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# Attracted to open access journals: A bibliometric author analysis in the field of biology

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**Purpose** - Scholars from developing countries have limited access to research publications due to expensive subscription costs. However, the open access movement is challenging the constraint to access. Consequently, researchers in developing countries are often mentioned as major recipients of the benefits when advocating open access (OA). One of the implications of that argument is that authors from developing countries are more likely to perceive open access positively than authors from developed countries. The present study is an investigation of the use of open access by researchers from developing countries and is thus a supplement to the existing author surveys and interviews.

**Design/methodology/approach** - Bibliometric analyses of both publishing behaviour and citing behaviour in relations to OA publishing provide evidence of the impact of open access on developing countries.

**Findings** - The results of the multivariate linear regression show that open access journals are not characterised by a different composition of authors than the traditional toll access journals. Furthermore, the results show that authors from developing countries do not cite open access more than authors from developed countries.

**Originality/value** - This paper argues that authors from developing countries are not more attracted to open access than authors from developed countries.

**Keywords** - open access, bibliometrics, author analysis, developing countries.

**Article Type:** Research paper

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“The advent of Open Access strategies [...] has the potential to revolutionize access to essential research” (Kirsop & Chan, 2005).

## **Introduction**

The poorest countries<sup>2</sup> will benefit the most from OA initiatives, although some will have a greater impact than others (Kirsop & Chan, 2005). Chan and Kirsop (2001) list several advantages for developing countries: (a) free access to research information from developed countries; (b) researchers in developing countries can archive their own research and thus make it available to researchers in developed countries; (c) local research can be distributed.

Developing countries are often mentioned when describing the advantages of open access: “One of the great beneficiaries of open access may be users in developing countries, where there are currently some universities with no journal subscriptions at all” (Wikipedia.org/wiki/open\_access). Along the same lines Xuemao and Chang (2006) state that “OA will benefit the developing countries in the two-way scholarly communication and accelerate the development of science accordingly.” Furthermore, Nicholas, Huntingdon and Jamali (2007: 877) makes the prediction about a journal (Nucleic Acids Research) moving to an OA model “(that) it would be assumed that there is some further growth in the pipeline, predominantly from second and third world users”.

The open access movement consists of various objectives but essential for the movement is the ambition of distributing peer-reviewed (journal) literature freely available to the public through the internet. The success of open access greatly depends on authors supporting the principle of open access by using an OA model for their publications. Several models for financing open access have been proposed, and Willinsky (2006) identifies ten different financing models. However, simplifying the complexity of financing models open access can be seen as consisting of two main strategies for

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<sup>2</sup> “Poor countries” is one of many terms used to refer to “less developed countries”, “developing countries” (see e.g. Chan & Kirsop, 2001 and Kirsop & Chan, 2005) and nations of the “South” (see e.g. Lor & Britz, 2005). Another term is “peripheral countries”, although it should be noted that that term is not necessarily used as an equivalent to the aforementioned terms. Peripheral countries in science can be used to describe “not-central countries” in terms of language (Bordons, Fernandez, & Gomez, 2002; Velho, 1986). However, the term can also be used to describe countries “whose economic potential is small and where financial support of science is relatively small” (Puliselic & Petrak, 2006).

achieving open access: open access journals and self-archiving<sup>3</sup>. Both strategies depend greatly on authors being willing to support open access by making their own work available either through self-archiving or open access publishing.

One of the implications of viewing authors from developing countries as great beneficiaries of open access is that such authors are more likely to perceive OA positively than authors from developed countries as it enables them to access research that they otherwise would have had limited access to due to expensive subscription costs. Correspondingly, authors from developed countries should perceive OA less positively than authors from developing countries as they already have access to the necessary research publications within their field.

However, this hypothesis is somewhat contradicted by the results of Swan and Brown (2005) as they find the perception of open access to be tied to a number of other factors than the geographic location of the author.<sup>4</sup> One of the results from the survey is that the principle of free access is the strongest imperative for publishing in an open access journal. Furthermore, authors publishing in an open access journal consider it to have a larger audience than toll-access journals, to publish more rapidly and to be prestigious in their field. On the other hand, authors who have not (yet) published in an open access journal state that it is due to being unfamiliar with open access journals in their field and being unable to identify a suitable open access journal to publish in. Perception of open access journals is closely related to having published in an open access journal or not. Swan and Brown (2005) analyse geographical relations on the basis of the region of the author. However, the geographical origin is only included in a very limited amount of their analyses, and the number of respondents from the developing countries are small (e.g. 52 respondents from African countries and 39 from China). Finally, analysing the questions by geographic origin does not reveal a clear pattern. Furthermore, as stated by Papin-Ramcharan and Dawe (2006), developing countries may not be able to fully benefit from the advantages of OA:

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<sup>3</sup> The green self-archiving strategy comprises of persuading authors to self-archive the articles they publish in traditional toll-access journals in institutional open access archives. The many archives are to be searched collectively provided that they comply with a standard. The gold open access publishing strategy comprises of creating or converting traditional toll-access journals into open access journals. Furthermore, the strategy includes finding funding support for the publication costs and persuading authors to publish in open access journals (Harnad et al., 2004). More colours have been added to the scheme to describe the hybrids (Jenkins et al., 2007).

<sup>4</sup> The response rate (about 5 per cent) in the survey by Swan and Brown (2005) must be taken into account as such small samples may not necessarily be generalisable.

“Although there are the obvious benefits to developing country researchers of free access to the scholarly literature, there are many hindrances to such researchers fully benefiting from this largesse.” (Papin-Ramcharan & Dawe, 2006: 24)

Papin-Ramcharan and Dawe (2006) move on to claim that developing countries are struggling with technical, financial, human and infrastructural limitations making the scholars in these countries unable to access the research publications of others and disseminate their own research results the way it is intended by the open access movement. However, the specific issues of developing countries are easily overlooked when focusing on the many difficulties of achieving open access (see e.g. Björk, 2004).

