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# Citation speed as a measure to predict the attention an article receives: An investigation of the validity of editorial decisions at *Angewandte Chemie International Edition*

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ABSTRACT

The scientific quality of a publication can be determined not only based on the number of times it is cited but also based on the speed with which its content is disseminated in the scientific community. In this study we tested whether manuscripts that were accepted by *Angewandte Chemie International Edition* (one of the prime chemistry journals worldwide) received the first citation after publication faster than manuscripts that were rejected by the journal but published elsewhere. The results of a Cox regression model show that accepted manuscripts have a 49% higher hazard rate of citation than rejected manuscripts.



## 1. Introduction

Since peer review is so central to what is published and where, and since so much hinges on peer review in and outside of science, it is essential that it is carried out well and professionally (Hames, 2007). In a comprehensive research project, we investigated the validity of the journal peer review process at *Angewandte Chemie International Edition* (AC-IE), one of the prime chemistry journals worldwide, and conducted a citation analysis for manuscripts that were accepted by the journal or rejected but published elsewhere. In the absence of other operationalizable criteria, a conventional approach is to use citation counts as a proxy for research quality, since they measure the international impact of the work by individuals or groups of scientists (Bornmann & Daniel, 2008c). Our analyses of the citation counts for the submissions at AC-IE showed that the editorial decisions made by AC-IE have high predictive validity (Bornmann & Daniel, 2008a, 2008b): Although the results of Bornmann and Daniel (2009a) point to type I (*overestimation* of the manuscript's future performance) and type II (*underestimation* of the manuscript's future performance) errors in the AC-IE publication decisions, on average, accepted manuscripts have clearly higher citation counts than manuscripts that were rejected but published elsewhere. These results suggest for AC-IE that the publication decisions correspond on average with the scientific impact of the manuscripts.

According to van Dalen and Henkens (2005), the scientific quality of a publication can be determined not only based on the number of citations but also based on citation speed:

> The quality of articles ... is approximated by the *impact* and *speed* with which knowledge is disseminated in the scientific community ... The reason why the chances of a first citation decrease over time may be that observed uncitedness of articles signals to prospective readers that the article is of low quality. In other words, uncitedness

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may become a stigma and the longer an article remains uncited, the lower the perceived quality of the article (pp. 210–211, see also van Dalen & Henkens, 2004).

Whereas the citation count is a bibliometric standard indicator in the assessment of research, the amount of time up to the first citation is an indicator which has been scarcely used in bibliometric studies. The citation speed measure was introduced by Schubert and Glänzel (1986) as a meaningful addition to the bibliometric toolkit. The time at which an article receives its first citation ($t_1$) "is important for an article since at this time the article shifts its status from 'unused' to 'used' and the smaller $t_1$ is, the more we can say – in general – that the article under study is important and early visible in the scientific world" (Egghe, 2000, p. 346). Rousseau (1994) develops double-exponential models for the first-citation distribution and Egghe (2000) models this distribution by using a decreasing exponential model and a classical Lotka function (see also Egghe & Rao, 2001). For the publications that appeared in AC-IE, Peter Gölitz, Editor-in-Chief of AC-IE, pointed out that the speed with which they find reception within the scientific community is a sign of quality:

> It is most pleasing to see how rapidly publications in *Angewandte Chemie* are noticed and bear fruit in the work of others. This is reflected in the extremely high Immediacy Index of 1.655 . . . This value implies that each manuscript published in *Angewandte Chemie* in 2003 was on average cited in the same year 1.66 times (Gölitz, 2005, p. 6).

In the present study we tested the extent to which manuscripts accepted for publication in AC-IE receive a first citation faster than manuscripts rejected by AC-IE (but published elsewhere). If this were confirmed, it would mean that accepted manuscripts not only had an advantage over rejected manuscripts with regard to impact (Bornmann & Daniel, 2008a, 2008b) but also with regard to the speed with which the manuscripts' contents were disseminated in the chemical community.

## 2. Methods

### 2.1. Manuscript review at AC-IE

AC-IE is one of the prime chemistry journals in the world, with a higher annual Journal Impact Factor (JIF, provided by Thomson Reuters, Philadelphia, PA) than the JIFs of comparable journals (at 10.879 in the 2008 Journal Citation Reports, Science Edition). AC-IE is a journal of the German Chemical Society (Gesellschaft Deutscher Chemiker (GDCh), Frankfurt am Main, Germany) and is published by Wiley-VCH (Weinheim, Germany).

