Jointly published by Akadémiai Kiadó, Budapest
and Springer, Dordrecht

Scientometrics, Vol. 72, No. 3 (2007) 427–437
DOI: 10.1007/s11192-007-1777-2

Does self-citation pay?

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Self-citations – those where authors cite their own works – account for a significant portion of all citations. These self-references may result from the cumulative nature of individual research, the need for personal gratification, or the value of self-citation as a rhetorical and tactical tool in the struggle for visibility and scientific authority. In this article we examine the incentives that underlie self-citation by studying how authors' references to their own works affect the citations they receive from others. We report the results of a macro study of more than half a million citations to articles by Norwegian scientists that appeared in the Science Citation Index. We show that the more one cites oneself the more one is cited by other scholars. Controlling for numerous sources of variation in cumulative citations from others, our models suggest that each additional self-citation increases the number of citations from others by about one after one year, and by about three after five years. Moreover, there is no significant penalty for the most frequent self-citers – the effect of self-citation remains positive even for very high rates of self-citation. These results carry important policy implications for the use of citations to evaluate performance and distribute resources in science and they represent new information on the role and impact of self-citations in scientific communication.

Introduction

Whenever citations are used as indicators to evaluate scientific research, self-citations are often considered problematic.[1,2] Although authors may have good reasons

Received November 14, 2006

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0138–9130/US $ 20.00

to cite their own works, these citations do not necessarily reflect the importance of their work or its impact on the rest of the scientific community.[3,4] If scholars have a strategic incentive to cite themselves[5], it may distort the information in citation counts and reduce their reliability as a proxy for quality or visibility. Thus, it is important to know how prevalent self-citation is and how it influences citations from others. Many scholars have studied self-citation[6-11] and some suggest that self-citations should be removed from citation counts, at least at micro and meso levels (e.g. analyses of persons, research groups, departments, and institutions).[3,11] In fact, some producers of bibliometric indicators have begun to identify and publish the proportion of self-citations in order to be able to draw more reliable conclusions about the real impact each publication has on the scientific community.[12]

While these studies have initiated a debate about the role of self-citation, they have not examined the incentives presented to individual authors. Most recent studies on self-citation have focused on the *publication level*, defining a self-citation as one in which the citing and cited paper have at least one author in common.[10] This means, however, that all the authors of an individual article are lumped together when counting self-citations. To analyze individual incentives we focus instead on the *author level*, counting the total number of times authors cite their own works in all their publications for a given period. Note, for example, that a single publication may contain more than one self-citation since an author may refer to several of his or her earlier papers. If self-citation improves the visibility of authors' prior works or the authority of their arguments, we would expect self-citations to generate more citations from others in the future as others become more aware of the authors' past research or more convinced of their credibility. This would suggest that a real career motivation exists for self-citation.

Data and methods

To study whether self-citations influence future citations from others, we used the database National Citation Report (NCR) for Norway provided by Thomson Scientific (formerly Institute for Scientific Information, ISI). This database contains bibliometric information for Norwegian articles (papers with at least one Norwegian address) including data on the citing papers. Only regular articles, notes, and reviews were included in the analysis and publications from the social sciences and the humanities were excluded. We applied the 2001 edition of the database with data covering 1981–2000. In total 692,455 citations were analysed to 64,842 publications. For each cited and citing paper we collected information on the name of the authors. When an author name of a citing paper was identical to an author name of the cited paper, we credited that author with one self-citation.

As a consequence of our sample frame, a large number of foreign (i.e. non-Norwegian) co-authors were included in the source data. Because we did not have the complete publication record of these persons they were removed. To determine which authors to remove, we defined as "Norwegian" any author who had authored at least one paper in which all authors had a Norwegian address (it would be unlikely for a Norwegian scientist not to have produced a single paper with only Norwegian contributors). In addition the articles from the research laboratory CERN (Switzerland) often have several hundred authors and these papers accordingly result in an extremely large number of cited author-citing author links. We therefore decided to remove the CERN publications from the material. Similarly, we also removed the five authors with the highest number of total cites since they had substantially more citations than the sixth ranked and lower-ranked authors (the fifth ranked author had 30% more total citations than the sixth ranked author and the first ranked author had 100% more citations than the sixth ranked author – in contrast the largest gap between any other authors with contiguous rank was 5%).

