

Analyzing Interdisciplinary Research along Multiple Dimensions of Research Impact

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ABSTRACT

Past research has found an inverted-U relationship between the most interdisciplinary research (IDR) and citation impact. We explore whether the most IDR is also penalized or rewarded by broader consumers of academic research. Comparing analyses of publications aggregated at the country level, we analyze the relationship between the most IDR publications and alternative metrics of research impact, such as publication usage and citations of academic research in patents.

Keywords

Interdisciplinary Research; Cross-disciplinary Research; Measurement; Methodology; Citation Analysis; Publication; Bibliometrics; Scopus; Altmetrics

INTRODUCTION AND MOTIVATION

Interdisciplinary research (IDR) is an important aspect of 21st century scientific collaboration, and the integration of knowledge from multiple disciplines is often heralded for its ability to advance the understanding of complex issues and scientific problems. Yet, past research on IDR suggests an inverted-U relationship between the level of interdisciplinarity and citation impact (Lariviere and Gingras 2010). That is, neither the most interdisciplinary research (those drawing on a distal interdisciplinary research as Yegros-Yegros et al. 2015 describe or those with both high tail novelty and low median convention as Uzzi et al. 2013 find) nor the most disciplinary research achieves the highest citation impact. This is consistent with past theories in the sociology of categorization and strategy that audiences (in this case, other academics who may cite the IDR) reward actors (pieces of IDR research) that exhibit a balance of conformity to and deviation from prescribed category behaviors (Phillips and Zuckerman 2001; Zuckerman et al. 2003). Such past studies have similarly

found an inverted U relationship in many different domains (from legal services to investment banks to the film industry) between the level of conformity an actor displays and the rewards that that actor achieves.

However, IDR (and all scientific research more broadly) is evaluated by more than just the immediate audience of other academics. In particular, the broader communities of scientific research consumers (including students and professionals) as well as corporations seeking to commercialize scientific research are two overlapping though distinct audiences from that of academics and/or researchers that actively publish. Pontikes (2012) suggests that audiences with different motivations may evaluate and reward category deviants differently. However, whereas Leahey et al. (2012) apply Pontikes's theory to argue that academics are "market-makers" and would reward other academics who cross disciplines, we argue the opposite. Academics are in fact market-takers, evaluating according to their disciplinary silos. But, non-academic audiences that consume research are market-makers – seeking to make sense of scientific research for their own purposes, and we argue that such audiences may be more likely to reward IDR.

Given the multiplicity of audiences, our analysis explores whether the most interdisciplinary research achieves high performance along other dimensions of research impact. In particular, we proxy for the "rewards" conferred by broader communities of scientific research consumers (and specifically that of corporations) through usage of academic research and citations of academic research in patents (Roach and Cohen 2013).

METHODOLOGY

An essential step (a pre-requisite) in this study is to define IDR. Many methods have been used in the bibliometric literature to define IDR. Bordons et al.'s chapter in *The Handbook of Quantitative Science and Technology Research* summarizes many of these methods including collaboration amongst authors from different disciplines, co-occurrence of several classification codes in publications, interdisciplinary nature of publication journals, and cross-disciplinary references and citations. Cross-disciplinary references and citations that rely on the

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journal classification of an article's references and citations is one of the most frequently used methods.

The main drawback of the above mentioned methods is their reliance on existing subject classification schemes, particularly journal classification schemes. Such classification schemes require stability and therefore do not always reflect new developments in areas of research. Similarly, the rigidity of such a classification system does not allow for subtle differences between disciplines. A publication in a discipline that is relatively small in size, citing a publication that is in the nearest adjacent discipline makes this article multidisciplinary. If a publication is in a larger discipline, citing a publication that is still within the discipline but on nearly unrelated topics would make this publication mono-disciplinary. One could question whether this level of arbitrariness is suitable when studying the phenomenon of IDR.

Our methodology focuses on the extent to which publications within the Scopus abstract and citation database are interdisciplinary. Similar to Porter et al.'s approach, we operationalize the interdisciplinarity of a publication by analyzing the extent to which that publication cites journals that are "far away" from each other (in terms of the topics or disciplines they cover).

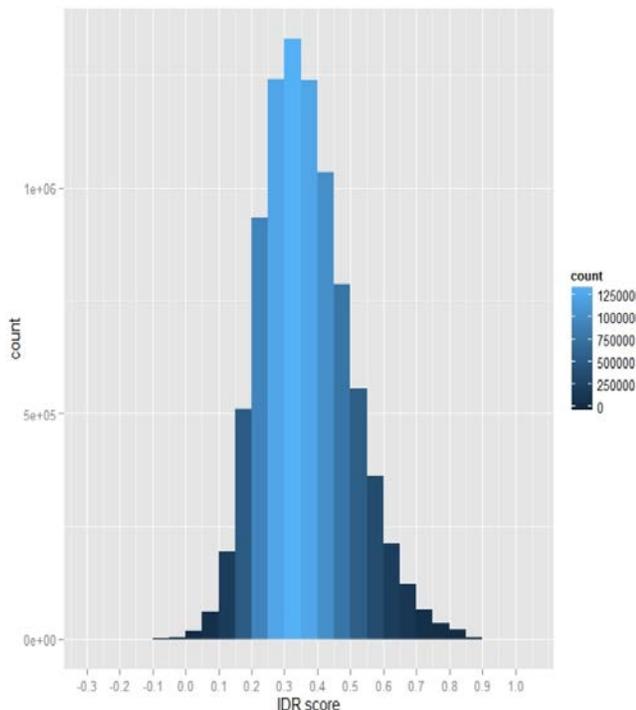


Figure 1. Histogram of distribution of IDR scores for all suitable publications, 2009-2013, Scopus®

To define how "far" or "close the references of an article are, we look at the journals in which they are published and determined whether said journals are "far" or "close" to one another. We define the closeness between two journals to be the frequency in which two journals are co-cited in the

references of all Scopus publications for the five-year period of 2009-2013. Our calculations normalize the range of IDR values between -1 and 1, with lower numbers corresponding to a higher level of interdisciplinarity.