The purpose of the present study is to analyse the behaviour of authors in relation to OA publishing. More specifically, the aim is to examine whether the behaviour of authors can be tied to author characteristics (in terms of geographic location) or journal characteristics (being familiar with the open access principle). The main research question can be elaborated into the following sub-questions:

- Are authors from developing countries more attracted to publishing in OA journals? Are OA journals thus characterised by a greater share of authors from developing countries than traditional subscription based journals?
- Do authors from developed and developing countries cite differently in OA journals than authors of same nationalities publishing in NOA journals?

### **Related research**

This study draws primarily on existing studies of author analyses in relation to OA and analyses of the degree of internationality.

The existing literature provides numerous author analyses in relation to OA and several of them indicate various author reservations. Author reservations can be seen falling in three categories: (a) willingness to pay, (b) perception of quality and (c) awareness of OA. Willingness to pay for OA is a complicated issue as authors are willing to pay although not the full costs. Cozzarelli, Fulton and Sullenberger (2004) conduct a survey of authors having their paper accepted for publishing in The Proceedings of the National Academy of Sciences USA (PNAS) in a two month period in 2003.

Although restricted to a very small data sample their analysis shows that almost 50 per cent of the authors would be willing to pay a surcharge to make their PNAS article open access. However, almost 80 per cent of those willing to pay would only agree to a surcharge of \$500 which is in contrast to the estimated costs in 2004 of \$2500 (Wellcome Trust, 2004). Richardson and Saxby (2004) investigate the willingness of authors to pay an author charge of \$500 per article in the journal *Nucleic Acids Research* and attain agreement from 90 per cent of the papers in an issue in January 2004. The surveys by Rowlands, Nicholas, and Huntingdon (2004a,b) and Nicholas, Huntingdon and Rowlands (2005) reveal discipline variances in the willingness to pay author charges.<sup>5</sup>

Secondly, the perceived quality is a crucial issue in the development of OA. Hess et al. (2007) study the perception of OA publishing based on 688 responses to an online survey. They find very positive attitudes towards the OA principle in general. However, at the same time authors are reluctant to publish their own work in OA journals. Pelizzari (2003) surveys the staff at two faculties of a single university, but the sample size is too limited to be able to make any solid conclusions. Furthermore, a survey by Schroter and Tite (2006) including 468 respondents (a response rate of 42 per cent) reveals that 66 per cent of authors would prefer publishing in a journal that is not an open access author-pays journal. Furthermore, Schroter, Tite and Smith (2005) interview 28 authors, and although the results can hardly be generalised, they conclude that authors perceive journal quality to be more significant than any potential author charges when deciding on a journal to submit a paper to.

Thirdly, many authors are not aware of open access (Rowlands, Nicholas & Huntingdon, 2004a,b; Nicholas, Huntingdon & Rowlands, 2005). Schroter, Tite and Smith (2005) find that authors are increasingly aware of open access although few have published in an OA journal.

Summing up the existing author analyses, it is fair to say that they are mostly limited to experiments with heavily subsidised author charges, low response rates and limited samples. Furthermore, they are all based on either surveys or interviews. There seems to be a lack of investigations on a larger scale focusing less on the opinions of authors and more on the actual publishing and citing behaviour of authors. Large scale investigations are possible using bibliometrics, however, the existing bibliometric studies have focused modestly on OA and author behaviour.

The degree of internationality has been the subject of several analyses. The term “international” lacks a clear definition leading to a highly ambiguous term according to Buéla-Casal et al. (2006). Their aim is to construct a set of criteria designed to measure the degree of internationality and identify four

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<sup>5</sup> It should be noted that the response rate is very low (less than 5 per cent).

core criteria. The first is the multinational collaboration patterns (the share of articles written by at least two authors affiliated to institutions from two different countries). The remaining criteria are the multinational distribution of editorial board members, associate editors and authors. Using these criteria or another set of criteria the analyses can be made on various levels. One approach is on the level of countries (e.g. Glänzel & Schubert, 2005; Schubert & Glänzel, 2006) and another is on the level of disciplines (e.g. Abt, 2007; Jappe, 2007). A subset of the analyses of internationality is focused on developing countries and the centre of attention is typically on the collaboration patterns of one or a few developing countries (e.g. Kim, 2005; Royle et al., 2007), and in some cases the studies are also delineated to only one or a few disciplines (e.g. Kim, 2006).

As can be seen from this review of the existing literature, to make definitive conclusions about the potentials of open access for developing countries, there is a need for more studies in this research area, especially those analysing developing countries at a larger scale and investigate the actual publishing and citing behaviour of authors from those countries.

## **Data**

This paper is based on two analyses. Although the first is a publication analysis and the second is a citation analysis, the starting points of the two analyses are the same. The dataset collected for the analyses includes journals from the discipline of biology using the classification scheme of Ulrich's Periodicals Directory™ (Ulrich's). Biology is a field characterised by a large number of OA journals making it a suitable field for this study. The dataset consists of a selection of 150 journals that are either general biology journals or belong to one or several of the following sub-disciplines: entomology, zoology, microbiology, biochemistry, genetics, and biotechnology.

