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Citation delay in interdisciplinary knowledge exchange

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As part of a larger project to investigate knowledge flows between fields of science, we studied the differences in speed of knowledge transfer within and across disciplines. The age distribution of references in three selections of articles was analysed, including almost 800.000 references in journal publications of the United Kingdom in 1992, 700.000 references in publications of Germany in 1992, and more than 11 million references in the world total of publications in 1998.

The rate of citing documented knowledge from other disciplines appears to differ sharply among disciplines. For most of the disciplines the same ratio's are found in the three data sets. Exceptions show interesting differences in the interdisciplinary nature of a field in a country. We find a general tendency of a citation delay in case of knowledge transfer between different fields of science: citations to work of the own discipline show less of a time lag than citations to work in a foreign discipline. Between disciplines typical differences in the speed of incorporating knowledge from other disciplines are observed, which appear to be relatively independent of time and place: for each discipline the same pattern is found in the three data sets. The discipline specific characteristics found in the speed of interdisciplinary knowledge transfer may be point of departure for further investigations. Results may contribute to explanations of differences in citation rates of interdisciplinary research.

Introduction

Investigations in the ways knowledge flows between disciplines of science gain interest, because cutting-edge science nowadays increasingly involves collaboration across disciplinary boundaries. In many science policy documents high expectations for benefits from interdisciplinary research are expressed and at many places efforts are undertaken to encourage scientists to engage in interdisciplinary projects. Policies to stimulate interdisciplinary co-operation among others are based on evidence found in the history of science that breakthroughs in one field proved to be important for the progress of other fields. One of the many examples is the work on atomic spin in the

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field of physics that led to magnetic resonance imaging in medicine which in turn led to many applications and new discoveries in medicine and biology.

Studies on such interdisciplinary impacts often are of a qualitative nature. Given the increasing relevance of interdisciplinary research, however, also questions about the extent at which knowledge exchange across disciplines takes place, about fields where 'it happens' or about changes in the course of time, become more interesting. (The term interdisciplinary research is used here as equivalent to terms like multidisciplinary, cross-disciplinary or interdependent research).

Studies in which interdisciplinary knowledge transfer is quantitatively measured, are rather scarce. An earlier example is the examination of the mutual influencing of different disciplines by taking field mobility of individual scientists as an indicator.[1,2] Not only scientists can be carriers of knowledge from one discipline to another, transfer may also take place by means of instruments or methods. Another, even more obvious carrier of knowledge appears to be the scientific article. One of the first attempts to study interdisciplinary research processes by bibliometric methods was undertaken in an NSF-project exploring potential indicators of interdisciplinary research.[3]

Our present approach is based on the assumption that empirical studies may contribute to the further understanding of processes of interdisciplinary knowledge transfer. A project was started to investigate whether bibliometric methods may yield empirical data about the mutual influencing of different disciplines of science. We further proceed along the methodological line of the study by *Porter* et. al., assuming that citations to scientific articles partly reflect the use made of (documented) knowledge by researchers in successive research. However, compared to this explorative study a much larger set of journals is used and a lower aggregate level of (17) disciplines is chosen.

In this paper one aspect of the mutual influencing of different disciplines of science is analysed, namely differences in the time involved and the speed at which knowledge is transferred within and across disciplines. Which period should be considered before research performed in one discipline eventually has impact in other disciplines? Is the speed at which knowledge is exchanged with other disciplines the same in all fields? Are there obstacles for rapid exchange? By intuition, one might expect that scientific results from more distant disciplines take more time before eventually being incorporated, than results from within a discipline. Indications for such a delay were first reported by *Moed* and *Van Raan,* based on a small scale study of publications at two faculties.[4]

If citation delay is a general aspect of interdisciplinary knowledge exchange, then it will be useful to obtain insight into these processes, in order to offer a basis for further analyses of interdisciplinary knowledge transfer. An additional question is the role interdisciplinary journals play in knowledge transfer between disciplines and in the speed at which it takes place.

The time passing in the process of citing scientific literature, also called ‘aging’, has been extensively studied. *De Solla Price* already showed that indications of differences among the sciences in their processes of knowledge growth can be found in referencing patterns.[5] Many studies further elaborated these findings, particularly with respect to aging processes of (articles in) scientific journals.[6,7] Most of these studies however, deal with aging irrespective of disciplinary boundaries. To our knowledge no study was done on aging processes involved in knowledge exchange between different disciplines.

