ResearchGate: Disseminating, Communicating and Measuring Scholarship?[1]

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ResearchGate is a social network site for academics to create their own profiles, list their publications and interact with each other. Like Academia.edu, it provides a new way for scholars to disseminate their publications and hence potentially changes the dynamics of informal scholarly communication. This article assesses whether ResearchGate usage and publication data broadly reflect existing academic hierarchies and whether individual countries are set to benefit or lose out from the site. The results show that rankings based on ResearchGate statistics correlate moderately well with other rankings of academic institutions, suggesting that ResearchGate use broadly reflects traditional academic capital. Moreover, while Brazil, India and some other countries seem to be disproportionately taking advantage of ResearchGate, academics in China, South Korea and Russia may be missing opportunities to use ResearchGate to maximise the academic impact of their publications.

Introduction

The Web has introduced many new ways in which academics can publicise their work and communicate with each other at a distance. These two activities seem to have been separated to some extent, however, with articles publicised via links on author home pages (Kousha & Thelwall, in press; Mas Bleda, Thelwall, Kousha, & Aguillo, 2014) and in preprint archives (Shuai, Pepe, & Bollen, 2012), whereas communication and connections seem to occur more naturally in listservs (Cronin, Snyder, Rosenbaum, Martinson, & Callahan, 1998; Schoch & Shooshan, 1997) and general social network sites, such as Facebook and LinkedIn (Allen, Stanton, Di Pietro, & Moseley, 2013; Mas Bleda et al., 2014). The sites Academia.edu and ResearchGate now combine communication and dissemination by incorporating a repository for academics' publications within a social network site for researchers (Gewin, 2010; Lin, 2012; Madisch, 2008; Mangan, 2012). According to Alexa.com, both sites were moderately popular by November 2013, with ResearchGate.net being ranked 3,947 and Academia.edu 2,243 for popularity amongst all websites. If academic social network sites like these are changing patterns of scholarly communication by providing an alternative method to discover publications then it is important to detect what the implications are for important stakeholders in science, such as individual countries and institutions.

Founded in 2008, ResearchGate apparently has more than 3 million users (www.researchgate.net/aboutus.AboutUs.html), with about a third visiting monthly (Dembosky, 2013). ResearchGate allows individuals to list or upload their publications into their profiles, which can potentially give an extra access point to research. Nevertheless, little is known about using ResearchGate for formal or informal scholarly communication. A survey of 160 University of Delhi researchers found many users for ResearchGate (54%), Academia (51%), LinkedIn (39%) and CiteULike (35%) (Madhusudhan, 2012) and a survey of

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71 bibliometricians found that 21% used ResearchGate and Academia, with Mendeley being slightly more popular (24%) and LinkedIn being much more popular (68%) (Haustein, Peters, Bar-Ilan, et al., 2013). A survey of 100 researchers in one Indian university (Chakraborty, 2012) found common reasons for using ResearchGate to be finding out about others' research (24%), keeping up-to-date (31%) and forming study groups (37%), with some social scientists but no scientists finding it to be useful. A study of the web presence of about 1,500 highly cited scientists working at European institutions, however, found a minority to be represented in major social network sites: a fourth had LinkedIn profiles and even less had Academia and Mendeley profiles, although ResearchGate was not checked (Mas Bleda, Thelwall, Kousha, & Aguillo, 2013). Little research has investigated the impact of academic social network sites, however. In one exception, a study of Academia.edu profile pages found that success for individual academics seemed to reflect a combination of academic capital and social networking skill (Thelwall & Kousha, in press), supporting the idea that academic social network sites are a hybrid phenomenon and, in this sense, are a genuinely new addition to the scholarly communication infrastructure.

This study investigates whether ResearchGate use broadly reflects traditional academic capital to the extent that its metrics correlate with traditional academic rankings at the university level, although, as discussed below, these metrics should be interpreted carefully. In addition, the study investigates whether ResearchGate is changing scholarly communication from the perspective of countries: whether some nations are using it more than others, relative to their international scholarly production. This important because countries that fail to adopt new technologies risk being left behind.

Background

In theory, scientists and social scientists are obligated to conduct thorough literature reviews at the start of any new project. These reviews should identify and evaluate all relevant articles, which should then be analysed and cited in articles published to report any findings. The importance of literature searching is such that there have been calls for the search steps to be documented in academic articles (Vom Brocke et al., 2009), as routinely occurs in systematic reviews (Higgins, 2008) and meta-analyses (Glass, McGaw, & Smith, 1981).

In practice, it is impossible to identify all articles relevant to a given project, even if following a systematic literature search method (Dickersin, Scherer, & Lefebvre, 1994), and so scholars use a finite set of searches and other methods in order to identify relevant research (Haines, Light, O'Malley, & Delwiche, 2010; Niu et al., 2010; RIN, 2006). For example, a researcher could use keyword searches in general, local or disciplinary digital libraries to find relevant articles in the hope that this method will not miss many relevant papers. In addition, they may recall relevant articles from previous studies, or from previous literature scanning or conference presentations attended. They may also use email, listservs or even face-to-face communication in order to ask others to suggest relevant articles – harnessing their invisible college (Crane, 1972). The combined result of these activities is likely to be a biased subset of articles, for example with non-English articles and articles without significant results being less likely to be included (Egger & Smith, 1998). Moreover, the researcher may decide to exclude papers that are difficult to obtain full-text copies of, particularly if they are similar to other articles that are more easily available or are not central to the new investigation.