The classification scheme used by Ulrich's is only one scheme among many possible as countless different classification systems can be used to divide a discipline. First and foremost the discipline needs to be determined which may not necessarily be an easy task. Levine (1965) uses the terms bio sciences, life sciences, human biology and biology. Furthermore, Levine (1965: 346) states that "(t)he particular system used is determined by preference and proposed use." According to Dullemeijer (1980) the principle of a division in biology can be made on objects and aspects. He stresses that "(d)ividing biology into subdisciplines is not merely an amusing game, but the basis for management in a science policy and a necessity for theoretical biology" (Dullemeijer, 1980: 87). It must be noted that the division used in this study is made on journal level and not on the more detailed level of articles.

The unit of analysis is a group of articles and it is thus just as difficult to determine their sub-discipline as a whole. Consequently, the subject division is made on journal level and for that purpose the scheme of Ulrich's is ideal.

The set contains 150 journals, however, some journals lacked information for certain variables and were excluded from one or both of the models (resulting in 130 journals in the first analysis and 136 in the second). A list of the included journals is available in appendix 1. Furthermore, it should be noted that the analysis was performed on the basis of data from 2006 as that is the most recent year completed in the citation indexes at the time of the data gathering process.

The unit of analysis was the publications of the 150 journals. Initially, the publications of all journals were divided into three groups in terms of the geographic location of the author(s): (a) publications written by author(s) all located in developed countries, (b) publications written by author(s) from developing countries, and (c) publications written by author(s) from developed countries as well as author(s) from developing countries. The division of countries into two categories (developing and developed) is made on the basis of the country classification by The World Bank which is based on gross national income (GNI) per capita.<sup>6</sup> Based on its GNI per capita, every economy is classified as low income, middle income (subdivided into lower middle and upper middle), or high income ([www.worldbank.org](http://www.worldbank.org)). In this study the developing countries are defined as those belonging to either the group of low income countries or the group of lower middle income countries.

It should be noted that some publications lack information in the geographic location-field and they are thus excluded from the analysis. However, the lack of information in some publications is not directly related to the research questions of this study and thus we can expect the excluded publications to be distributed randomly across the dataset.

In order to be able to analyse the publishing and citing behaviour of authors some control variables were needed as means to ensure that underlying factors are not distorting the results. If, say, journals from developing countries are more likely to be OA than journals from developed countries and if authors from developing countries are more likely to publish their work in journals from developing countries, then failing to control for the geographic location of the journal would lead to a bias in the

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<sup>6</sup> There are a number of problems related to this definition of poor countries. One issue is the skewed income distribution that implies that a country with a relatively high per-capita GNI could have a majority of citizens with relatively low levels of income, due to concentration of wealth in the hands of a small fraction of the population. Although, the definition is arguable, it is applicable for operational and analytical purposes.

estimates, as it would appear as if developing authors are more likely to publish OA, even though it is in fact not the case, since all they do is to publish their work locally. Indeed, the analysis below confirms that this is in fact the case.

Information about the journals included in the study was collected using Ulrich's, the Journal Citation Reports (JCR) and the ISI (or the Institute for Scientific Information) citation database called the Science Citation Index (SCI) which can be searched in what is currently known as Web of Science. As already mentioned the classification scheme of Ulrich's has been used to divide the journals into sub-disciplines. Each journal can belong to more than one sub-discipline depending on the classification in Ulrich's (the journals belong to a maximum of three sub-disciplines). Furthermore, information on the geographic location of the journals was available through Ulrich's. However, it should be noted that the geographic location listed by Ulrich's may not necessarily depict the whole picture as some journals may be listed with the location of the publisher although the editorial board members and associate editors are located in a completely different parts of the world. However, although using the geographic location available through Ulrich's is not unblemished it can be a valuable variable to include as a journal located in a developing country is likely to have a higher share of authors from that country. Ulrich's was also used to determine the OA status of the journal as the website provides a link to the freely available full text of the journal. JCR can provide information on the journal impact factor (JIF) of the journal. Although highly disputed JIF is probably the central quantitative indicator for measuring journal quality.<sup>7</sup> The most recent edition (at the time of the data gathering process) of the JCR was used to collect the data (the 2005 edition). The SCI has been used to collect data on the share of publications in the journal that is not written in English. On the one hand, journals written in Hindi, Spanish or Russian are expected to have a smaller audience than journals written in English. The audience is smaller simply because more scholars are able to read English than e.g. Hindi. A journal in Hindi would primarily attract Indian authors and thus the variable was added to control for that possible bias on the results. Furthermore, the share of reviews was determined using SCI. The

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<sup>7</sup> The idea of an impact factor first emerged in 1955 (Garfield, 1955) but it was not expected to become the subject of widespread controversy. The inventor himself describes the impact factor as a mixed blessing (Garfield, 1999). The impact factor was created in order to be able to compare journals regardless of their size in order to perform the journal selection for SCI. The intent of the IF was to provide an objective method for quantifying published research output, rank and evaluate journals (Garfield, 1996). According to the ISI JIF is a measure of past usage of journals and is an indicator of the effectiveness of a journal within the wider context of the international research community (O'Neill, 2000). JIF rapidly became accepted and widely used because of its comprehensibility, robustness and availability (Glänzel & Moed, 2002). Although extremely critical, Bordons, Fernandez & Gomez (2002) emphasize that JIF give a visible form to the invisible hierarchy of scientific journals that is tacitly accepted by scientists.

variable was added to capture the possible effect of journals publishing many reviews may cite OA journals less. One explanation is a reluctance to accept OA articles as a part of state-of-the-art within a discipline. Another is that because of the higher average age of references in review papers (see e.g. Price, 1965) and the fact that many OA journals have only existed for 2 to 3 years, review papers have a lower share of references to OA journals.