Referencing or citation speed is related to the subject of the first citation process.[8] It is also related to the so-called publication delay.[9,10] However, these processes are not our first objective. Although they may play a role in the speed of knowledge transfer, we are primarily interested in the general process of (delay in) knowledge exchange between disciplines.

Method

Three data sets were used, based on the CD-ROM version of the *Science Citation Index* (SCI) produced by ISI, including publications with an address in the United Kingdom and Germany in 1992, and for the world total in 1998. The data sets were processed in the context of a larger project in order to investigate various aspects of knowledge flows between fields of science. The study of citation delay, reported in this paper, is part of this larger project. References given in these publications were examined for the period 1960-1992 in case of the two countries and for the period 1966-1998 for the world total, so an equal period of thirty-three years has been considered for all three data sets. References to articles in press, which should have to be attributed to the year of publication of the citing article (or the subsequent year), were not included.

References to journals not included in the SCI, but in the SSCI or A&HCI, were excluded from this analysis. References to non ISI journal literature (conference proceedings, books or private communications) were also excluded. We suppose that for most basic fields, the scientific journal is the primary means of communication and will offer a first insight into interdisciplinary knowledge exchange. It is realised, however, that conferences may play an important role with respect to the speed of knowledge transfer, and may deserve a separate analysis.

Publications of the United Kingdom in 1992 contained almost 800.000 references to ISI journals, publications of Germany in 1992 included 700.000 references. The world total 1998 contained more than 11 million references. Source publications as well as cited references were classified according to the ISI- category to which the journal belongs. If a journal belongs to more than one category, articles are fractionally counted for each of the categories. We realise that a journals-based field classification of articles is not a perfect means of attributing publications to a discipline. However, it is one of the few classification system available, spanning all disciplines.

ISI-journal categories apparently are too small for our present goal: a number of the 163 categories sometimes are too closely related to interpret cross referencing between them as interdisciplinary. In this analysis the primary aim is namely, not to examine knowledge exchange between smaller subfields, for instance between Nuclear Physics and Elementary Particle Physics, but exchange between larger disciplines, like for instance between Physics and Biology. Therefore, we classified all 163 ISI-categories to 17 broader disciplines and the latter were taken as primary object of this study. Two disciplines, Economics and Social Sciences, appeared to contain a very low number of articles included in the SCI and were left outside this analysis.

In total 26% of the journals which belong to more than one category are in turn classified in more than one discipline. It is realised that this type of journals may play an essential role in interdisciplinary knowledge transfer. This will be discussed afterwards.

In this analysis cross referencing between one of the remaining fifteen broader disciplines is perceived as interdisciplinary knowledge transfer. Therefore, a basic distinction among the references was made between references to articles in the same discipline, *internal references*, (R_i) and references to other disciplines, *external references*, (R_e).These two categories are comparable with the distinction made by *Chubin* and *Porter* into citations inside and citations outside category.[3]

It provides a way to discover whether knowledge which is referred to by present research, is stemming from the same or from other disciplines and it may give an indication of the degree of knowledge transfer between disciplines.

The ISI category of Multidisciplinary Sciences is a special category, which consists for a large part of mono disciplinary articles in multidisciplinary journals as *Nature*, *Science* and others. Recently, a method was described to distinguish the subject of the papers published in these journals.[11] We did not apply this method in this study, and Multidisciplinary Sciences was considered as a separate category, both from the citing as from the cited perspective. From the citing perspective it was considered as a separate 'discipline', though it should be realised that it is the journals, not the articles, that are multidisciplinary. Nevertheless we think it is informative to see what the characteristics of articles in these journals are, for instance concerning the average age of references.

From the cited perspective Multidisciplinary Sciences was not included. Citations to this 'discipline' can as well be to articles in the same field as to some other field. Therefore, references from another discipline to articles in the Multidisciplinary Sciences were singled out and excluded from the category of external references of the discipline concerned.

We concentrate in this article on *references to* older publications by current research, assuming that it gives indications of the (cross-)disciplinary usage of research findings.[3] An analysis of the same data from the viewpoint of the *citations by* measure, which takes the citing of older literature as a starting point, is not given here.

Results

First a general characteristic of the age distribution of all references (both internal and external) is given in Table 1. On average 42% of the references in the world total of publications are given to publications of the last five years (Price-index). For the United Kingdom and Germany this fraction is somewhat higher. Typical differences between disciplines can be observed. The extent at which recent literature is cited more often (immediacy effect), was found to correlate with intuitive divisions between the 'hard' and 'soft' sciences.[5] As has been shown before by others,[12] also within the 'hard sciences' some disciplines built more rapidly on recent research than others. Here we find that Multidisciplinary Sciences and Basic Life Sciences are on top with around 50%, Environmental Sciences and Geo Sciences at the bottom, with around 35% of the references of age 0-4. Percentages in United Kingdom and Germany are more or less identical and in the world total they are slightly lower. When disciplines are ranked, considerable agreement in the order of disciplines is shown between the United Kingdom, Germany and the world.