In the database the authors are indexed by their surname and first name initials. We use the author rather than the publication as the unit of analysis. Thus, if a paper authored by P AROE and G FJOSNES is cited by a paper authored by K RUD and P AROE, this citation counts as a self-citation for P AROE but not for G FJOSNES. This yields fewer self-citations as a proportion of total citations (11% here compared to 21% using publication as the unit of analysis[3]), as would be expected due to the different methodology applied. In total the study is based on 18,819 authors with unique names who are indexed by their surname and first name initials.

Table 1 shows summary statistics for these authors and Table 2 shows their Spearman rank correlations. We find large individual variability both in the production of papers and in the self-citation patterns. On average each author had published 7 papers during the period and self-cited these papers 10 times, while 85 citations were received from others. Thus self-citations account for about 11% of all citations. The more papers one has published the more self-citations one can give, and the persons with the highest productivity of papers accordingly tended to have the highest number of self-citations (Spearman rank correlation, $\rho = 0.64$). At the individual level there is large variability: extreme self-citers and persons who hardly or never cite themselves. For example, one person had published 26 papers and self-cited these papers 132 times while receiving only 20 citations from others. At the other end, one person had published 45 papers and self-cited these papers 17 times while receiving 1517 citations from others.

Figure 1 shows how average values observed in the raw data change over time. The points indicate the cumulative citations from others after 1 year, 2 years, etc. for authors who publish at least one article and do not cite themselves (open diamonds), cite themselves once (solid circles), and so on. These data suggest that individuals who do not cite themselves fare considerably worse than those who do. In fact, the effect is self-reinforcing as can be seen by the increase in citations from others among those who cite themselves at least once. Of course, Figure 1 is not definitive because self-citation itself may be a proxy for the influence or impact of the authors' research. Authors have more opportunities for self-citation if they publish more in better journals with many coauthors, and they may be more inclined to cite themselves if their prior work is seen as important by others. Thus, we need to model cumulative citations and control for these other author-specific attributes to see what effect self-citation has on citations from others.

Table 1. Summary statistics, by author (N = 18,819)

	Minimum	Median	Mean	Maximum	Standard Deviation
Citations from others	0	18	84.74	4695	220.23
Self-citations	0	1	10.06	1061	37.30
Publications	1	2	6.91	288	12.76
Number of co-authors	1	8	13.53	128	15.27
Average journal citation rate	0.51	6.64	7.27	30.15	3.76

Table 2. Spearman rank correlations (N = 18,819)

	Citations from others	Self-citations	Publications	Number of co-authors	Average journal citation rate
Citations from others	1.00	0.88	0.53	0.39	0.39
Self-citations	0.88	1.00	0.64	0.54	0.54
Publications	0.53	0.64	1.00	0.83	0.83
Number of co-authors	0.39	0.54	0.83	1.00	0.98
Average journal citation rate	0.39	0.54	0.83	0.98	1.00

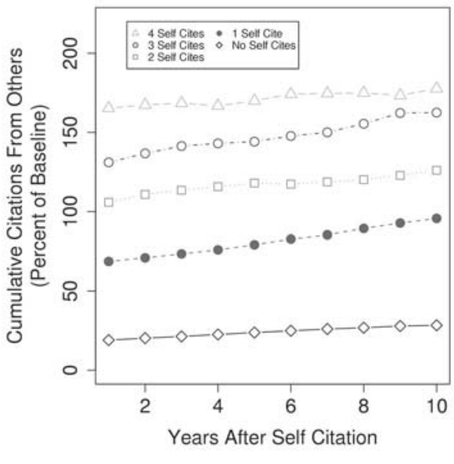

Figure 1. Observed cumulative other citations to individuals who publish a paper by number of self-citations and year. Since there are some over time differences and sample differences due to censoring of the observed network of citations between 1980 and 2000, we report these cumulative citations as a percent of baseline, which is the average cumulative other citation rate among *all* other authors who publish at least one article.

To model cumulative citations from others we use Poisson regression. We also investigated the use of negative binomial models because they allow for over-dispersion, but they could not reject the null hypothesis that over-dispersion does not exist and the substantive results were not meaningfully different. To ensure that multiple observations for each author do not artificially shrink our standard errors, we estimate the models using generalized estimating equations with clustering on each author. Since we are interested in the dynamics of these effects we generate several models. In each model we fix a $z \in \{1,2,...,10\}$ and we include all possible observations in which the independent variables are observed at time t and citations from others are observed $t+z$ years in the future. We restrict our observations to those authors who have published at least one article in the current year (since non-publishing authors have no opportunity to self cite).