Finally, the set of cited OA journals needs to be constructed for the analysis of citing behavior. For that purpose a list of active OA journals was essential, however, as no comprehensive directory of OA journals exists the lists of biology OA journals in Ulrich's and the Directory of Open Access Journals (DOAJ) was merged and duplicates were removed (data gathering took place in August 2007). Combining the two lists yielded 427 OA journals (279 on the list from Ulrich's and 274 on the list from DOAJ). However, there was an overlap of 126 journals (30 per cent) resulting in 301 unique OA journals. It is evident that the size of the overlap is not impressive and a combination of the two lists provides a more comprehensive list.

#### *Analysis of the publishing behavior*

The dependent variable in this analysis is the share of publications in the journal written exclusively by authors from developing countries.<sup>8</sup> This data was collected using the SCI searched. An example could be a journal comprising of 35 publications in 2006 made up by 25 publications by authors from developed countries, 7 by authors from both developed and developing countries and finally 3 by authors from developing countries. In this case the percentage of publications in the journal written exclusively by authors from developing countries is 8.6. A minimum of 10 publications per year for each journal was set as the inclusion of journals with fewer publications led to very unstable figures. The model used for this analysis includes the following independent variables: (a) geographic location of journal; (b) share of publications not written in English; (c) share of reviews; (d) OA status (dummy variable<sup>9</sup>); (e) sub-disciplines (dummy variables); and (f) JCR JIF. An overview of the dependent and independent variables is available in Table 1.

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<sup>8</sup> The analysis could be done on the level of authors. However, an analysis on that level requires a fractional scheme that attributes to that paper a fraction of countries or regions. An integer scheme, however, assigns the paper integrally or wholly to countries or regions (see e.g. Moed, 2005: 273-274). In this case the scheme is integral, although a paper can only be assigned to one of the two regions (developing or developed) or in a category containing publications which have authors from both regions.

<sup>9</sup> A variable that takes on the values 0 or 1 and is used to describe the effects of the different levels of a qualitative independent variable in a regression model (Bowerman & O'Connell, 2007)

Variable	Range	Mean	Std. Dev.
<b>Dependent variable</b>			
Percentage of authors from developing countries	0 - 86	12.33	16.71
<b>Independent variables</b>			
JIF	0.027 - 22.74	2.79	3.69
OA	0 - 1	.26	.44
Sub-discipline: Entomology	0 - 1	.16	.37
Sub-discipline: Zoology	0 - 1	.16	.37
Sub-discipline: Microbiology	0 - 1	.15	.36
Sub-discipline: Biochemistry	0 - 1	.26	.44
Sub-discipline: Genetics	0 - 1	.15	.36
Sub-discipline: Biotechnology	0 - 1	.16	.37
Geographic location of journal: developing country	0 - 1	.25	.44
Share of reviews	0 - 1	.13	.26
Share of articles not in English	0 - 0.97	.02	.13

Table. 1. The range of the dependent and independent variables included in the multivariate linear regression regarding publishing behaviour.

The present model is not characterized by dependent variables being highly inter-correlated with each other. The highest inter-correlation is found between the following variables: JIF is related to the share of reviews ( $r = .490$ ). Journals containing a high proportion of review articles tend to have higher IFs than other journals which Garfield (1996) also notes. However, adding the statistically significant correlating variables to the model as interaction variables did not contribute significantly to the explanation of the dependent variable and were consequently excluded from the model. An overview of the inter-correlations is available in appendix 2.

#### *Analysis of the citing behavior*

The dependent variable in this analysis is the share of references in the journal to OA journals. This data was also collected using the SCI searched in Web of Science. The method of calculating the share

of references to OA journals is not entirely the same for OA and NOA journals. Journal self-citations make up a considerable amount of citations both in terms of self-citing and self-cited rate (Frandsen, 2007; Tsay, 2006). Including journal self-citations would lead to biased results as they would affect the calculation of OA shares for OA journals more than NOA journals. But as stressed by White (2001) self-citations are not an insurmountable difficulty as they can be excluded from the analyses. In this case self-citations only pose a problem for the calculation of references to OA journals in OA journals and consequently the self-citations were omitted from these calculations. The share of references to OA journals from OA journals is calculated as follows:

$$\text{Share of references from OA to OA} = \frac{\text{Number of references to OA journals} - \text{self-citations}}{\text{Total number of references} - \text{self-citations}}$$

The calculation of the share of references to OA journals from NOA journals is slightly different as the numerator does not include self-citations. The share is calculated as follows:

$$\text{Share of references from NOA to OA} = \frac{\text{Number of references to OA journals}}{\text{Total number of references} - \text{self-citations}}$$

A minimum of 300 references per year for each of the three author groups was set as the calculation of shares on the basis of fewer references led to very unstable figures. The model used for this analysis includes the following independent variables: (a) geographic location of journal; (b) share of publications not written in English; (c) share of reviews; (d) OA status (dummy variable); (e) sub-disciplines (dummy variables); and (f) JCR JIF. Table 2 provides an overview of the included variables. It should be noted that the ranges and means differ from the dataset constructed to analyse publishing behaviour as the same journal can be represented by the three different groups of authors and some of the journals excluded in the former analysis can be included in the latter.

Variable	Range	Mean	Std. Dev.
<b>Dependent variable</b>			
Percentage of references to the set of OA journals	0 - 11.31	1.67	1.66
<b>Independent variables</b>			
Author(s) from developing countries	0 - 1	.20	.40
Author(s) from both developed and developing countries	0 - 1	.15	.36
JIF	0.027 - 22.74	2.77	3.28
OA	0 - 1	.26	.44
Sub-discipline: Entomology	0 - 1	.13	.34
Sub-discipline: Zoology	0 - 1	.13	.33
Sub-discipline: Microbiology	0 - 1	.17	.38
Sub-discipline: Biochemistry	0 - 1	.30	.46
Sub-discipline: Genetics	0 - 1	.15	.36
Sub-discipline: Biotechnology	0 - 1	.18	.38
Geographic location of journal: developing country	0 - 1	.18	.38
Share of reviews	0 - 1	.12	.25
Share of articles not in English	0 - 0.97	.01	.10

Table. 2. The range of the dependent and independent variables included in the multivariate linear regression regarding citing behaviour.