This order remains largely the same when the proportion of references to articles of the last ten years is considered. Generally about 73% of all references concerns literature published in the last 10 years. Between disciplines this percentage differs considerably. Again there is a striking similarity of the ranking of disciplines between the United Kingdom, Germany and the world.

Table 1
Proportions of references of age 0-4 and of age 0-9

	References age 0-4						References age 0-9					
	World 1998		UK 1992		Germany 1992		World 1998		UK 1992		Germany 1992	
	%	rank	%	rank	%	rank	%	rank	%	rank	%	rank
Multidisciplinary Science	49	*1*	57	*1*	55	*1*	79	*1*	84	*1*	83	*1*
Basic Life Science	45	*2*	52	*2*	49	*3*	77	*2*	81	*2*	80	*3*
Physics	44	*3*	49	*3*	49	*5*	76	*3*	79	*3*	79	*5*
Clinical Life Sciences	44	*4*	49	*4*	47	*6*	73	*4*	79	*4*	77	*6*
Engineering	42	*5*	48	*5*	50	*2*	72	*5*	79	*5*	79	*2*
Computer Sciences	41	*6*	47	*7*	49	*4*	72	*6*	75	*7*	76	*4*
Material Sciences	41	*7*	44	*8*	45	*7*	71	*7*	75	*8*	75	*7*
Pharmacology	40	*8*	48	*6*	45	*8*	70	*8*	71	*6*	73	*8*
Chemistry	39	*9*	42	*9*	41	*9*	68	*9*	71	*9*	67	*9*
Mathematics	36	*10*	41	*10*	39	*13*	67	*10*	71	*10*	68	*13*
Psychology & Psychiatry	35	*11*	39	*13*	36	*14*	66	*11*	71	*13*	69	*14*
Biology	35	*12*	39	*12*	41	*10*	65	*12*	69	*12*	70	*10*
Food, Agriculture & Biotechnology	35	*13*	41	*11*	40	*12*	64	*13*	67	*11*	70	*12*
Environmental Science	34	*14*	36	*15*	41	*11*	63	*14*	68	*15*	65	*11*
Geo Science	33	*15*	37	*14*	36	*15*	62	*15*	68	*14*	66	*15*
Total	42		48		46		73		77		75	

When we focus our attention to external references (R_e) only, rather large differences between disciplines become apparent (Table 2). On top is Multidisciplinary Sciences where 81% of the references in journals included in this ‘discipline’ are given to other disciplines. At the other end is Physics with about 21% external references.

Disciplines which generally refer for more than two third to publications from other disciplines are Computer Sciences, Engineering & Technology, Multidisciplinary Sciences, Pharmacology and Psychology & Psychiatry. At the other end are disciplines like Clinical – and Basic Life Sciences, Geo Sciences, Mathematics, Chemistry and Physics which refer for less than one third to publications in other disciplines. For most disciplines a rather large correlation between the values and the rankings for the two countries and the world is found, showing that the rate of knowledge import is to a large degree specific a discipline.

Table 2
Proportions of external references (R_e) in publications of the United Kingdom and Germany in 1992 and of the world total in 1998

	World 1998 %	UK 1992 %	Germany 1992 %	World 1998 rank	UK 1992 rank	Germany 1992 rank
Multidisciplinary Science	81	77	78	*1*	*1*	*1*
Psychology & Psychiatry	78	76	76	*2*	*2*	*2*
Pharmacology	74	69	70	*3*	*3*	*3*
Computer Sciences	73	68	66	*4*	*4*	*5*
Engineering	69	64	67	*5*	*5*	*4*
Food, Agriculture & Biotechnology	61	61	55	*6*	*6*	*9*
Material Sciences	59	60	66	*7*	*7*	*6*
Environmental Science	58	57	62	*8*	*8*	*7*
Biology	55	56	55	*9*	*9*	*8*
Mathematics	34	36	19	*10*	*10*	*14*
Chemistry	34	32	33	*11*	*11*	*10*
Clinical Life Sciences	33	25	25	*12*	*13*	*12*
Geo Science	32	22	22	*13*	*14*	*13*
Basic Life Science	32	32	28	*14*	*12*	*11*
Physics	21	21	17	*15*	*15*	*15*
Total	39	35	32			