The independent variables of interest are self-citations in the current year and self-citations squared. We include a squared term in the model because it allows us to estimate a *marginal* effect of self-citation. A positive value on the linear term and a negative value on the squared term suggests that self-citations increase future citations from others, but the effect gets smaller as the total number of self-citations increases. We can find the point at which an extra self-citation actually *decreases* citations from others by simply dividing the linear coefficients by the squared coefficients.

We expect authors who have carried out influential research to be more inclined to cite themselves since their work is higher quality, so it is very important to include citations from others as a control. Thus, we include cumulative citations from others and a squared term in the model to control for previous peer evaluations of an author and the marginal effect of an extra citation from others. We also include a variable that indicates average expected citations in the journals in which the author has published (their “impact factor”) to control for the quality of publication outlets and the visibility of the author’s work. It also helps to control for norms of citation that may differ between fields.

Another important consideration is the *opportunity* for self-citation. Authors who publish more have more opportunities to cite previous work, and those who previously published more have more work available to be cited. Thus, we include variables for current publications and cumulative previous publications because these both increase the opportunity for self-citation. We also include a variable that indicates how many co-authors an author has, and finally, we include a variable for the current year to control for the linear secular upward trend in foreign citations over time in our sample.

It should be emphasized that our analysis is carried out for one nation only: Norway. The results obtained may, therefore, not have general validity. Further investigations are required in order to assess this question. Still, representing a large-scale analysis involving more than half a million citations, the patterns identified are likely to be typical. We think it is unlikely that Norwegian researchers differ radically in citation behaviour from other researchers.

Results

Table 3 in the Appendix shows results from the Poisson regressions. Using numerical simulation, we examine the models' predictions concerning the change in cumulative citations from others, in the year indicated, resulting from a single self-citation. The left panel in Figure 2 summarizes these results. A single self-citation increases citations from others in the following year by about 1.03 (95% C.I. = 0.64,1.42). In other words, each additional self-citation generates an additional citation from others, increasing the total citation count by two. The effect on cumulative citations increases by the fourth year to 2.83 (95% C.I. = 2.00,3.68) – in other words, each self cite generates an additional three cites from others. The effect continues to grow, albeit at a slower pace, so that by the tenth year a single self-citation generates 3.65 (95% C.I. = 1.13,6.19) additional citations from others.

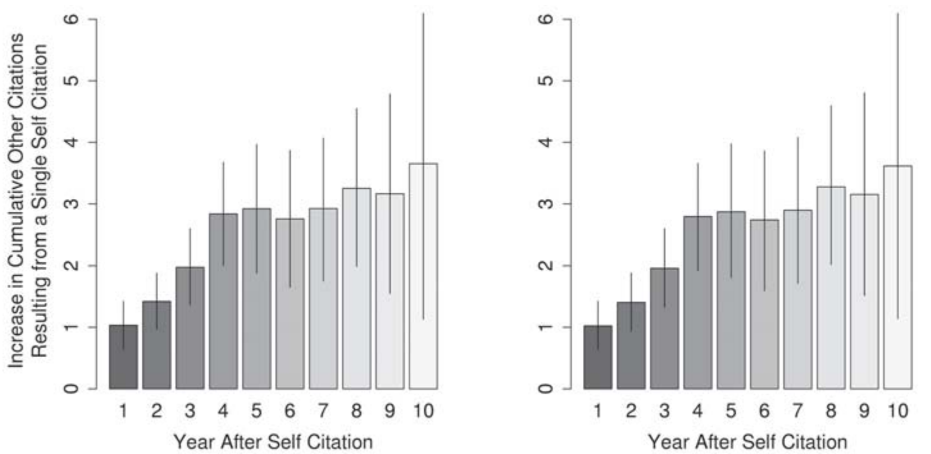

Figure 2. Poisson regression estimates of the effect of a single self-citation on cumulative other citations in each year after the self-citation occurs. These figures show that an additional self-citation increases the expected number of citations from others, and the effect tends to increase over time. As shown in Table 1, models regress self-citations, self-citations squared, other citations, other citations squared, publications this year, previous publications, number of coauthors, average journal citation rate (impact factor), and the year on other citations to an author that occur *z* years in the future. Mean effect sizes and 95% confidence intervals in both panels calculated by simulating first difference in self-citation (changing from the mean to the mean plus one) using 10,000 randomly drawn sets of estimates from the coefficient covariance matrix and assuming all other variables are held at their means. Left panel shows model estimates for all authors, right panel shows model estimates excluding authors who have one of the ten most common surnames.

