On the scientific impact of ArXiv: A case study of astrophysics

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Introduction

Since its creation by Paul Ginsparg in 1991, arXiv has become central to the diffusion of research in a number of fields—most notably in physics, mathematics, and computer science. Previous research on ArXiv focused on use (Brown, 2001), ordering and citation rates (Haque & Ginsparg, 2009), coexistence of e-prints and journals (Henneken et al., 2007) and the effect of arXiv on citation rates (Moed, 2007). This paper uses data from the Web of Science (WoS) and the ArXiv to investigate the impact and aging patterns of e-prints and their published alter egos.

Methods

All arXiv metadata from 1990 to March 22, 2012 were downloaded (N = 744,583 e-prints) and matched with the WoS for the 1990-2011 period. Two types of links between the data sources were created: (a) between the arXiv e-print and its published version indexed in WoS and (b) between the arXiv e-print and its citation in WoS. The link was created using (a) a fuzzy match between the title of the e-print and the title of the WoS, as well as the first author. Additional matching was performed using the journal field of arXiv and lowering the threshold of similarity between titles of e-prints and published papers. For the second matching (b) we utilized a specific structure of the references to the arXiv e-prints in WoS. For example, a reference to an e-print from the condensed matter section of arXiv will have the string 'CONDMAT' followed by the series of seven or eight digits that correspond to its document ID in the online e-print database. Given that a paper belonging to more than one arXiv category can be cited using both categories as prefixes the matching process used the seven or eight digits as well as it prefix. For the astrophysics domain, we separated documents into four categories: 1) arXiv e-prints never published in a journal, 2) the arXiv version of an arXiv e-print subsequently published in a journal, 3) the journal version of an article previsouly published as an arXiv e-print and 4) journal articles that were never published as arXiv e-prints.

Results and Discussion

At the level of the entire ArXiv, the delay between the submission of a manuscript on the e-print archive and its publication in a peer-reviewed journal has reduced over time. Whereas papers were once published a year after appearing on arXiv, publication in a journal is now likely to occur in the same year as the appearance on arXiv. There are two possible reasons for this: 1) a higher proportion of researchers are now waiting for the paper to be published or accepted for publication before submitting to arXiv or 2) the introduction of arXiv may have prompted publishers to decrease publication delays. We also observe that slightly less than 50% of arXiv submissions were also found in WoS.

Figure 1 presents, for astrophysics, (A) the trends in the numbers of papers that have appeared on arXiv only, on arXiv and WoS (arXiv version), only in WoS and on arXiv and WoS (WoS version) and (B) the mean number of citations these documents have received using a one-year citation window plus publication year. We see an increase in the number of documents published both in arXiv and in journals, and increase in the number of papers published

only in arXiv, and a decline of papers published only in journals. The citation rates among the four groups vary over time. WoS versions of arXiv e-prints obtain the highest citation rates, a finding consistent with the documented association between open access and citation. However, this impact is decreasing and is approaching that of other WoS papers not submitted to arXiv, whose mean impact is increasing. There is no difference in the impact of the arXiv versions of both published and unpublished papers. One could have expected that these unpublished papers, being non-refereed, would have a lower impact. However, it is possible that researchers prefer to cite the published version of an e-print which is likely to reduce *published* e-print impact and, hence, make the two measures comparable. Of course, e-prints and published papers follow different patterns. E-prints citations peak on the year following their submission, while citations to papers are similar during the two years following publication. The decline is much faster for e-prints, with a small proportion of citations (less than 5%) received past the fifth year following publication. Given the transfer of citations from *to be published* e-prints to their published version, the citations to their e-print versions decay faster than those received by unpublished e-prints.

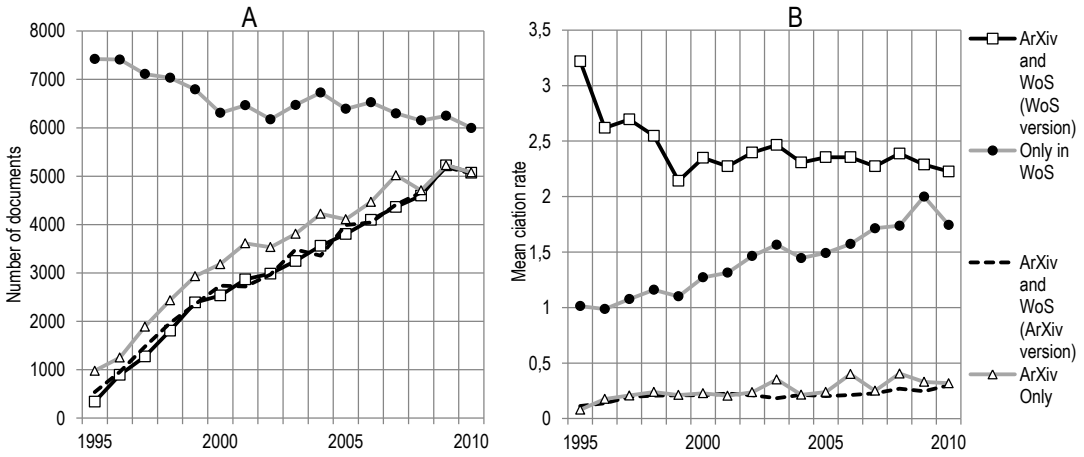

Figure 1. A) Number of documents published and B) mean number of citation received (publication year plus one year), for documents published on arXiv only, on arXiv and WoS (arXiv version), only in WoS and on arXiv and WoS (WoS version), 1995-2010

Conclusion and Future Research

Our data shows that the average delay between submission to arXiv and publication in a WoS-indexed peer-reviewed journal has decreased. For astrophysics, the number of papers appearing on arXiv is increasing. This can be an indicator of changing role arXiv plays within this community. The role of the arXiv has moved from the space for sharing pre-prints by a minority, to the place for archiving the majority of produced research. This finding can be further supported by the very similar scientific impact of papers appearing in arXiv and journals. Future work will explore the potential of these combined datasets for understanding the thematic and temporal relationships between these genres and how individuals interact in this space.

References

Brown, C. (2001). The E-volution of Preprints in the Scholarly Communication of Physicists and Astronomers.Journal of the American Society for Information Science and Technology, 52(3):187–200

Haque, A.U., & Ginsparg, P. (2009). Positional Effects on Citation and Readership in arXiv. Journal of the American Society for Information Science and Technology, 60(11):2203–2218,

Henneken, E.A.,Kurtz, M.J., Eichhorn, G., Accomazzi, A., Grant, C.S., Thompson, D., Bohlen, E., & Murray, S.S. (2007). E-prints and journalarticles in astronomy: a productiveco-existence. Learned Publishing, 20(1): 16–22

Moed, H.F. (2007).The Effect of “Open Access” on Citation Impact: An Analysis of ArXiv’s Condensed Matter Section. Journal of the American Society for Information Science and Technology, 58(13):2047–2054