Highly inter-correlated independent variables do not pose a greater problem to this model than the previous one. The highest inter-correlation is found between the following variables: JIF is related to the share of reviews ( $r = .445$ ). However, adding an interaction variable for these and the other statistical significant inter-correlated variables did not contribute significantly to the explanation of the dependent variable and the interaction variables were consequently excluded from the model. An overview of the inter-correlations is available in appendix 3.

The analyses below consist of multivariate linear regression analyses of the statistical relations between the dependent and the independent variables.

## Results

The results of this study are presented in two sections: (a) publishing behaviour; and (b) citing behaviour.

### *Publishing behavior*

The unit of analysis (and thus number of observations) for this analysis consists of 130 (journals). The share of authors from developing countries is 12 per cent in the NOA journals and 14 per cent in the OA journals. The higher level of authors from developing countries in OA journals does not change by including the publications co-authored with authors from developed countries although the difference reduces slightly. However, as already mentioned a number of factors can be influencing the share of authors from developing countries in journals and a multivariate linear regression makes it possible to control for the effects of those factors. Table 3 shows the results of the multivariate linear regression.

Variable	Coefficients	P-value
Intercept	12.99	.00
<b>JIF</b>	<b>-1.21</b>	<b>.01</b>
OA	-4.51	.16
Sub-discipline: Entomology	-2.69	.54
Sub-discipline: Zoology	-2.72	.53
Sub-discipline: Microbiology	-5.33	.18
Sub-discipline: Biochemistry	5.25	.11
Sub-discipline: Genetics	-3.70	.34
Sub-discipline: Biotechnology	6.14	.12
<b>Geographic location of journal: developing country</b>	<b>15.26</b>	<b>.00</b>
Share of reviews	3.78	.52
<b>Share of articles not in English</b>	<b>-25.71</b>	<b>.02</b>
R squared	.311	
# of observations	130	

Table 3. Multivariate linear regression analysis. Dependent variable: share of authors from developing countries excluding authors co-authoring with authors from developed countries. Variables statistically significant at the .05 level are marked with bold.

The most important number in Table 3 is in fact a variable that is not statistically significant. The third row of the table showing the OA-variable has a p-value of .16. This implies that OA journals do not differ from NOA journals with respect to the share of publications written by authors from developing countries. The difference in the percentage of authors from developing countries in NOA and OA journals is consequently not related to the OA status of the journal but (at least to some extent) other variables.

Turning now to the coefficients of the variables that enter the estimation significantly Table 6 shows that there are three such variables at the .05 level: (a) JIF; (b) geographic location of the journal being a developing country; and (c) share of articles not in English. The values of the coefficients to these variables can be interpreted as follows: (a) an increase by one unit in the JCR impact factor leads to a decrease in the share of publications written by authors from developing countries of 1.2 percentage points; (b) a geographic location of the journal in a developing country leads to an increase of 15 percentage points; and (c) for every increase in the share of articles not in English of 10 per cent, the share of publications written by authors from developing countries decreases by 2.5 percentage points. JIF is related to the share of authors from developing countries. However, it must be stressed that causation cannot be determined and it could be the share of authors from developing countries affecting the JIF. Furthermore, the coefficient of -1.21 implies that a decrease in the share of publications written by authors from developing countries of 1.2 percentage points is statistically associated to an increase in JIF by 1 unit. Given that the overall average of the share of publications by developing authors is around 12-13 per cent quite a substantial degree of the variation can thus be explained by differences in JIF across the journals in the sample. The negative effect of the non-English language variable on the share of authors from developing countries is much greater (and less complicated to change). If a journal with all their publications written in a non-English language changes the language to English it implies an increase in the share of authors from developing countries by 25.71 percentage points. To a large extent the effect is caused by the specific languages of the journals included in this study. Russian is one of the included languages that probably will not attract many authors from developing countries (Russia is not characterised as a developing country according to the country groups by The World Bank). Non-English languages are associated with a more national profile in the author distribution and changing the language to English does attract

more foreign authors, including authors from developing countries (Dinkel et al., 2004; Puliselic & Petrak, 2006).

A result of the calculations performed with programs such as SPSS is the R-square, which is used as indicators of the “goodness of fit.” Generally speaking, an R-square (percentage of total variance) that is close to 1 is indications that the data fit the model well. The R-square values of this model and the following model show that about 30 per cent of the variance is explained by the selected variables. Higher R-square values would have indicated a better fitted model, although, this level of R-squares is not atypical in analyses of this character. Multivariate analysis dealing with social science data typically result in R-squares ranging from 0.1 to 0.5 (Lattin; Carroll & Green, 2003). Data on the behaviour of scholars at the level of single papers or authors tend to be largely dispersed with values widely scattered. Schrum and Campion (2000) analyse the degree of isolation of scientists in developing countries and their multiple regression analyses have R-squares of 0.17-0.21. Nemeth and Goncalo (2003) study the citation impact of collaborations between authors at different universities or locations and the R-squares are 0.067 and 0.068. A much better fit is achieved at the level of countries (Tijssen & Leeuwen, 2006) or journals (Frandsen, 2007). Although, the models in this study do not fit the data excellently there are variables that can explain about 30 per cent of the variance.