A consequence of the way in which scholars find relevant articles is that papers that are easier to find or access seem likely to be more cited than other papers with similar topics and quality. Given that citations confer recognition on the cited author (Merton, 1973) and that this recognition is important for academic careers and evaluations (Moed, 2005), authors and institutions should benefit from making their publications easier to find and access. For example, open access research seems to be more highly cited than other research (Davis & Fromerth, 2007; Gargouri et al., 2010; Kousha & Abdoli, 2010), and although author selection of important articles to publish open access may be the main cause (Gaulé & Maystre, 2011; Craig, Plume, McVeigh, Pringle, & Amin, 2007), this still shows that authors believe that open access publishing is useful enough to employ strategically. Logically, then, authors may seek to ensure that their publications are accessible and visible to as wide a variety of search methods as possible. This could start from attempting to get articles published in high profile journals or conferences, but may also include depositing them in institutional or subject repositories, advertising them in listservs and social media, listing them in online CVs, and listing or depositing them in academic social network sites, including ResearchGate. Whilst some authors may believe that their work only needs to be listed in one place in order that other researchers may be able to find it, each additional place listing their work is an additional chance for it to be found, especially by scholars that do not conduct extensive literature searches or who just use a general search engine (Haglund & Olsson, 2008). If an author chooses to self-archive in only one place then their choice of venue probably depends upon their level of access to them and perhaps also field and institutional norms. It may also be that archiving in ResearchGate or other sites is sometimes conducted by administrators on behalf of academics, if an institution believes that it is important.

Assuming that the increased visibility benefits of listing publications in multiple places online outweigh the cost of the time taken to register them, individuals and organisations that adapt to new methods of disseminating research online seem likely to gain increased recognition. This multiple online availability of research can presumably increase citation impact (Xia, Myers & Wilhoite, 2011).

Institutional rankings

Although research impact metrics can be used to evaluate individual academics, metrics for education, research and prestige are also used to rank and compare institutions. There are currently several international ranking schemes for universities, some of which use citations to an institution's articles to estimate its impact (Buela-Casal, Gutiérrez-Martínez, Bermúdez-Sánchez, & Vadillo-Muñoz, 2007). Nevertheless, there have been debates about whether bibliometric methods should be used for ranking academic institutions (e.g., van Raan 2005; Ioannidis et al., 2007). There seem to be five well-known institutional ranking schemes.

- QS World University Rankings: aims to rank "the world's top universities" based upon academic reputation (40%, from a global survey), employer reputation (10%, from a global survey), faculty-student ratio (20%), citations per faculty (20%, from Scopus), the proportion of international students (5%), and the proportion of international faculty (5%) (http://www.iu.qs.com/university-rankings/world-university-rankings/, December 21, 2013).
- THE World University Rankings: aims "to judge world class universities across all of their core missions - teaching, research, knowledge transfer and international

outlook" (http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking, December 21, 2013) using the Web of Science, an international survey of senior academics and self-reported data. The results are based on field-normalised citations for five years of publications (30%), research reputation from a survey (18%), teaching reputation (15%), various indicators of the quality of the learning environment (15%), field-normalised publications per faculty (8%), field-normalised income per faculty (8%), income from industry per faculty (2.5%); and indicators for the proportion of international staff (2.5%), students (2.5%), and internationally co-authored publications (2.5%, field-normalised) (http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking/methodology, December 21, 2013).

- The Academic Ranking of World Universities (ARWU) aims to rank the "world top 500 universities" based upon " the number of alumni and staff winning Nobel Prizes and Fields Medals, number of highly cited researchers selected by Thomson Scientific, number of articles published in journals of Nature and Science, number of articles indexed in Science Citation Index - Expanded and Social Sciences Citation Index, and per capita performance with respect to the size of an institution" (http://www.shanghairanking.com/aboutarwu.html, December 21, 2013).
- The CWTS Leiden Ranking aims to measure "the scientific performance" of universities using bibliometric indicators based upon Web of Science data through a series of separate size- and field-normalised indicators for different aspects of performance rather than a combined overall ranking. For example, one is "the proportion of the publications of a university that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited" and another is "the average number of citations of the publications of a university, normalized for field differences and publication year" (http://www.leidenranking.com/methodology/indicators, December 21, 2013). These are perhaps the most sophisticated indicators, both in the nature of the calculations and in the data cleaning for the indicators but only reflect research perfomance aspects of a university.
- The Webometrics Ranking of World Universities Webometrics Ranking aims to show "the commitment of the institutions to [open access publishing] through carefully selected web indicators" (http://www.webometrics.info/en/node/19, December 21, 2013): hyperlinks from the rest of the web (1/2), web site size according to Google (1/6), and the number of files in the website in "rich file formats" according to Google Scholar (1/6), but also the field-normalised number of articles in the most highly cited 10% of Scopus publications (1/6) (http://www.webometrics.info/en/node/19, December 21, 2013).

Current international ranking systems thus use a variety of factors in their calculations, including web presence, number of publications, citations to publications and peer judgements (Aguillo, Bar-Ilan, Levene, & Ortega, 2010). Despite typically reflecting a combination of different factors, as shown above, and with different objectives, they tend to give similar rankings. This suggests that universities producing good research also tend to have an extensive web presence, perform well on teaching-related indicators, and attract many citations. Any new website that attempts to be a general resource for academics, such as ResearchGate, therefore raises the possibility that statistics derived from it could be used for a new ranking scheme for academic institutions. Nevertheless, even the top institutions

vary between ranking schemes, suggesting that there are substantial differences between the schemes. For example, UK universities seem to perform particularly well in the Quacquarelli Symonds (QS) World University Rankings, which relies heavily on international peer judgements but the questionnaires for these had the higher rates of return in the USA and UK than elsewhere, at least in 2008 (Huang, 2012). Similarly, ranking systems that rely upon bibliometric databases can inherit language and international biases from them (Archambault, Vignola-Gagné, Côté, Larivière, & Gingras, 2006; van Leeuwen, Moed, Tijssen, Visser, & Van Raan, 2001) and the results can be misleading if the data is not properly cleaned or field-normalised. Perhaps most importantly, however, the concept of rankings for universities is probably flawed in itself. It may be reasonable to rank universities on specific, narrowly defined aspects of their goals, as the CWTS indicators do to some extent, but any general ranking must necessarily be based upon a series of simplifying assumptions and heuristics, such as the percentages given to each category making up an indicator, and so the results should only be taken as very approximate even if the methods used are essentially sound. Perhaps university ranking schemes survive because they are useful marketing tools for universities that perform well in them, with the marketers that use them perhaps not being as concerned with their validity as would bibliometricians.