However, in some disciplines slight differences between the two countries are visible. This is most clearly the case for Mathematics in Germany. This discipline appears to be less interdisciplinary oriented when compared with United Kingdom and the world, with only 19% of external references. Taking a closer look at the ISI-categories which make up this discipline, we find that in Germany, for instance in the subfield of Applied Mathematics much less (external) references are made to the discipline of Physics, as compared with the United Kingdom. Mathematics in the United Kingdom appears also to be more related with Social Sciences than in Germany. Here, we cannot go into more detail. It shows, however, that a separate analysis of internal and external references and citations may reveal interesting patterns, for instance in national characteristics in subfields.

It should be noted that the size of a discipline and also the attribution of (peripheral) ISI-categories to disciplines plays a role in the rate of referring to other disciplines. However, it might also be stated that inclusion of such categories is often typical for a discipline, and the (partial) reflection of it in figures in Table 2 is revealing aspects of the nature of this discipline.

A special case is Multidisciplinary Sciences, where a relatively large number of articles published in journals like *Science* and *Nature* actually are in the discipline of Basic Life Sciences. This is also reflected by a large fraction of around 40% of references from Multidisciplinary Sciences to Basic Life Sciences and is a main cause for the large share of external references (81%) found for this ‘discipline’.

A first impression of the age distributions of external and internal references is given in Figure 1. It shows the distributions of numbers of internal and external references in the word total of publications. In order to make comparisons possible, in this figure also the number of external references per year, scaled with the total number of internal references ($R_e\ (y) \cdot \Sigma R_i / \Sigma R_e$), is shown.

It gives a first indication of the differences between the two categories. Internal references (straight line) appear to be made relatively more often to literature of the most recent five years, external references (dotted lines), relatively more often concern older literature.

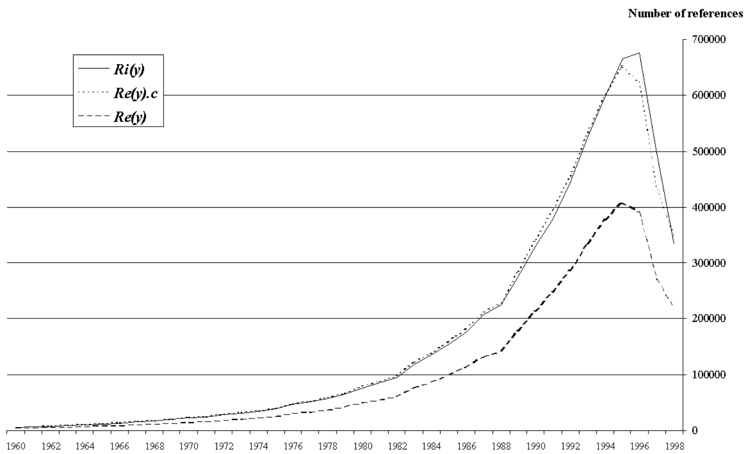

Figure 1. Age distribution of external and internal references in the world total of publications 1998. The age distribution of the number of external references is drawn for both the real values (line with large dots) as for the values scaled with the total number of internal references ($c = \Sigma R_i / \Sigma R_e$) (line with small dots)

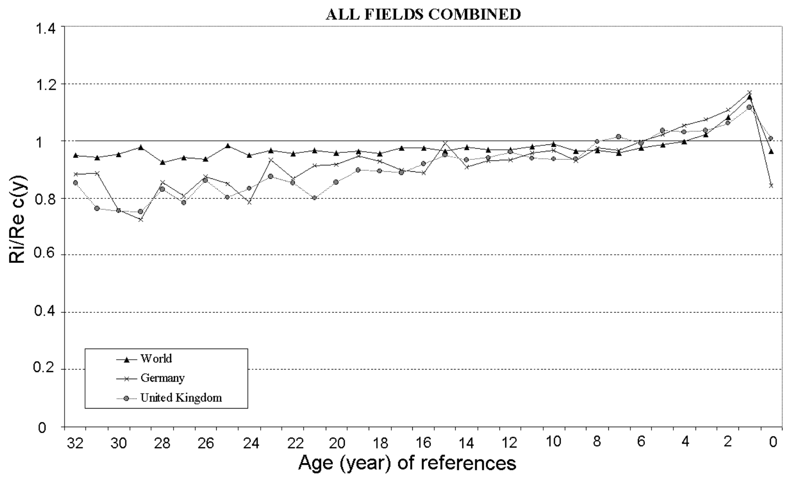

Figure 2a. Ratio of the number of internal and external references, All fields combined