A manuscript submitted to AC-IE is usually subject to internal and external review. First, editors at the journal evaluate whether the manuscript contributes to the development of an important area of research (internal review). If the editors find that this is so, the submitted manuscript is sent to several independent reviewers (external review), who review it using an evaluation form and a comment sheet. The journal editors then make the decision to accept or reject a manuscript for publication on the basis of these reviews and on their own evaluations.

AC-IE introduced peer review in 1982, primarily in conjunction with one of the document types published in the journal, "Communications," which are short reports on work in progress or recently concluded experimental or theoretical investigations. What the editors of AC-IE look for most of all is excellence in chemical research. Submissions that reviewers deem to be of high quality are selected for publication (Bornmann & Daniel, 2009b, in press).

### 2.2. Database for the present study and conducting of citation analysis

For the investigation of manuscript review at AC-IE we used information on all 1899 manuscripts that were reviewed in the year 2000. The information was taken from archived material that was stored electronically by the publisher, Wiley-VCH. Of the 1899 manuscripts, 46% ($n = 878$) were accepted for publication in AC-IE, and 54% ($n = 1021$) were rejected. A search in the literature databases Science Citation Index (SCI, Thomson Reuters) and Chemical Abstracts (CA, Chemical Abstracts Services, CAS, Columbus, OH) revealed that of the 1021 rejected manuscripts, 959 (94%) were later published in 136 other (different) journals within a time period of seven years (that is, between 2000 and 2006).

For accepted and rejected (but published elsewhere) manuscripts, we determined – in addition to number of citations – the number of months from date of publication to the first citation. With the number of months we used a finer-graded time measure than Moed and van Raan (1986) who used years as time units to analyze citations to Physics & Astronomy departments at the University of Leiden (The Netherlands). The publication date was taken from information either in the publication or in the Web of Science (WoS, Thomson Reuters). For all publications, the date of the first citation was searched in WoS. Of the total of 1837 manuscripts published in the AC-IE (accepted manuscripts) or another journal (rejected manuscripts), 1774 could be included in the analysis. For 63 manuscripts, a publication date and/or a first-citation date was not available. At the time of data collection, 1747 of 1774 manuscripts had at least 1 citation, and 27 manuscripts had no citations. These 27 manuscripts are "right censored" data.

In the search for a publication's first citation, we included self-citations, because (1) it is not expected that the occurrence of a self-citation as the first citation varies systematically for the accepted and rejected (but published elsewhere) manuscripts, and (2) self-citations of a publication can be modeled in the multiple regression analysis (the results of which are reported in the following) using the number of authors of a manuscript. As Herbertz (1995) showed, a greater number of authors are associated with a greater number of self-citations of a publication (see also Leimu & Koricheva, 2005). For the present

study, which looked at the length of time up to the first citation, this means that the greater the number of authors of a publication, the higher the probability of a self-citation being the first citation. (3) In a survey in which psychologists stated the importance of every reference in their own empirical paper and the primary citation reason, Safer and Tang (2009) found the following:

> Self-citations were generally not perfunctory citations. Our participants tended to rate self-citations as highly important, with the primary reasons being to justify conceptual ideas and/or methodological or quantitative techniques rather than being for general background or other reasons. Overall, self-citations were more likely than other citations to be discussed in some length rather than simply mentioned in the text (Safer & Tang, 2009, p. 52).

### 2.3. Statistical methods

The number of months from publication up to the first citation of a paper was analyzed using the Kaplan–Meier method (StataCorp., 2007b). With this method, whenever the first citation of a manuscript occurs in the dataset, the survival functions of manuscripts that have not yet been cited are always recalculated.

We used two tests to test the null hypothesis that the survival functions of accepted and rejected (but published elsewhere) manuscripts are the same. According to Cleves, Gould and Gutierrez (2004), the Wilcoxon test is preferred to other tests when – as in this study – "the hazard functions are thought to vary in ways other than proportionally" (p. 116). We used the Wilcoxon test here, because at certain times after publication, accepted papers show different hazard rates (to be cited) than rejected (but published elsewhere) papers (see the explanations in the following). The Tarone–Ware test is nearly identical to the Wilcoxon test, but it is "less susceptible to problems should there exist vast differences in the censoring patterns among the groups" (Cleves et al., 2004, p. 116). As Fig. 1 shows, these differences are clearly visible for accepted and rejected (but published elsewhere) manuscripts.