Country rankings and international comparisons

It is important to assess the international uptake of new science-related websites, like ResearchGate, in order to appreciate their reach and to assess whether they are being virtually ignored in any part of the globe. For this, it is useful to start from existing academic country rankings as benchmarks. Although less visible than institutional rankings, there are some attempts to rank countries based on their scientific production (Leydesdorff, 2012). Such rankings can help to identify the relative success of different nations and identify countries that are increasing or decreasing their scientific success relative to other countries. This can aid policy-making because individual nations can use rankings to judge the success or failure of their policy initiatives or to judge global trends (Zhou & Leydesdorff, 2006). Rankings can be based upon total productivity in a particular database or can be based upon citations in a bibliometric database and may be limited to a particular field (Hu & Rousseau, 2009) or could be general. Similar techniques can also be used to compare specific nations (Kostoff, 2008) or sets of nations (Hu & Rousseau, 2009).

Academic social network sites and altmetrics

Although academics can use institutional or subject repositories to list or store their publications or may list and link to them from a traditional web CV, publications can also be listed or hosted in various social web sites (Allen et al., 2013; Mas Bleda et al., 2014). Perhaps the first social web sites supporting authors to list their references were online reference managers like Mendeley (Henning & Reichelt, 2008), Zotero (Ritterbusha, 2007), CiteULike (Bogers & Bosch, 2008) and Connotea (Hull, Pettifer, & Kell, 2008). Although originally intended as sites for students and academics to list and share their references, they incorporated social networking features and a logical extension was to allow users to list and promote their own publications as part of a personal home page. The main difference now is perhaps one of emphasis because sites like Adacemia.edu and ResearchGate appear to be primarily spaces for academics to describe themselves and their works and to connect with others. Perhaps a more fundamental difference is that Adacemia.edu and ResearchGate currently do not have reference sharing functionalities.

A by-product of academic use of the social web is that it is possible to identify statistics about the popularity of individual articles within social websites, which has led to the creation of new online indicators for article impact and the emergence of the field of altmetrics (Priem, Taraborelli, Groth, & Neylon, 2011). Whilst several years are needed to gauge the citation impact of an article, counting the number of tweets (Eysenbach, 2011) or blogs (Shema, Bar-Ilan, & Thelwall, in press) mentioning it can give an early indication of its likely eventual citation impact and most altmetric studies have focused on evaluating them or interpreting them for sets of articles (Sud & Thelwall, in press; Thelwall, Tsou, Weingart, Holmberg, & Haustein, 2013), although not always with positive results (e.g., Haustein, Peters, Sugimoto, Thelwall, & Larivière, in press). Altmetrics can also give evidence of different aspects of the impact of an article compared to traditional citations (Thelwall, Haustein, Larivière, & Sugimoto, 2013). For example, although the number of readers of Mendeley articles correlates with their citations, Mendeley readers are likely to reflect more educational impact to a larger extent than do citations (Bar-Ilan et al., 2012; Li, Thelwall, & Giustini, 2012; Mohammadi & Thelwall, in press). The impact of an academic within Academia.edu seems not to correlate with their offline impact, however, perhaps because more senior academics are less likely to list all their publications in the site (Thelwall & Kousha, in press).

Few altmetrics have been used to rank institutions or countries, perhaps because they are typically most easily available for individual articles and the metadata for individual articles may not contain author institutional affiliation or country location information. Academia.edu and ResearchGate do not have this problem, however, because authors are naturally organised into institutions in both sites. In addition, ResearchGate presents a ranked list of institutions in its website (https://www.researchgate.net/institutions/), although this does not appear to be widely publicised.

No previous research has investigated altmetrics derived from ResearchGate. There are five different logical sources of such altmetrics.

- *Total publications*: The number of publications listed by an academic in their profile. This can be aggregated by institution (or country) to give an academic scholarly output indicator for the quantity rather than the quality, value or impact of the traditional scholarly outputs. At the institutional level it would be affected by the extent to which scholars joined ResearchGate and populated their profiles as well as the size of the institution. In addition it would be affected by field norms in the quantity of outputs produced, especially if an institution had large departments in areas with a particularly high or low average numbers of outputs.
- *Total impact points*: The cumulative journal Impact Factors of the publications of an academic. Aggregated by institution (or country) the results reflect a combination of quantity and (journal-based) citation impact. This seems to be a better institutional research quality indicator than total publications although it suffers from all of the same limitations as well as some additional problems of the journal Impact Factor. Perhaps most significantly, the raw impact points are not field-normalised and so would advantage institutions specialising in areas with a high citation impact and disadvantage institutions specialising in the arts and humanities.
- *Downloads*: The total number of downloads recorded by ResearchGate for full-text articles uploaded to the site by the author. Aggregated by academic, institution or country, the results would indicate the extent of readership for the article(s) concerned. Although reading an article does not equate to the article having an impact, it

nevertheless seems reasonable to consider download counts as a type of impact indicator because it seems likely that extensively-read articles will have had an impact in some way, such as within science, education or applications. In addition to having the same problems as total publications, downloads are probably biased towards fields with a large undergraduate student audience for research as well as being biased towards fields that allow articles to be published open access and for which many potential readers do not have access to the articles from other places (e.g., digital repositories or widely used open access journals).

- *Views*: The total number of views recorded by ResearchGate for the meta-data of articles. Aggregated by academic, institution or country, the results would indicate the extent of interest for the article(s) concerned and would probably correlate highly with download counts, when full-text articles were available in the site. The biases are probably similar to those for downloads, although perhaps less substantial for articles with full text easily available in other places.
- RG Score: This is a number for each academic and institution calculated by ResearchGate using an algorithm that is not fully disclosed but which is based upon contributions to members' ResearchGate profiles, interactions with other members and reputation amongst other members. This presumably includes components from the above four indicators and hence shares their limitations. In addition, its activity component gives a large bias towards academics and institutions that employ ResearchGate the most, making it a hybrid scholarly achievements and site use indicator.