#### *Citing behavior*

The unit of analysis (and thus number of observations) for this analysis consists 200 groups of publications. There are publications by author(s) from developed countries, author(s) from developing countries and author(s) from both developing and developed countries. In principle the dataset could consist of 150 \* 3 observations, however, as some journals had no or too few publications by one or more of the three author groups the dataset is reduced to 200 observations.

The lowest average shares of references to OA journals are found in publications by authors from developed countries as the average is 1.38 per cent. Slightly higher average shares are found in publications written by authors from developing countries as the average share is 1.59 per cent, and finally the publications from both developed and developing countries have the highest average share of 2.46 per cent. Given these crude numbers it thus appears that developing authors use OA less, and not more, than authors from developed countries. However, in order to be able to understand the factors at work, a multivariate linear regression model is applied to control for a number of factors that may influence the citing behaviour of the authors. Table 4 presents an overview of the results.

Variable	Coefficients	P-value
Intercept	1.13	.00
Author(s) from developing countries	-.09	.75
<b>Author(s) from both developed and developing countries</b>	<b>.93</b>	<b>.00</b>
<b>JIF</b>	<b>-.11</b>	<b>.01</b>
<b>OA</b>	<b>.56</b>	<b>.02</b>
<b>Sub-discipline: Entomology</b>	<b>-.73</b>	<b>.05</b>
Sub-discipline: Zoology	.37	.32
Sub-discipline: Microbiology	-.15	.63
Sub-discipline: Biochemistry	-.42	.10
<b>Sub-discipline: Genetics</b>	<b>1.77</b>	<b>.00</b>
Sub-discipline: Biotechnology	-.07	.82
Geographic location of journal: developing country	.13	.68
<b>Share of reviews</b>	<b>-.95</b>	<b>.04</b>
Share of articles not in English	1.86	.08
R squared	.306	
# of observations	200	

Table 4. Multivariate linear regression analysis. Dependent variable: share of references to OA journals. Variables statistically significant at the .05 level are marked with bold.

Of special interest to this study Table 4 clarifies that the share of references to OA journals is not different between authors from developed and developing countries. Consequently, authors from developing countries do not cite OA significantly more (or less) than authors from developed countries. However, the OA status of the journal is related to the share of references to the set of OA journals implying that authors publishing in OA cite other OA journals more than authors publishing in NOA journals.

Going through the model, Table 4 shows that it has six coefficients that are statistically significant at the .05 level: (a) author(s) from both developed and developing countries; (b) JIF; (c) OA; (d) the sub-discipline entomology; (e) the sub-discipline genetics; and (f) the share of reviews in the journal. The

values of these coefficients can be interpreted as follows: (a) publications by author(s) from both developed and developing countries have a share of references to OA journals of .93 percentage points higher; (b) an increase by one unit in the JCR impact factor corresponds to a decrease in the share of references to OA journals by .11 percentage points; (c) OA journals have shares of references to OA journals of .56 percentage points higher; (d), the sub-discipline entomology have shares of references to OA publications .73 percentage points lower; the sub-discipline genetics have shares of references to OA publications 1.77 percentage points higher; and (f) an increase in the share of reviews in the citing journal leads to a decrease in the share of references to OA journals of .95 percentage points. Finally, it should be noted that the variable describing the share of articles not in English is significant at the 0.1 level indicating that journals publishing many articles not in English may cite OA journals more.

## **Discussion**

First of all, the sub-disciplinary differences in the share of references to OA journals should be noted. It is well established in the existing literature that the use of Internet based communication varies considerably from field to field. These differences have been affirmed in the existing literature on the level of disciplines (e.g. Barjak, Li & Thelwall, 2007; Kling & McKim, 2000; Törmä & Vakkari, 2004)) as well as sub-disciplines (e.g. Frandsen & Nicolaisen, 2007; Fry, 2006; Sotudeh & Horri, 2007). In the present analysis not all the sub-disciplines are statistically significant variables contributing to the understanding of the dependent variable. However, as stated by Kling and McKim (2000: 1307) there are great differences “from one field (or closely related set of fields) to another.” Some of the sub-discipline specific journals are thus not differing from the general biology journals whereas other sub-discipline specific journals cite OA journals either less or more than the general biology journals.

The results of this study indicate that having controlled for other factors authors from developing countries are not more attracted to OA journals than authors from developed countries. Furthermore, the results indicate that authors from developing countries do not cite OA journals more than authors from developed countries. Authors from developed and developing countries thus have similar publishing and citing behaviour which could be a reflection of the fact that the incentives in terms of publishing and citing being equivalent. Authors from developing countries are competing for attention just as authors from developed countries. Attention is a scarce resource in science and an

object of competition (Klamer & van Dalen, 2002). An author can gain attention through reputation, the journals the author publishes in and the citations he or she receives (van Dalen & Henkens, 2005). Reputation is, however, closely related to the latter two ways of gaining attention. Appointments, promotions, and grant applications are strongly influenced by publication records (Daniel, 2005) and citation records (Lewison et al. (1995; Saiz-Salinas, 1996). The distribution of publications and citations among individuals, departments, institutions and countries is thus an increasingly important feature of contemporary science. The increased focus on evaluation based on publication and citation analyses has according to Kaltenborn and Kuhn (2004) led authors more or less voluntarily to adapt their publication strategy to a maximation of their impact. Authors seek to and are pressured to publish in journals with high JIFs (Maffuli, 1995; Vinkler, 1986). The authors from developing countries compete to get their research published in the same high JIF journals as the authors from developed countries. The survey by Alemna, Chifwepa and Rosenberg (1999) indicates that although authors from African countries use African journals the greater importance of non-African journals to teaching and research remains undisputed.<sup>10</sup>

On the basis of the data included in this study authors cannot be characterised on the basis of being located in either a developed or a developing country. However, it must be stressed that the authors from developing countries in this study may not be representative of the population of authors from these countries. The authors included in this study have been able to get their research published in journals included in the Science Citation Index which could be related to the topic of their research (being of interest outside their own country or region). Tijssen et al. (2006) find that African journals are to a large extent invisible in international databases, and Shrum (1997) finds that many of the characteristics of the scientists from developing countries that are visible in international databases differ from the wider population of scientists from developing countries. Consequently, the international databases depict a picture of the scientists from the developing countries that is not accurately reflecting the population of researchers or domestic productivity.