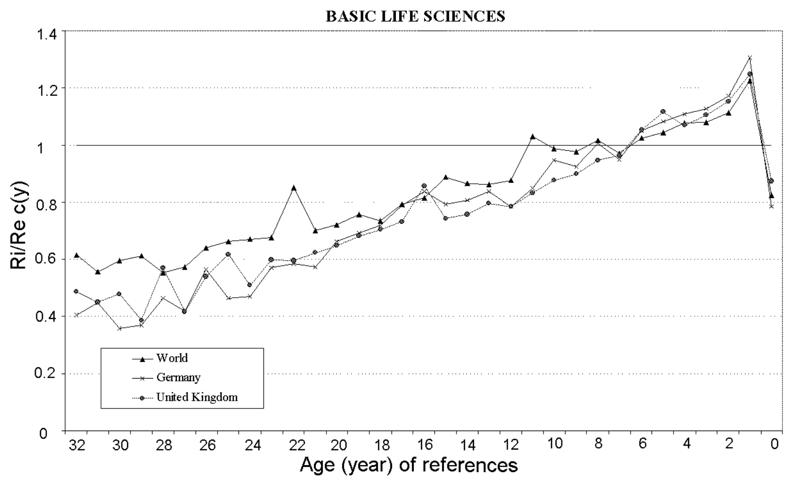

Figure 2b. Ratio of the number of internal and external references, Basic Life Sciences

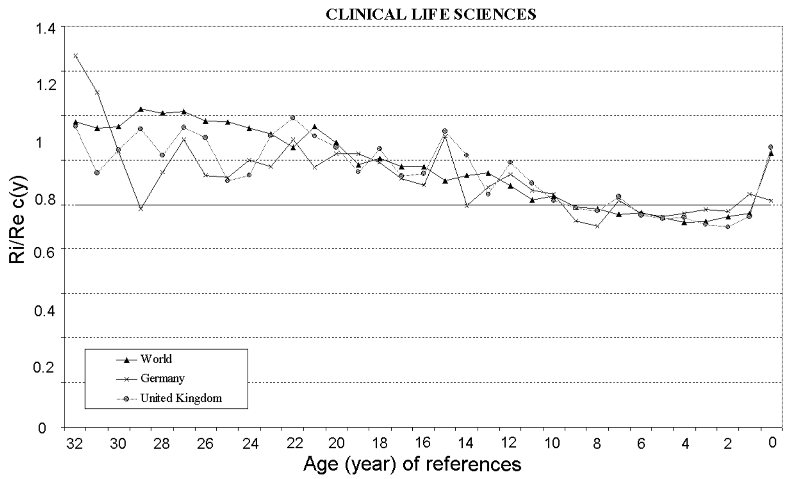

Figure 2c. Ratio of the number of internal and external references, Clinical Life Sciences

In order to make the differences between the age distributions of the two categories better visible, in Figure 2 the ratio between internal references (R_i) and external references (R_e scaled with R_i) for each year is given for all disciplines combined and for the disciplines of Basic Life Sciences and Clinical Life Sciences. The first discipline is shown as an example of the typical pattern found in most the disciplines, the second as example of a discipline showing a more rare and contrasting pattern.

The first figure (Figure 2a), representing the distribution of the R_i/R_e-ratio for all disciplines combined, shows a ratio above one for references of age 1-4 years and a ratio below one for references 'older' than five years. So, internal references take a relatively larger share among references of the first years, whereas in later years external references are represented relatively more. More pronounced this is shown by the R_i/R_e-ratios of the two countries. The first data point, which represents references to articles of the same year as the citing publication, shows hardly any differences between R_i and R_e. As in the distribution of Figure 1, it is shown that in the short term internal knowledge flow is relatively more represented than external knowledge flow, and it may be concluded that knowledge transfer within the same discipline proceeds faster than between different disciplines. The more so because the share of references of age 1-4 makes up almost 40% of the total number of references.

Furthermore, for the world and both countries, a very similar pattern of the distribution of the ratio of internal and external references can be observed.

Examining the R_i/R_e-ratios for each discipline separately, we find in a majority of disciplines the same trend as the general pattern of all disciplines combined, though often more pronounced. Most disciplines show ratios of $R_i/R_e >1$ for references of younger age and $R_i/R_e <1$ for references of older age. A clear example is given in the case of Basic Life Sciences (Figure 2b). Largely the same pattern is shown in Computer Sciences, Engineering & Technology, Environmental Sciences, Materials Sciences, Multidisciplinary Sciences, Pharmacology and Physics.