Research questions

The dual purposes of this article are to assess whether ResearchGate statistics reflect existing academic hierarchies in the sense that they can give plausible rankings of institutions and whether leading science nations are unequal in their uptake of the site, as encapsulated in the following research questions. The first research question is important not only to investigate the use of ResearchGate but also because one ranking is already published by ResearchGate and others can be relatively easily calculated and so their possible meanings should be assessed. The second research question is based upon the assumption that the use of ResearchGate should be approximately proportional to the amount of research conducted by a country, and so any discrepancies between ResearchGate indicators and national science rankings would suggest relatively high or low uptake for the site within any given country. Assuming that ResearchGate use is valuable for scientists, the results would point to countries that are likely to benefit from, or lose out from, the site.

RQ1: Do ResearchGate indicators give similar rankings to established university ranking schemes?

RQ2: Are some countries making more (or less) use of ResearchGate than would be expected for their position in world science?

Methods

A list of institutional home pages in ResearchGate was obtained in October 2013 from https://www.researchgate.net/institutions/ by repeatedly hitting the *More* button until the list was complete (taking about a day). This appears to be a complete list of institutional home pages in ResearchGate (over 31,000 URLs). The list of institutions was crawled by

SocSciBot (http://socscibot.wlv.ac.uk) in October 2013 to download the home page and the statistics page for each institution, using the *SocSciBot* multiple simultaneous crawls option and entering the home pages as a list of starting pages for individual crawls. For example, the University of Wolverhampton home page is https://www.researchgate.net/institution/University_of_Wolverhampton and its statistics page is https://www.researchgate.net/institution/University_of_Wolverhampton/stats. The crawl took place 10-15 October, 2013 with an additional crawl 25-26 October 2013 for institutions returning no results). The crawl was set to a rate of one page per 5 seconds to avoid overloading the ResearchGate servers. *Webometric Analyst* (http://lexiurl.wlv.ac.uk) was then used to extract relevant statistics from the crawled pages, using a new function written for this purpose (in the *Services* menu). Institutions without any statistics were removed from the results as were pages for subunits within a university, such as departments.

ResearchGate provides statistics about how often an institution's publications have been downloaded and viewed and also reports the number of weekly downloads and views from the three countries most downloading and viewing each institution's publications. Manual checking of the weekly results revealed anomalies in these statistics, however, such as more downloads than views in some cases as well as values that were too large to be credible, suggesting large scale systematic activities. As a result, the statistics about the top three countries and institutions were not analysed. The statistics extracted and used for each institution were as follows.

- *Total RG Score* (from the institutional home page): The sum of the RG Scores of all members of the institution.
- *Total Impact Points* (from the institutional home page): The sum of the journal Impact Factors of all articles of all members of the institution. Presumably, this total (and the three totals below) includes all articles with at least one author from the institution, and articles with multiple authors from the same institution are only counted once.
- *Publications* (from the institutional home page): The number of publications listed in members' profiles.
- *Downloads* (from the institution stats page): The number of downloads of the institutions' publications in the previous week.
- *Views* (from the institution stats page): The number of views of the institutions' publication information pages in the previous week.

Publication statistics for each country were obtained by searching in October 2013 for journal articles published in 2013 in the Web of Science and restricting the results to just the country in question.

Results

The data was analysed separately for individual institutions and for entire countries.

Institutions

Correlations were calculated between the university ranking systems and ResearchGate metrics. Spearman correlations were used rather than Pearson because some of the data was sets of rankings rather than scores. Spearman correlations were used instead of Kendall's tau in the belief that the underlying relationship was likely to be approximately

linear, if present. If Kendall's tau values had been used then the magnitude of all the correlations would have been reduced, as is normal for this statistic, but none would have changed from positive to negative or vice versa. Rankings formed from the five ResearchGate values available for each institution correlated positively (Table 1) with all five existing ranking systems, with most values being medium (>0.3) or large (>0.5) (Cohen, 1988). The correlations were lower (not shown) if the ResearchGate values were size-normalised by dividing by the number of registered ResearchGate members.

Out of all the ResearchGate statistics, the total impact points have the highest correlations with the five academic ranking systems. This is unsurprising because it is based upon a traditional impact metric, the journal Impact Factor. The lower correlations for both ResearchGate views and downloads, despite being arguably more direct indicators of the value of an individual document, suggest that these statistics are a somewhat skewed reflection of the articles' academic impact. For instance, they may reflect educational impact rather than academic impact, may be too low (particularly for older articles) to give the statistic sufficient statistical power or perhaps many downloads and views are created by students from the same institution out of curiosity. Similarly, the ResearchGate score, which incorporates both impact and activity, had low correlations, suggesting that there was not a strong association between the most active members of ResearchGate and membership of the highest ranking institutions.

In general, the correlations between the ResearchGate scores and the academic rankings are lower than those between the rankings themselves. The highest of the former, 0.612 between total impact points and ARWU rankings, is higher than the correlations between the CWTS rankings and three of the other rankings, however. Overall, whilst the THE and ARWU rankings are the most similar to each other, total impact points, the CWTS ranking, the QS ranking and the Webometrics ranking do not stand out as anomalously different from each other. The average of the correlations between each system and the other five systems are: total impact points 0.514; CWTS 0.531; QS 0.556; Webometrics 0.568; THE 0.648; ARWU 0.668.

Table 1.Spearman correlations between the ResearchGate (RG) metrics and different university ranking indictors.