The results also indicate that OA journals as a publishing medium cannot be characterised as particularly attracting authors who have less access to NOA journal articles and consequently have to depend more on the publications freely available in OA journals. However, OA journals can be characterised by attracting a certain group of authors. Authors publishing in OA journals are citing

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<sup>10</sup> In spite of the dominating international journals there are several motives for African scientists not to publish in international journals (Pouris & Richter, 2000).

other OA journals more. The share of references to OA journals (excluding journal self-citations) are .56 percentage points higher than in NOA journals.

Finally, the results show that although authors from developing and developed countries do not differ in terms of citing OA journals, publications by both authors from developed and developing countries differ from the two former groups. Their share of references to OA journals is on average more than 1.5 times greater than equivalent share in publications by authors from developed countries and about 1.8 times greater than the share in publications by authors from developing countries. First of all it must be stressed that this sample of publications is more likely to contain co-authored publications than the other two as this group must consist of two geographic locations as a minimum. International scientific collaboration is an area of great attention in bibliometrics (for recent contributions see e.g. Bookstein, Moed & Yitzahki, 2006a,b; Glänzel & Schubert, 2005; Jappe, 2007 and Ponds, van Oort & Frenken, 2007). Collaboration is typically analysed through co-authorships, although co-authorships are only a partial indicator of collaboration which may not provide the full picture (Katz & Martin, 1997 and Laudel, 2002). Two key issues of interest in international scientific collaboration are the growth and the potential benefits of the collaboration. International collaboration is growing and this growth can be explained by internal as well as external factors to science (Wagner & Leydesdorff, 2005). Moed (2005: 285) provides an example of an analysis of the benefits of international collaboration. Unfortunately, studies on international collaboration including the perspective of distance are few. Collaboration characterized by a long distance between the participating researchers can also be described as remote collaboration (Lorigo & Pellacini, 2007), collaboration with weak ties (Wagner, 2005), collaborators-with-a-difference (Wagner, 2005) or dispersed collaboration (Cummings & Kiesler, 2005). The distance of the collaborators can be defined in a number of ways, e.g. geographical (e.g. Ponds, van Oort & Frenken, 2007 studying scientific collaboration in the Netherlands), disciplinary (e.g. Cummings & Kiesler, 2005 studying multidisciplinary research projects) or financial (the present study using GNI). However, very few studies focus on international collaboration by collaborators-with-a-difference. An essay from 2005 discusses the globalization of science by focusing on collaboration in terms of guests between developing and developed countries (Shrum, 2005: 737). He argues that data collection is extremely difficult if a representative sample is to be collected in the developing countries. Furthermore, conditions there are fundamentally very different from those in developed countries and thus comparisons are almost impossible to make. An example of the different conditions is provided by Duque et al. (2005: 756) stating that collaboration

has become a scientific value in itself. However, they find that collaboration in three African countries is not associated with a general increase in productivity which is the case in developed countries. Consequently, collaboration becomes a paradox for researchers in those countries as their investments in collaboration do not seem to provide them with a fair return. Concluding the discussion of collaborators-with-a-difference it should be noted that further research is needed to determine why the publications by both authors from developed and developing countries differ from publications by authors from just one of those two groups. It could be caused by the lack of a representative sample or the fact that a sample with many co-authored publications is being compared to samples consisting of fewer co-authored publications. However, it could also be caused by inherent characteristics of collaborations by collaborators-with-a-difference.

## **Conclusion**

The results of this study indicate that authors from developing countries are not more attracted to OA journals than authors from developed countries. Authors from developing countries do not publish more in OA journals than authors from developed countries and furthermore, authors from developing countries do not cite OA journals more than authors from developed countries. Consequently, based on this study author behaviour in terms of OA publishing and citing cannot be distinguished on the basis of the author(s) being located in developed or developing country. However, OA journals can be characterised by attracting a certain group of authors as the results show that although authors from developing and developed countries do not differ in terms of citing OA journals, publications by both authors from developed and developing countries differ from the two former groups.

Because the data used in this study does not include other demographic information than the geographic location, it would be interesting to see future research on the topic of attraction to OA include e.g. the age of the author(s). Further, it will be important to test the generalizability of the present findings by (a) investigating the phenomenon not only in biology fields but also as practiced in other disciplines, (b) investigating other OA models such as self-archived publications as well as open access published publications, and (c) including usage data to analyse reading behaviour as a supplement to publishing and citing behaviour. Finally, content analyses of publications could provide valuable information of qualitative differences citing behaviour.