Numerous studies have shown that the probability that a paper will be cited depends not only on its scientific quality (and thus on the judgment of the AC-IE editors) but also on factors that can generally increase or decrease the probability of citations (Bornmann & Daniel, 2008c). For example, the probability that a manuscript will be cited increases with the number of authors (through self-citations or wider dissemination of the manuscript in the scientific community). For this reason, the association between editorial decision and the length of time up to the first citation should be tested in a multiple regression model, so that these general factors can be controlled for in the analysis. The Cox proportional hazards regression model is a method related to multiple or logistic regression that can be used to test how a set of independent variables influences the hazard rate of manuscripts being cited and that allows the inclusion of censored data (Cox, 1972).

When modeling a Cox proportional hazards model a key assumption is proportional hazards (Cleves et al., 2004). In this study, we tested this assumption for each independent variable on the basis of Schoenfeld residuals. As the assumption was violated especially by the variable editorial decision (see above), we introduced two variables as stratification variables into the model: a manuscript's publication year and its field (five broad headings for five main areas of chemical research, provided by CA). By considering these stratification variables, the test of proportional hazards for each independent variable and the global test were non-significant. That means that when the stratification variables are considered, an interaction of time (length of time up to the first citation) and the editorial decision are prevented in the analysis.

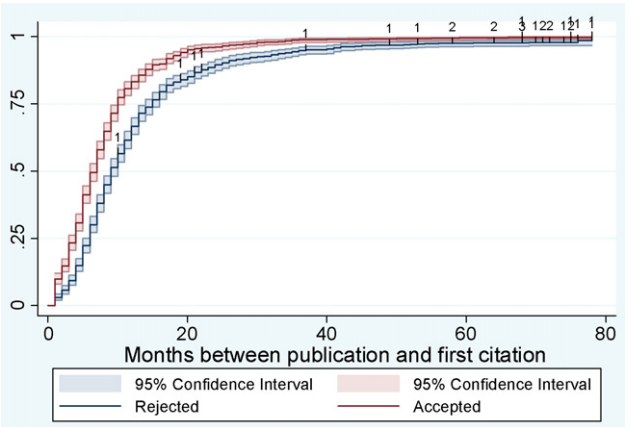


**Fig. 1.** Kaplan–Meier estimates for the length of time up to the first citation with 95% confidence interval and with the number of censored manuscripts ($n = 1774$). *Notes*. One month between publication of a manuscript and its first citation means the citation was made within the first month after publication. Two months means that the manuscript received the first citation within the second month after publication. The Wilcoxon test and the Tarone–Ware test reject the null hypothesis that the survivor functions of accepted and rejected (but published elsewhere) manuscripts are the same, $\chi^2$ ($n = 1747$) = 116.15, $p < 0.05$ (Wilcoxon test); $\chi^2$ ($n = 1747$) = 116.04, $p < 0.05$ (Tarone–Ware test).

The violation of the assumption of independent observations by including the length of time up to the first citation of more than one publication per journal is considered in the model by using the cluster option in Stata (StataCorp., 2007a). This option specifies that the times are independent across papers published in different journals but are not necessarily independent within papers of the same journal (Hosmer & Lemeshow, 2000, Section 8.3).

### 2.4. Factors that may influence the probability of receiving the first citation

The probability of citations may be influenced by the number of authors (Glänzel, Debackere, Thijs, & Schubert, 2006; Leimu & Koricheva, 2005), the number of pages in a publication (Bornmann & Daniel, 2007), and the language of the journal in which a publication appears (Bornmann & Daniel, 2008c). In addition, consistent with Merton's interpretation of the Matthew effect in science (Merton, 1968) and Cozzens (1985) "success-breeds-success" phenomenon, publications by authors whose works have been very frequently cited in the past can be expected to be cited more often than publications by authors that have not published highly cited works in the past. This means that publications of the same intrinsic worth will be cited differently depending on the status of the author (Garfield, 2002).

## 3. Results

Fig. 1 shows the Kaplan–Meier estimates for the length of time up to the first citation for accepted and rejected (but published elsewhere) manuscripts. The cumulative survival estimates in the figure indicate that the probability for the first citation is higher for accepted manuscripts than for rejected (but published elsewhere) manuscripts. As the results of the Wilcoxon test and the Tarone–Ware test show, this difference between the two groups in the length of time is statistically significant (see the results in the Fig. 1 notes). This finding is an initial indication that – based on the speed with which the results were disseminated in the chemical community – the editorial decisions at AC-IE are valid.