	RG score	Total impact points	RG total pubs	RG downlds	RG views	THE rank[a]	QS rank[b]	ARWU rank[c]	CWTS rank[d]	Webo. rank[e]
RG score	1	.829 n=300	.817 n=300	.877 n=300	.970 n=300	.426 n=200	.342 n=200	.327 n=100	.200 n=276	.483 n=200
Total impact points		1	.952 n=300	.692 n=300	.813 n=300	.530 n=200	.474 n=200	.612 n=100	.366 n=276	.589 n=200
RG total pubs			1	.683 n=300	.814 n=300	.519 n=200	.442 n=200	.522 n=100	.237 n=276	.579 n=200
RG downlds				1	.902 n=300	.438 n=200	.333 n=200	.365 n=100	.299 n=276	.522 n=200
RG views					1	.483 n=200	.412 n=200	.401 n=100	.233 n=276	.523 n=200
THE rank[a]						1	.725 n=158	.791 n=93	.568 n=186	.627 n=133
QS rank[b]							1	.652 n=87	.521 193	.408 n=127
ARWU rank[c]								1	.634 n=98	.650 n=83
CWTS rank[d]									1	.567 n=192
Webo. rank[e]										1

a) The Times Higher Education Ranking (2013-2014). http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking
b) The QS World University Rankings (2013). http://www.topuniversities.com/university-rankings/world-university-rankings/2013
c) The Academic Ranking of World Universities (2013). http://www.shanghairanking.com/ARWU2013.html
d) The CWTS Leiden Ranking (2013). http://www.leidenranking.com/ranking (proportion of top 10% publications)
e) The Webometrics Ranking of World Universities (2013). http://www.webometrics.info/en/WORLD

Some of the correlation differences in Table 1 could be due to the different sample sizes, especially if, as could be expected, the order at the top of the rankings was more similar than the order of the rankings lower down so that correlations based upon small numbers (which would mainly be the highest ranked universities) would be higher than correlations based upon larger numbers (which would include more low-ranked universities). To test for this, Table 2 reports the correlations for the 74 institutions with exact rankings reported by all of the systems (i.e., excluding all institutions for which at least one of the systems did not report an exact rank). The total impact points again have the highest correlations of the ResearchGate metrics with all the other ranking systems. Similarly, also, whilst the total impact points are again the most out of step with the other systems compared to their correlations with each other, the difference remains not large. The average correlations with the other five systems are: total impact points 0.467; CWTS 0.504; QS 0.535; Webometrics 0.572; THE 0.696; ARWU 0.703.

Table 2. Spearman correlations between the ResearchGate (RG) metrics and different university ranking indictors (n=74 in all cases).

	RG Score	Total impact points	RG total pubs	RG down.	RG views	THE rank[a]	QS rank[b]	ARWU rank[c]	CWTS rank[d]	Webo. rank[e]
RG score	1	0.699	0.653	0.795	0.952	0.157	0.233	0.205	-0.084	0.251
Tot. imp. pts		1	0.940	0.544	0.719	0.523	0.444	0.603	0.227	0.540
RG total pubs			1	0.530	0.681	0.421	0.311	0.487	0.066	0.522
RG downld.				1	0.857	0.204	0.227	0.289	0.046	0.387
RG views					1	0.256	0.326	0.306	-0.039	0.251
THE rank[a]						1	0.808	0.831	0.658	0.659
QS rank[b]							1	0.690	0.379	0.355
ARWU rank[c]								1	0.671	0.721
CWTS rank[d]									1	0.585
Webo. rank[e]										1

a) The Times Higher Education Ranking (2013-2014). http://www.timeshighereducation.co.uk/world-university-rankings/2013-14/world-ranking
b) The QS World University Rankings (2013). http://www.topuniversities.com/university-rankings/world-university-rankings/2013
c) The Academic Ranking of World Universities (2013). http://www.shanghairanking.com/ARWU2013.html
d) The CWTS Leiden Ranking (2013). http://www.leidenranking.com/ranking (proportion of top 10% publications)
e) The Webometrics Ranking of World Universities (2013). http://www.webometrics.info/en/WORLD

All the ResearchGate indicators in tables 1 and 2 are not size-normalised but can be normalised using data from within the site, such as dividing document views and document downloads by the number of documents, and dividing impact scores and RG scores by the number of members. With such normalisations, the correlations in Table 1 and Table 2 decrease, however. For member normalisation, this is presumably because a higher proportion of researchers or a greater numbers of students join from more successful universities. For document normalisation, this is presumably because the volume of publishing is part of the reason for the success of universities, rather than primarily the average quality of each publication. Figures 1 and 2 illustrate the relationship between the raw indicators with the highest correlation (ResearchGate impact points and the AWRU scores underlying the AWRU rankings) and the same for the normalised version of the impact points indicator. The main difference may be just a single point, Rockefeller University, which had only 328 ResearchGate members and specialises in biological sciences and medical science research (it was called The Rockefeller Institute for Medical Research until 1965). Its status as an outlier in Figure 2 is probably due to its specialisation in high impact research areas and its relatively small size. In contrast, the apparent outlier status of the University of Washington in Figure 1 may be due to a combination of its large size, successful medical school (medicine is a high impact research area) and perhaps also extensive use of ResearchGate. The relatively low ResearchGate scores in both figures for Harvard, in contrast, could be due to its more balanced portfolio and perhaps a lower uptake of ResearchGate (for Figure 1). Perhaps the most important implications for the use of any ResearchGate indicator for ranking is therefore that size and field normalisation are essential (despite the lower correlations found after normalisation) in order to get any kinds of reasonable indicators of an aspect of science performance, assuming that this is desirable.

To check that there were different levels of uptake of ResearchGate between institutions, the number of ResearchGate Publications for 258 of the top insitutions was divided by their

number of publications in WoS 2006-13 (an arbitray range, given that ResearchGate publications could be older). The ratio ranged from 0.01 (Florida State University System) to 1.9 (University of Illinois, Chicago), a substantial difference (the mean was 0.9). Harvard was below average (0.2) compared to the mean (0.9), explaining its relatively low ResearchGate values.