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## Appendix 1. List of included journals in the study

Acta Biochimica Polonica  
Acta Bioquímica Clínica Latinoamericana  
Acta Protozoologica  
Acta Zoologica.  
Advances in Applied Microbiology  
Advances in Biochemical Engineering -  
Biotechnology  
African Entomology  
African Zoology  
Agricultural and Forest Entomology  
American Journal of Hematology  
American Journal of Primatology  
American Museum Novitates  
Animal Biology  
Animal Biotechnology  
Animal Genetics  
Annales Zoologici  
Annals of Applied Biology  
Annals of Human Biology  
Annual Review of Entomology  
Annual Review of Genetics  
Annual Review of Microbiology  
Apidologie  
Applied Biochemistry and Microbiology  
Applied Entomology and Zoology  
Archives of Biochemistry and Biophysics  
Archives of Insect Biochemistry and Physiology  
Archives of Microbiology  
Behavior Genetics  
Biochemistry  
BioControl  
Biological Chemistry  
Biological Research  
Biology Bulletin  
Bioprocess and Biosystems Engineering  
Bioscience  
Bioscience, Biotechnology, and Biochemistry  
Biotechnology Advances  
Biotechnology Letters  
BMC Biotechnology  
BMC Evolutionary Biology  
BMC Genetics  
BMC Genomics  
BMC Microbiology  
Brazilian Archives of Biology and Technology  
Brazilian Journal of Microbiology  
Canadian Entomologist  
Canadian Journal of Microbiology  
Caribbean Journal of Science  
Clinical Biochemistry  
Clinical Microbiology and Infection  
Contributions to Zoology  
Critical Reviews in Biotechnology  
Current biology  
Current Microbiology  
Current Opinion in Chemical Biology  
Current Opinion in Genetics & Development  
Developmental Biology  
Electronic Journal of Biotechnology  
Entomologica Fennica  
Entomological News  
Ethology  
European Journal of Entomology  
Experimental & Molecular Medicine  
FASEB Journal  
Florida Entomologist  
Folia Parasitologica  
Folia Zoologica  
Food Biotechnology  
Food Microbiology  
Food Technology and Biotechnology  
Frontiers in Bioscience  
Genes & Genetic Systems  
Genes, Brain and Behavior  
Genetics and Molecular Biology  
Genome  
Genomics  
IEEE Transactions on Information Technology in  
Biomedicine  
Indian Journal of Biochemistry and Biophysics  
Insect Molecular Biology  
Insectes Sociaux  
International Journal of Acarology  
International Journal of Molecular Sciences  
International Microbiology  
Italian Journal of Zoology  
Journal of Animal Ecology  
Journal of Applied Entomology  
Journal of Basic Microbiology  
Journal of Biochemistry and Molecular Biology  
Journal of Biomedicine and Biotechnology  
Journal of Biosciences

Journal of Chemical Technology and  
Biotechnology  
Journal of Clinical Microbiology  
Journal of Genetics  
Journal of Insect Behavior  
Journal of Insect Physiology  
Journal of Lipid Research  
Journal of Microbiology  
Journal of Microbiology and Biotechnology  
Journal of Molecular Catalysis B: Enzymatic  
Journal of Pest Science  
Journal of Plant Biochemistry and Biotechnology  
Journal of Proteome Research  
Korean Journal of Genetics  
Laboratory Animals  
Medical & Veterinary Entomology  
Microbiology and Immunology  
Microbiology and Molecular Biology Reviews  
Molecular and Cellular Biology  
Molecular Biology  
Molecular BioSystems  
Molecular Vision  
Mutagenesis  
Nature Biotechnology  
Neurogenetics  
North American Journal of Aquaculture  
Nucleic Acids Research  
Physiological Entomology  
PLOS Biology  
Process Biochemistry  
Raffles Bulletin of Zoology  
Russian Journal of Genetics  
Steroids  
Structure  
Systematic Biology  
Trends in Biochemical Sciences  
Trends in Biotechnology  
Trends in Microbiology  
Zoo Biology  
Zoologicheskii Zhurnal  
Zoosystema

**Appendix 2. Inter-correlations of the independent variables in the first model.**

	2	3	4	5	6	7	8	9	10	11
1 JIF	-.13	-.16*	-.22*	.44	.10	.06	.02	-.32*	.49*	-.11
2 OA		-.17*	.02	-.01	.004	.04	.02	.38*	-.13	.05
3 Entomology			-.14	-.19*	-.21*	-.19*	-.19*	-.11	-.09	-.07
4 Zoology				-.19*	-.26*	-.13	-.19*	-.02	-.17*	.11
5 Microbiology					-.01	-.01	-.13	.05	.18*	-.07
6 Biochemistry						-.06	.07	.06	.02	.11
7 Genetics							-.13	-.004	.06	-.07
8 Biotechnology								.03	.11	-.07
9 Geographic location of journal: developing country									-.17	.26
10 Share of reviews										-.03
11 Share of articles not in English										

\* p < .05 level (two-tailed).

**Appendix 3. Inter-correlations of the independent variables of the second model.**

	2	3	4	5	6	7	8	9	10	11	12	13
1 Author(s): developing countries	-.21*	-.13*	.00	-.12	-.07	.01	.15*	.01	.11	.17*	-.05	-.05
2 Author(s): developed and developing countries		.09	.01	-.08	-.07	-.00	.04	-.06	.03	-.12*	-.04	-.06
3 JIF			-.11	-.20*	-.16*	-.03	.13*	.03	-.03	-.27*	.45*	-.10
4 OA				.01	-.15*	-.05	-.00	.11	.00	.24*	-.13*	.04
5 Entomology					-.10	-.18*	-.25*	-.08	-.18*	.02	-.15*	.10
6 Zoology						-.17*	-.21*	-.16*	-.17*	-.13*	-.08	-.05
7 Microbiology							-.06	-.00	-.10	.11	.05	-.06
8 Biochemistry								-.09	-.01	.02	-.03	.07
9 Genetics									-.16*	.03	-.02	-.06
10 Biotechnology										-.04	.18*	-.06
11 Geographic location of journal: developing country											-.14*	.27
12 Share of reviews												-.03
13 Share of articles not in English												

\* p < .05 (two-tailed).