Some disciplines show a less clear difference between R_i and R_e (Biology, Food, Agriculture & Biotechnology, Geo Sciences, Psychology & Psychiatry). In three disciplines a more exceptional reverse pattern is shown. This is the case in Clinical Life Sciences (Figure 2c) and in Mathematics and Chemistry. Here a reverse process appears to take place by which documented knowledge of other disciplines (in case of Clinical Life Sciences mainly of the Basic Life Sciences) is incorporated slightly faster than results from within the discipline itself.

Interestingly, in almost all of the disciplines the patterns of the distribution of the R_i/R_e-ratio for the United Kingdom, Germany and for the world are very similar (deviations in the longer term between the United Kingdom and Germany, for references of older age, may be related to the fact that after many years smaller and smaller numbers are concerned). These similarities of the trends give a further indication that patterns in the speed of interdisciplinary knowledge exchange are for a large part particular for a discipline.

Remarkably, references to articles of the same year (age zero) show in most disciplines a deviation of the general trend per discipline. As is shown in Figure 2b, for instance in Basic Life Sciences, articles of other disciplines published in the same year as the citing publication, are referred to relatively fast, whereas documented knowledge from other disciplines in general is referred to relatively slow.

The same tendencies as found above, are also reflected when the average age of external and internal references is compared. In the world total of publications, in eight disciplines internal references are clearly younger than external references (for instance in Basic Life Sciences 7.1 years versus 7.8 years respectively). In four disciplines they are of about the same age. In three disciplines, exceptionally, documented knowledge from outside the discipline is clearly referred to more quickly: internal references are on average older than external references (Mathematics (10.1 versus 8.8 years) and Clinical Life Sciences (7.6 vs. 7.1 years) and to a lesser degree Chemistry (9.4 versus 9.2 years).

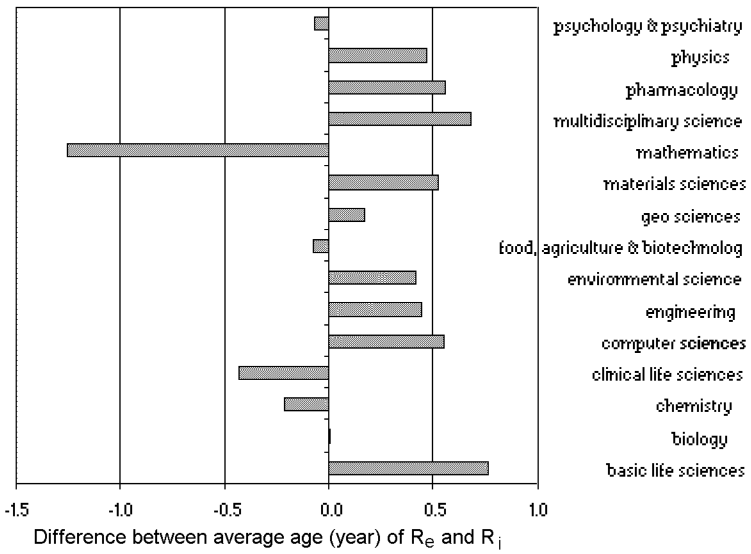

Figure 3. Differences between the average age of external and internal references (R_e–R_i) in the world total of publications 1998

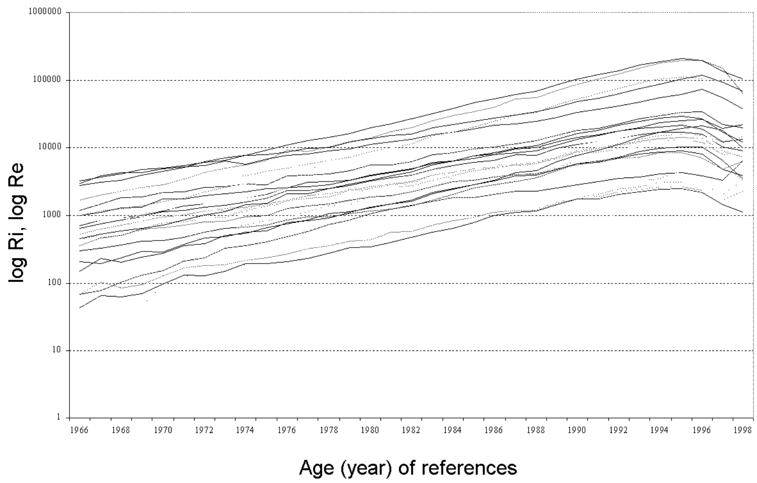

Figure 4. Age distributions of R_e and R_i in the world total of publications 1998 plotted on a logarithmic scale