Table 1 describes the independent variables that were included in the Cox regression model predicting time up to the first citation. The results of the regression analysis are shown in Table 2. With the exception of the variable "language of the journal in which the publication appeared," all of the independent variables are statistically significantly associated with time up to the first citation. Of the factors that generally influence the probability of citations, time up to the first citation is statistically significantly dependent on number of authors of the article, length of the publication, and number of highly cited authors. In agreement with the findings of Bornmann and Daniel (2008a, 2008b), the association between the editorial decision and the length of time up to the first citation is statistically significant. Table 2 shows exponentiated regression coefficients (hazard ratio) for the individual independent variables; these coefficients can be interpreted as ratios of the hazards for a one-unit change in the corresponding independent variable (Cleves et al., 2004). For the variable editorial decision, this means that there is a 49% higher hazard of citation for accepted manuscripts than for rejected (but published elsewhere) manuscripts. When controlling for factors that generally affect the probability of citations, this result confirms the validity of the editorial decisions, when taking citation speed as the quality criterion.

For manuscripts with at least one citation, we calculated the type and strength of the correlation between citation speed and citation counts (the number of citations for a fixed time window of three years after the publication year searched in CA) by using Spearman's rank-order correlation ($n = 1757$). The results show a negative correlation coefficient of −0.52. According to the guidelines of Kraemer et al. (2003) this correlation is lying in a range that can be called larger than typical in the applied behavioral sciences ($r = 0.50$). The faster a publication is cited the higher is the probability of frequent citations.

**Table 1**
Description of the independent variables ($n = 1768$).

| Independent variable | Values | Mean |
|---|---|---|
| Editorial decision | Rejected (0) → accepted (1) | 0.50 |
| Number of authors of the publication | 1 → 15 | 4.27 |
| Length of the publication (in number of pages) | 2 → 19 | 4.06 |
| Language of the journal in which the publication appeared | English (0) → multiple or non-English language (1) | 0.07 |
| Number of authors listed in ISIHighlyCited.com | 0 → 0.5 | 0.03 |

**Table 2**
Stratified Cox regression model predicting time up to the first citation for accepted or rejected (but published elsewhere) manuscripts ($n = 1768$).

| Independent variable | Hazard ratio | Robust standard error | $z$ |
|---|---|---|---|
| Editorial decision | 1.49 | 0.08 | 7.69* |
| Number of authors of the publication | 1.03 | 0.01 | 2.69* |
| Length of the publication (in number of pages) | 1.06 | 0.01 | 4.14* |
| Language of the journal in which the publication appeared | 0.80 | 0.13 | −1.35 |
| Number of authors listed in ISIHighlyCited.com | 2.23 | 0.44 | 4.03* |

*Notes*. Standard errors are adjusted for the dependency in the data set caused by the publication of several accepted and/or rejected (but published elsewhere) manuscripts in one journal ($n = 102$ clusters).

* $p < 0.05$.

## 4. Discussion

Starting out from Schubert and Glänzel's (1986) proposal to determine the scientific quality of a publication not only based on number of citations but also based on the length of time after publication up to the first citation, we tested in the present study whether manuscripts accepted for publication by AC-IE are cited for the first time faster than are manuscripts that are rejected by AC-IE but published elsewhere. As the results of a Cox regression model show, accepted manuscripts have a 49% higher hazard of citation than rejected manuscripts. This finding accords with Bornmann and Daniel's (2008b) finding that 50% more citations are to be expected for accepted manuscripts than for rejected manuscripts. The editorial decisions at AC-IE are thus valid not only with regard to impact but also with regard to the speed with which knowledge is disseminated in the chemical community.

All in all, the results indicate that the length of time up to the first citation is a meaningful addition to the standard indicator toolbox of evaluative bibliometrics. We have demonstrated this by using data of a high impact journal as a case study. In order to test the general validity of the speed indicator, further empirical studies (especially for low impact journals) with extensive datasets and in various disciplines are needed. The advantage of citation speed over citation counts is mainly that the analysis does not have to be conducted only after at least three years have elapsed since publication (Seglen, 1992) but instead can be conducted sooner. Publications that have not yet been cited within the time window being used can be included in the analysis as censored cases.

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