competition strength!* It is remarkable that the markets in science seem to be better suited for having a measure of their competition strength than the markets in economics - to our knowledge such a measure does not even exist in economics.

Matthew Effect on all levels? Towards a theory of the MEX

We started 10 years ago with the Matthew effect for countries (MEC). We found numerous outcomes - the *Matthew Index* for ranking scientific nations, the *Matthew citations* as "atoms" for Matthew phenomena and for the significance of scientific journals, the *Matthew core journals* as the most significant scientific journals and as *markets* with the heighest scientific competition strength. We found that the Matthew citations exist as *positive and negative Matthew citations* - as a result of comparison of observed (given) citations and - according to the impact factor - expected citations.

But what about the other levels of aggregation - papers, authors, institutions? Do there exist similar Matthew effects for papers (MEP), or for authors (MEA), or for institutions (MEI)? What about the number of Matthew citations at others than the aggregation level of countries? When we measured the MEC we found that the number of Matthew citations is only 4 or 5 per cent of the really given citations, thus the MEC is a small but nevertheless well established effect. Stepping down from the countries to the institutions, authors, papers, we can theoretically expect that the number of Matthew citations will grow, it will be largest at the level of papers (to which the real citations are given) - obviously a Matthew effect at this level should be considerably greater. It is one of the most striking features of the Matthew world that the number of Matthew citations (the positive as well as the negative pools) is vice versa diminishing when going through the levels from papers up to countries and WORLD, while the number of really given citations remains constant at all levels. The reason lies in the very nature of the Matthew citations: due to their different signs the "pools" of Matthew citations (positive and negative, respectively) will partially compensate each other when combining papers of an author, authors of an institution, institutions of a country, and when the items to combine are lying in different pools.

The task of future Matthew thinking

The Matthew world is waiting to be fully experimentally and theoretically explored. At each level of aggregation the Matthew effect, and the dimension of the Matthew citations' pools

should be established. The evaluation capacity of the Matthew citations must be carefully investigated - may be they constitute the "currency" in the "economy of science"?

Research in these directions would be a good sign of gratefulness to our Biblical forerunners, but also to the father of Matthew thinking in our days - Robert K. Merton (Merton, 1968), (Merton, 1988).

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[2] The journal papers are given in the reference list: (Bonitz, Bruckner & Scharnhorst, 1997), (Bonitz, 1997), (Bonitz, Bruckner & Scharnhorst, 1999), (Bonitz, 1999), (Bonitz & Scharnhorst, 2001), (Bonitz, 2002)

[3] R.K.Merton, private communication

[4] The "rich versus poor" version is pessimistic, but convenient, while the essence of the parable is optimistic but challenging.