Because the average age is only partially reflecting the differences in the age distributions of internal and external references, a more refined measure to compare the distributions of R_i and R_e per discipline is proposed. It is based on the well known observation that numbers of references increase exponentially as a function of age. When R_i and R_e-numbers of all disciplines are plotted on a logarithmic scale (Figure 4), we see that this holds for all cases, except for references to publications of age zero to one, a fact which will be discussed afterwards. This exponential trend was used as a starting point for a new indicator. It expresses the differences between distributions of internal and external references by calculating the ratio of the slopes (regression coefficients) of the linear best fit of the logarithmic values of the number of references, R_i and R_e. This ratio of regression coefficients is called *RRC*. If $RRC > 1$, this indicates that literature from the same discipline is referred to relatively rapid, whereas literature from other disciplines is cited at a slower rate. For $RRC < 1$, literature from the own discipline is referred to relatively slow and literature from other disciplines is cited at a relatively faster rate. The resulting *RRC*-values are given in Figure 5 for all disciplines.

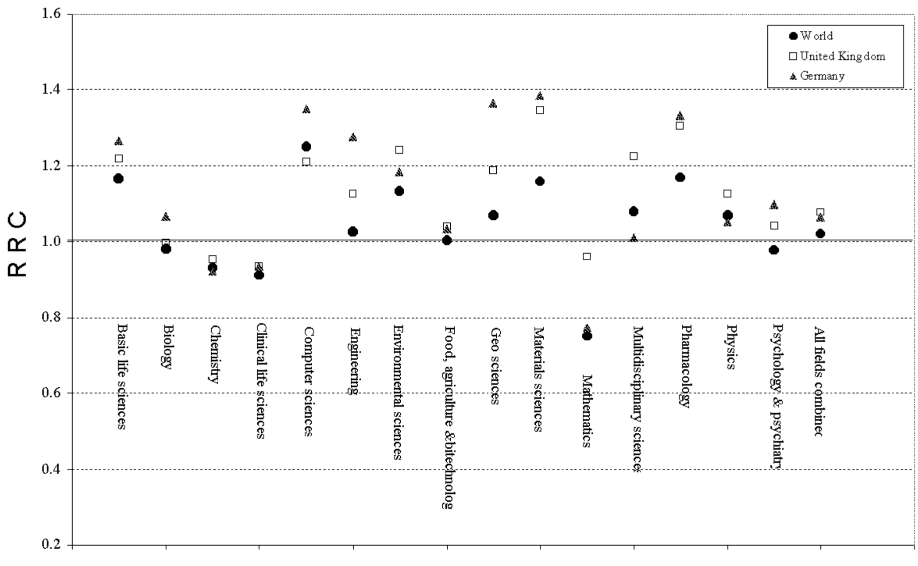

Figure 5. *RRC*-values for the world total, United Kingdom and Germany

The general impressions discussed before, are confirmed by the results of the *RRC*-indicator.

Most of the disciplines show a *RRC*-value > 1, reflecting that research findings from other disciplines are picked up slower in the journal literature than those from the own discipline.

A value above one is also obtained for all disciplines combined, though here values seem to be levelled off. Highest *RRC*-values are found for Basic Life Sciences, Pharmacology and Computer Sciences.

Values below one are found for Mathematics, Clinical Life Sciences and Chemistry.

As also became apparent in a previous section, the latter disciplines, especially Mathematics, appear to demonstrate a more interdisciplinary character and to cite relatively quickly results published outside the own discipline. Compared to the world and the United Kingdom, German publications in Mathematics in the short term show less interdisciplinary orientation. This was also concluded based upon findings given in Table 2.

The differences found in the speed at which publications of other fields are cited, compared to those of the same field, may play a role, especially when short term impact is concerned. This may be illustrated by, for example, citations to physics publications. We find that of all citations to Physics, given by articles of the same discipline in 1998, 29% is to publications of the last three years (age 0-2), whereas of all citations given to physics publications by other fields, 25% is to publications of the most recent three years. In the reverse and more exceptional case of Mathematics, these shares are 25% versus 31%, respectively. So, especially for groups or specialties with a relatively more or less interdisciplinary orientation, short term impact rates may deviate from the average in a given discipline.