The models also allow us to estimate the marginal effect of an additional citation. In other words, how does the mean effect change as we increase the total number of self-citations? Intuitively, if an author cites himself a lot, it may be due to a strategic attempt to make up for lack of quality and might be viewed by peers as just the opposite – thus, an extra self-citation would be less likely to have a positive effect. Although we find that the mean effect of an extra citation is *positive*, we also find that the marginal effect is *negative*, indicating that the benefit of self-citation is positive but decreasing in the total number of self-citations. We can use this information to estimate the point at which the marginal effect causes the mean effect to turn negative – in other words, how many total self-citations does it take to cause an additional self-citation to *decrease* cumulative citations from others? The models indicate that this point occurs somewhere between 40 and 50 self-citations for a given year. This number of self-citations is quite rare in the data, accounting for less than 0.1% of the observations. Thus, for the vast majority of authors it appears that self-citation is always beneficial.

The main advantage of macro-analysis of this data is that a very large number of publications and authors can be analyzed. However, as in other macro citation studies,[13,14] homonyms (different authors with identical author names) cannot be identified and may cause cases of "multiple persons" and erroneous self-citation counts. A similar problem is that variants or misspellings of author names, as well as changes of names (e.g. due to marriage), imply that we do not get the complete publication record of all persons and that some self-citations are not recognised as such. It is not possible to identify the exact effect of these errors, but we suspect that the problem will be exaggerated for those with common surnames since they are more likely to be mistakenly aggregated. As a test of our results we conducted analyses both with the whole data and with a subset of the data that excluded authors with the ten most common surnames (this removed approximately 700 authors). The results for the subsample are displayed in Table 4 in the Appendix and the right panel of Figure 2 – they show that removal of these potentially problematic names does not alter our findings.

Discussion

A recent study of four hundred articles in economics journals showed that an author's stock of self-citations did not have a statistically significant effect on a subsequent article's total number of citations.[15] The evidence of our macro study, however, suggests that self-citation does pay – the more one cites oneself the more one is cited by other scholars. These findings are not necessarily incompatible – self-citation advertises not only the *article* in question, but the *authors* in question. Scholars searching the literature may see the self-citation and refer to the authors' other works.

Thus, a self-cite may yield more citations to a particular author without yielding more citations to the paper in question. It would be very hard to detect this dual effect of self-citation in a meso-level study since the authors' numerous other articles are not included as they are in our study.

One might dismiss our results by arguing that the effect of self-citation is small since only 11% of all citations are self-citations. However, suppose (as our results suggest) that each self-citation yields an additional 3.65 citations from others after ten years. That means an additional 40% of total citations may be generated *indirectly* by self-citations. Adding these effects together, self-citation may therefore account directly or indirectly for more than half of all citations after 10 years. These results are especially important to consider when evaluating the average scholar who has a relatively small number of publications and citations – a few self-citations could easily tip the balance for funding and promotion decisions.

Some scholars[3,11] have suggested that self-citations should be removed when citations are used as indicators for research assessments. One implication of the current analysis is that this may not be enough. Since self-citations appear to influence citations from others, frequent self citers will still do better *even after excluding self-citations*. One radical suggestion would be to penalize self-citations through a formula based on estimates like the ones presented here. For example, our models suggest that *authors whose publications are, on average, about 5 years old should have their total citation count reduced by about three times their total number of self-citations*. While it is already well-known that citation counts are at best a noisy indicator of scientific contribution, our work suggests an even deeper problem – even counts of citations from others are sensitive to strategic manipulation by those who are willing to cite themselves frequently. This evidence reinforces the view that citation analysis should never function as a substitute for an evaluation carried out by peers.