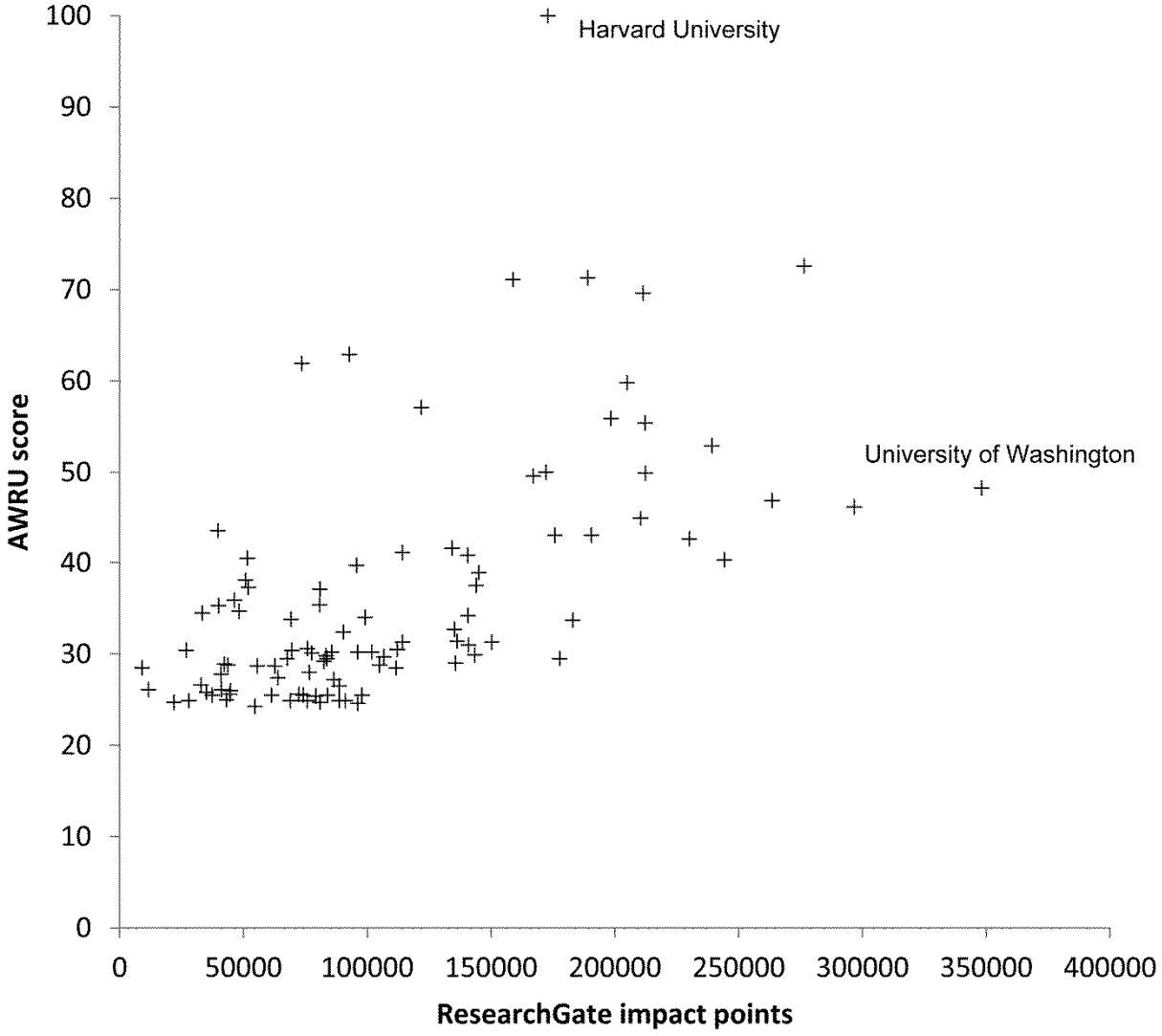

Figure 1. AWRU score against ResearchGate impact points for the top 100 institutions in AWRU.