In nine out of fifteen disciplines, the *RRC*-values of the world, the United Kingdom and Germany are more or less the same. In the other disciplines, the results vary somewhat between the three datasets, especially in Engineering, Multidisciplinary Sciences and Geo Sciences. Most deviations between the United Kingdom, Germany and the world appear to be in Geo Sciences where German publications are in the short term, much more building on results in their own discipline than in the United Kingdom and in the World.

However, *RRC*-values of the world and the two countries never show quite opposite trends. We may conclude that rates and speed at which knowledge from within a discipline or from other disciplines is incorporated, is to a large degree typical for each discipline.

In order to check *RRC*-results, we have compared these with the *GINI* index, which compares two distributions x_i and y_i using:

$$GINI = 2\sum_{i=1}^{N}(x_i - y_i)\Delta x_i$$

where x_i = 1/N. For our analysis $x = R_i$ or R_e, and y represents a distribution equally spread over the years.[13]

For the world total of publications, both *RRC*- and *GINI*-index values show a large correlation, as is visible in Figure 6. The data support our view that the *RRC*- indicator is a reliable measure of citation speed and delay.

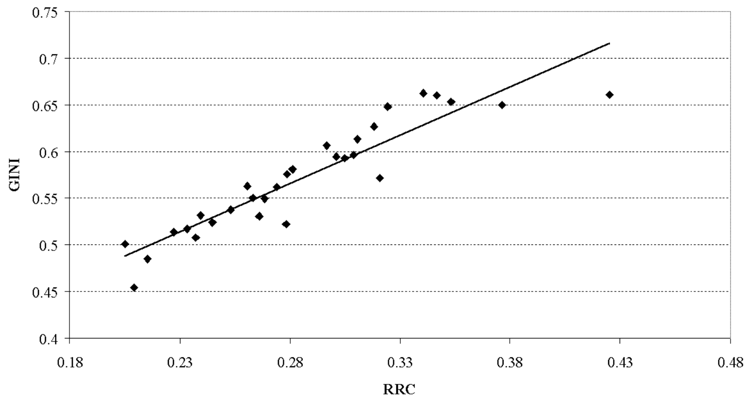

Figure 6. Scatter plot of *RRC*-values and *GINI*-index for the world total 1998

We have checked whether the deviation from the linear trend in the age distribution of references, for references of age zero to one (see Figure 4), is of influence on the results of the *RRC*-indicator.

It was found that when referencing year 0 and 1 were disordered from the analysis, results did not significantly change.

As a check, for some disciplines we have also calculated a revised ratio of the regression coefficients of R_i and R_e, in which standard errors of the separate data points were taken into account. (Standard errors were chosen to be $\sqrt{N}$, where N is the number of references). However no significant differences were found.

Conclusion

Scientific methods, techniques and results published in scientific journals in other disciplines, in general appear to take more time to be incorporated in a discipline than results from within this discipline. This may be concluded on the basis of an analysis of publications and references of the United Kingdom and Germany in 1992 and the world total in 1998. The degree to which a citation delay occurs, differs per discipline. Most visible it is in Basic Life Sciences, Computer Sciences, Materials Sciences and Pharmacology. The findings confirm intuitive assumptions that scientists first of all focus on results in their own field and secondly pick up results from more distant disciplines.

Exceptionally, in Mathematics and to a lesser degree in Clinical Life Sciences, results of other disciplines are incorporated faster than those of the same discipline. An explanation for this different pattern could not be found yet.

If the general tendency of a citation delay is an indication for a real delay in interdisciplinary knowledge transfer, then the findings are important for e.g. evaluation studies. Especially when looking at short term effects, interdisciplinary impact may be relatively underrepresented and as such undervalued. Delayed transfer of knowledge across different disciplines should be taken into account also in bibliometric analyses. Citation indicators, especially when restricted to a short, recent period, may be effected by these differences in delay.

Secondly, for each discipline we see striking similarities in the age distributions of internal and external references when the three data sets are compared. The patterns found for the two selected countries and the world appear to correspond to a large degree. This seems to indicate that processes of incorporation of knowledge from within or outside a discipline, as reflected by references, are very typical for a discipline. Future studies on these specific patterns may give further insights in the dynamics of knowledge exchange between disciplines. It may also reveal interesting characteristics of national research profiles.

As mentioned before, in this analysis both journals attributed to one discipline, as journals which belong to more than one discipline, are included. A future analysis which separately examines journals which are classified only once, versus those which are multiply classified, will give more insight in the role mono – and multiply classified journals play in knowledge exchange among disciplines.

Furthermore, this analysis of citation speed and delay was carried out for rather large disciplines. Future analyses at lower aggregate levels and for more specialised journal sets may yield further interesting outcomes.

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