Finally, although we have identified the existence of an incentive for self-citation, it will require further effort to understand *why* there is a connection between self-citations and citations from others. For example, it is not clear whether this phenomenon is due to *quality* (content of the research and its importance for the further scientific advancements) or *visibility* (prestige and availability of the publishing journal and the authority of the authors).[16] If visibility is the key variable, then the phenomena result from a "bandwagon" effect – when a paper is cited in many subsequent papers, even more people become aware of it. Thus, its visibility increases and thereby the chances for getting even more citations. Another mechanism but with the same result is known as the "Matthew effect" or principle of "cumulative advantage", the rich are getting richer, which with respect to citations means that articles written by famous or already highly cited scientists are likely to receive more citations than they would if written by relatively unknown scientists.[17,18] Total citation counts are probably being determined by both quality and visibility, but sorting them out will require future work.

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We declare that we participated in all aspects of this study and we have both seen and approved the final version. We have no conflicts of interest. JHF, DWA

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Appendix

Table 3. Effect of self-citations on cumulative other citations, by year

	Dependent variable: Cumulative other citations in the z^{th} year after observing independent variables									
	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Self-citations	0.014023	0.016533	0.020077	0.025228	0.022806	0.019271	0.018714	0.018912	0.016897	0.017969
	(0.002793)	(0.002869)	(0.003328)	(0.003881)	(0.004230)	(0.003968)	(0.003814)	(0.003799)	(0.004420)	(0.006280)
Self-citations	–0.000262	–0.000313	–0.000386	–0.000485	–0.000448	–0.000376	–0.000350	–0.000399	–0.000386	–0.000442
squared	(0.000046)	(0.000046)	(0.000056)	(0.000072)	(0.000080)	(0.000077)	(0.000074)	(0.000079)	(0.000105)	(0.000167)
Cumulative citations	0.003815	0.004190	0.004512	0.004894	0.005353	0.005849	0.006420	0.006950	0.007654	0.008518
from others	(0.000172)	(0.000176)	(0.000176)	(0.000193)	(0.000219)	(0.000245)	(0.000268)	(0.000333)	(0.000414)	(0.000510)
Cum. Citations from	–0.000001	–0.000001	–0.000002	–0.000002	–0.000002	–0.000003	–0.000004	–0.000005	–0.000006	–0.000008
others squared	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000001)	(0.000001)
Publications this	0.029149	0.042535	0.052617	0.059106	0.073426	0.081931	0.089910	0.106016	0.109333	0.110088
year	(0.006414)	(0.007235)	(0.007971)	(0.008110)	(0.008044)	(0.007568)	(0.007383)	(0.005179)	(0.005556)	(0.005608)
Previous	0.007312	0.005998	0.005056	0.004147	0.002979	0.002316	0.002042	0.001975	0.002977	0.003958
publications	(0.000807)	(0.000785)	(0.000769)	(0.000859)	(0.000931)	(0.001037)	(0.001119)	(0.001180)	(0.001337)	(0.001454)
Number of coauthors	–0.000903	–0.000072	0.002839	0.005030	0.006987	0.007850	0.008524	0.007239	0.008749	0.003971
	(0.002343)	(0.002127)	(0.002235)	(0.002332)	(0.002495)	(0.002561)	(0.002802)	(0.003030)	(0.003214)	(0.003520)
Average journal	0.027625	0.031993	0.036877	0.039902	0.042441	0.044584	0.046894	0.049140	0.051506	0.054030
citation rate	(0.001453)	(0.001375)	(0.001286)	(0.001376)	(0.001386)	(0.001356)	(0.001344)	(0.001469)	(0.001652)	(0.001786)
Year	0.059165	0.050655	0.044757	0.039078	0.034127	0.031595	0.029486	0.028275	0.025396	0.019550
	(0.001879)	(0.001729)	(0.001652)	(0.001552)	(0.001609)	(0.001835)	(0.002108)	(0.002331)	(0.002912)	(0.003463)
Constant	2.517998	2.707854	2.854124	3.012776	3.159248	3.284574	3.380404	3.445973	3.545953	3.709957
	(0.026348)	(0.026740)	(0.027560)	(0.028688)	(0.031098)	(0.034759)	(0.039429)	(0.039787)	(0.050109)	(0.060097)
Deviance	3577192	3456218	3358345	3311015	3322667	3351166	3354360	3327629	3296945	3271273
Null deviance	14816407	14101441	13202631	12345620	11567446	10791940	10044302	9331441	8564787	7887599
N	66846	62897	58093	53194	48415	43467	38909	34605	30350	26601

Poisson regression of cumulative other citations acquired up to the z^{th} year after independent variables are observed. Standard errors (in parenthesis) calculated with Generalized Estimating Equation assuming clustering on individual authors.