Based on this approach, we assign IDR scores to about 8.7 million records (that are articles, reviews, and conferences proceedings) of the 9.7 million records in Scopus from 2009-2013 that have references. We see that only a small percentage of the publications have an IDR score lower than zero (very interdisciplinary). The majority of the articles concentrate in the range between 0.2 and 0.4.

ANALYSIS AND RESULTS

We focus specifically on the subset of publications are in the world's top 10% most interdisciplinary in terms of IDR scores. By measuring citation impact in terms of field-weighted citation impact (FWCI), which normalizes for the year, Scopus subject area, and article type, our analyses corroborate past studies' findings that highly IDR is negatively correlated with FWCI. In particular, we find that for all countries, the FWCI of its publications in the world's top 10% IDR is lower than the FWCI of any publications with an IDR score. These trends largely hold when we analyze different subsets of the data (such as just UK data across subject area [see Pan and Katrenko 2015] or data from all countries on the subject of sustainability science [see Bos and Pan 2015]).

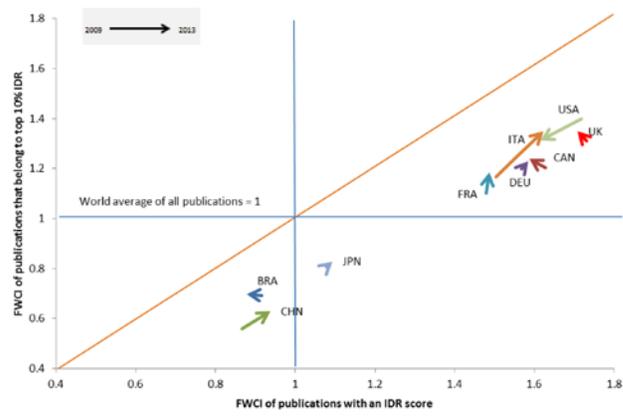


Figure 2. Field-weighted citation impact (FWCI) of the top 10% most IDR compared to FWCI of all research, 2009-2013, per selected countries, Scopus®

In terms of field-weighted download impact (FWDI) – a normalized measure of usage of research that controls for the subject area, year, and document type of a publication, our analyses show that highly IDR achieves a lower FWDI than all publications.

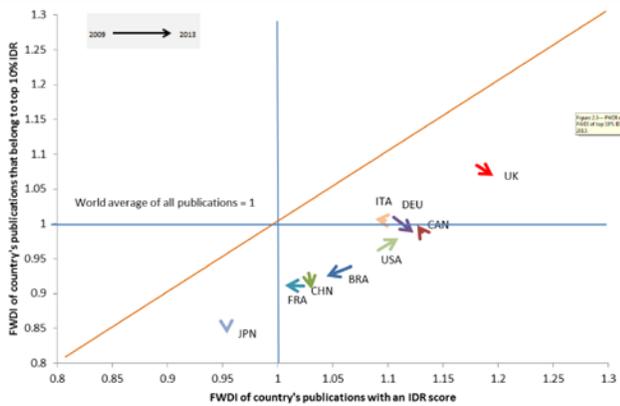


Figure 3. Field-weighted download impact (FWDI) of the top 10% most IDR compared to FWDI of all research, 2009-2013, per selected countries, ScienceDirect® usage

However, in terms of relative world patent citation share, our analyses suggest that for some countries, the most IDR is more likely to be cited in applications than all publications are.

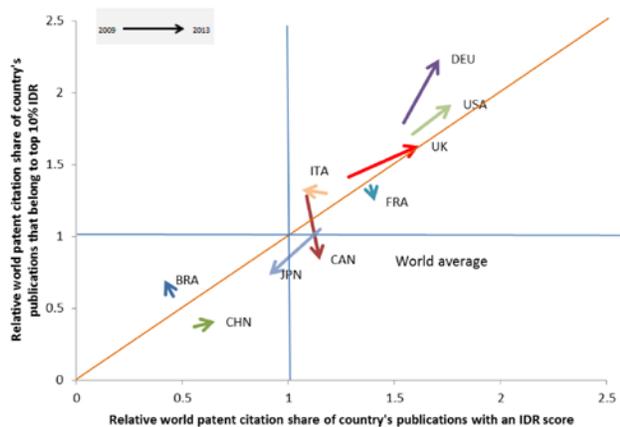


Figure 4. Relative world patent citation share (RWPCS) of the top 10% most IDR compared to RWPCS of all research, 2009-2013, per selected countries, LexisNexis Patent®

Our results suggest that downloads, to the extent that usage capture the rewards conferred by a broader base of academic research consumers (which some are skeptic about – see Bornmann 2014), accrue at a lower rate for the most IDR. However, in the context of patent citations, we see a mixed relationship. Further investigations, such as segmenting usage research by sector and negative binomial regressions of the number of patent citations by IDR score, may further elucidate whether the most high IDR is not penalized or rewarded by other audiences.

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