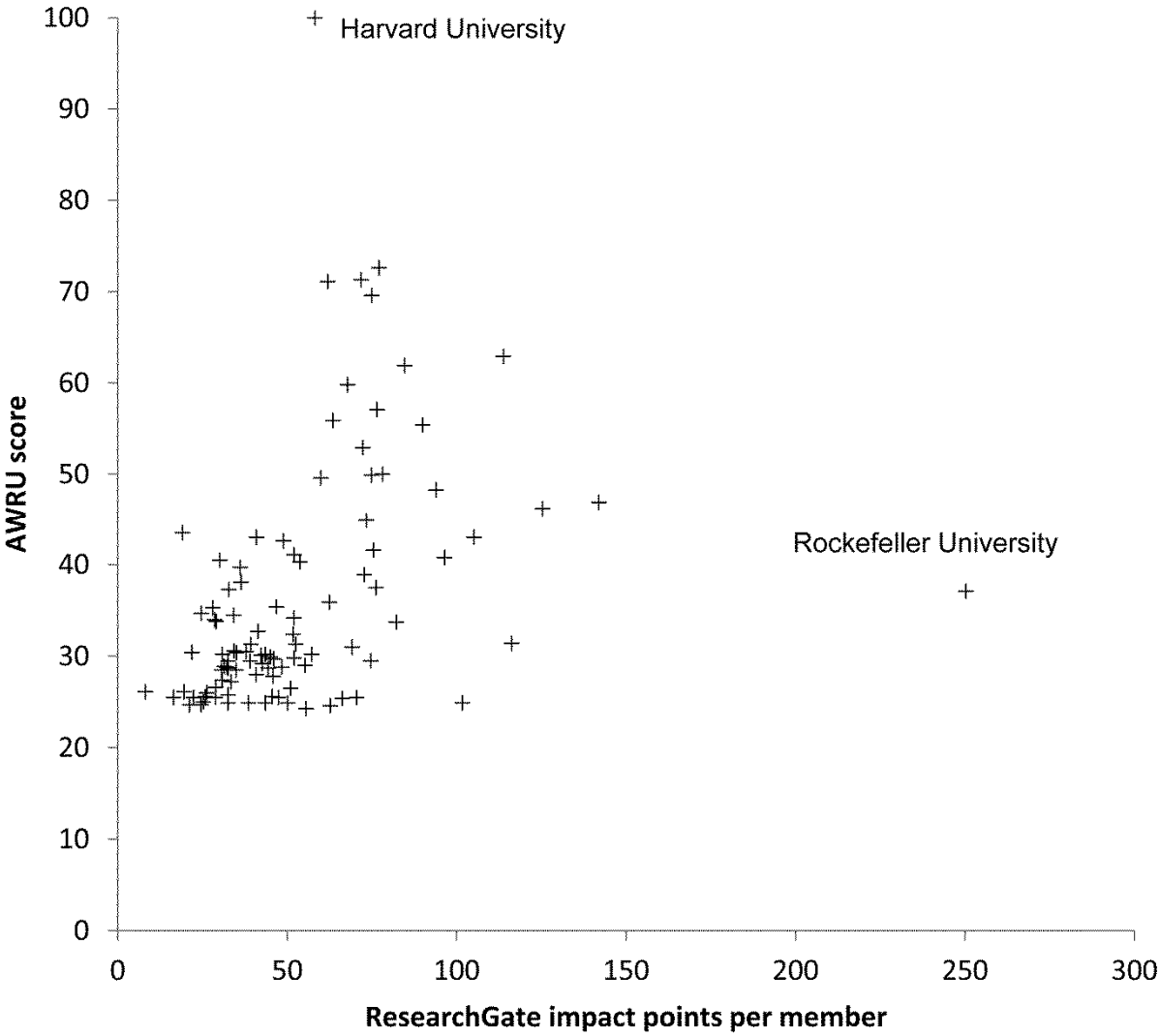

Figure 2. AWRU score against ResearchGate impact points per member for the top 100 institutions in AWRU.

Countries

Figure 3 is an attempt to identify the extent to which different countries record their publications in ResearchGate, by dividing by WoS publications from the first part of 2013. Although ResearchGate publications will include that are older than 2013, so the purpose of the 2013 WoS figures is to serve as a benchmark. The results suggest substantial differences in ResearchGate uptake between countries, with the USA the relatively largest publisher and China the smallest. The differences presumably reflect different research cultures and different levels of familiarity with social web use for research, although different national specialisms may also be a factor.

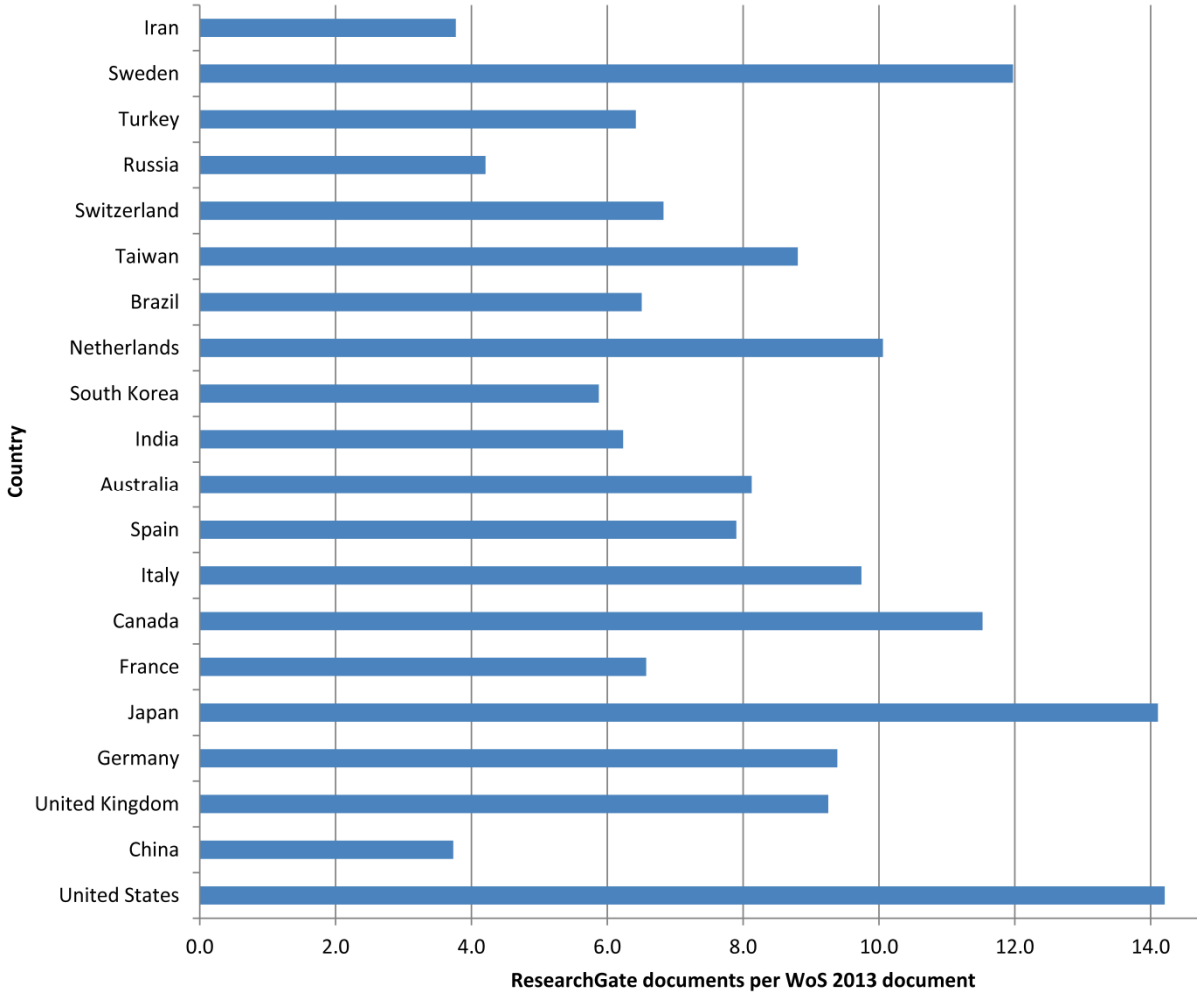

Figure 3. The ratio of ResearchGate publications to WoS 2013 publications for the top 20 countries for total WoS publications in 2013. Countries are listed in order of total WoS publications.