Table 4. Effect of self-citations on cumulative other citations, by year (authors with ten most common surnames removed)

	Dependent variable: Cumulative other citations in the z^{th} year after observing independent variables									
	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Self-citations	0.013774	0.016097	0.019651	0.024623	0.022294	0.018989	0.018496	0.018894	0.016891	0.017751
	(0.002856)	(0.002941)	(0.003423)	(0.004013)	(0.004356)	(0.004064)	(0.003901)	(0.003846)	(0.004448)	(0.006314)
Self-citations	–0.000260	–0.000309	–0.000383	–0.000480	–0.000443	–0.000372	–0.000347	–0.000396	–0.000383	–0.000437
squared	(0.000046)	(0.000047)	(0.000057)	(0.000073)	(0.000081)	(0.000078)	(0.000074)	(0.000079)	(0.000104)	(0.000167)
Cumulative citations	0.003815	0.004195	0.004520	0.004906	0.005370	0.005864	0.006438	0.006964	0.007661	0.008511
from others	(0.000172)	(0.000177)	(0.000177)	(0.000194)	(0.000220)	(0.000246)	(0.000269)	(0.000334)	(0.000416)	(0.000510)
Cum. citations from	–0.000001	–0.000001	–0.000002	–0.000002	–0.000002	–0.000003	–0.000004	–0.000005	–0.000006	–0.000008
others squared	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000000)	(0.000001)	(0.000001)
Publications this	0.028768	0.042463	0.053155	0.059986	0.073600	0.081800	0.089695	0.104930	0.108422	0.109852
year	(0.006674)	(0.007535)	(0.008356)	(0.008559)	(0.008405)	(0.007855)	(0.007623)	(0.005311)	(0.005684)	(0.005732)
Previous	0.007360	0.006014	0.005021	0.004083	0.002889	0.002196	0.001903	0.001926	0.002964	0.003975
publications	(0.000829)	(0.000804)	(0.000787)	(0.000875)	(0.000948)	(0.001053)	(0.001134)	(0.001196)	(0.001357)	(0.001475)
Number of coauthors	–0.000765	–0.000223	0.002774	0.004790	0.006479	0.007561	0.007963	0.007310	0.008567	0.003617
	(0.002387)	(0.002159)	(0.002274)	(0.002368)	(0.002534)	(0.002572)	(0.002785)	(0.003089)	(0.003276)	(0.003594)
Average journal	0.027473	0.031976	0.036663	0.039769	0.042391	0.044494	0.046960	0.049328	0.051920	0.054787
citation rate	(0.001483)	(0.001406)	(0.001304)	(0.001398)	(0.001410)	(0.001377)	(0.001361)	(0.001491)	(0.001684)	(0.001821)
Year	0.058663	0.050112	0.044147	0.038460	0.033333	0.030696	0.028405	0.027091	0.024144	0.018270
	(0.001890)	(0.001745)	(0.001669)	(0.001571)	(0.001636)	(0.001870)	(0.002150)	(0.002375)	(0.002966)	(0.003523)
Constant	2.524793	2.715108	2.862972	3.021478	3.171929	3.299043	3.396847	3.461963	3.561312	3.722348
	(0.026889)	(0.027272)	(0.028172)	(0.029431)	(0.031717)	(0.035431)	(0.040223)	(0.040474)	(0.051044)	(0.061174)
Deviance	3465032	3344852	3248479	3199867	3211033	3239062	3239720	3215449	3185097	3159320
Null deviance	14326452	13629937	12769699	11944919	11196518	10453155	9734135	9052542	8313749	7654516
N	64426	60615	55993	51267	46665	41895	37522	33396	29292	25674

Poisson regression of cumulative other citations acquired up to the z^{th} year after independent variables are observed. Standard errors (in parenthesis) calculated with Generalized Estimating Equation assuming clustering on individual authors.