Figure 4 reports three ResearchGate participation statistics for countries (total members, publications and Research Gate scores), using the largest user, the USA, as a benchmark. All of the statistics reported vary according to the size of the countries and, more specifically, according to the size and strength of their science systems, but the focus here is on relative differences between the statistics rather than on the absolute values of the statistics. Compared to the USA, some countries are making relatively little use of ResearchGate. These countries can be identified in Figure 4 from their three ResearchGate bars being shorter than their WoS bar. The most notable case is China, which has over half as many WoS publications as the USA but less than 15% as many members or publications as the USA. South Korea and Russia are similar cases. Perhaps surprisingly, no country has relatively many publications in ResearchGate compared to WoS publications. The opposite may have been suspected given that there is no quality control in ResearchGate in contrast to WoS journals; ResearchGate could, in theory, contain many low quality articles, whereas the USA is known for high quality research. The logical explanation for this is that US scholars are particularly active in uploading their papers to ResearchGate. Hence, in terms of publicity for publications, and perhaps counter intuitively, the USA seems to benefit from ResearchGate.

In contrast, some countries seem to provide particularly many ResearchGate members, including India, Brazil and Iran. This may reflect users in higher education rather than active scientists. Italy, France, Spain, the Netherlands, Brazil and Sweden all have relatively high ResearchGate scores, presumably reflecting particularly active engagement in the site because it reflects "how both your published research and your contributions to ResearchGate are received by your peers" (https://www.researchgate.net/RGScore/FAQ/ 9 November 2013).

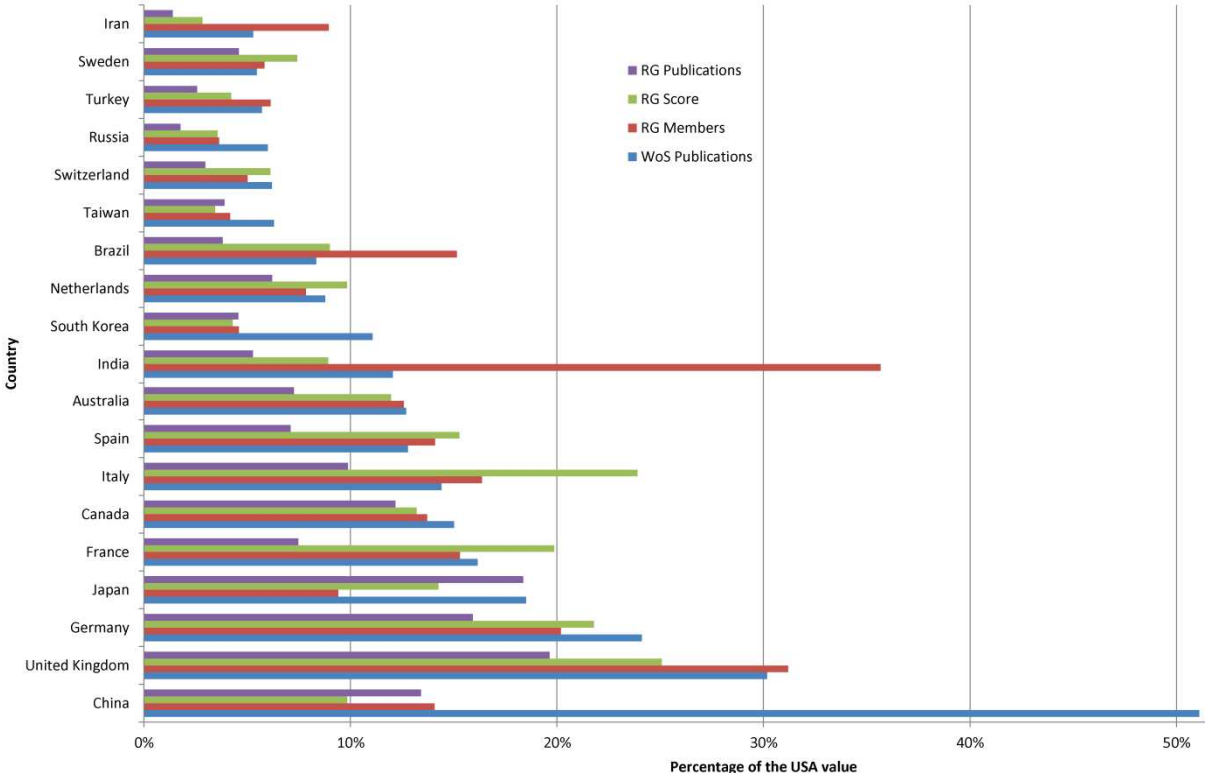

Figure 4. The top 20 countries for total WoS publications in 2013, with their WoS publications and ResearchGate members, publications and scores expressed as a percentage of the US value. Countries are listed in order of total WoS publications and the USA (100% for all four measures) is not shown.

Discussion and Limitations

An important limitation of this research is that the results reflect use of ResearchGate at a specific point in time and hence are likely to change if its membership increases substantially, as seems possible. For example, duplicate crawls in August and October 2013 of the same websites found an increase of 13% in members, 7% in publications and 15% in ResearchGate scores during these two months alone. In addition, the ability of academic social network sites to host open-access copies of publications may change in response to legal challenges by publishers (Clarke, 2013) and so ResearchGate may not be able to function in the future as it did in 2013.

The correlations reported above carry no evidence of causation. Hence it has not been demonstrated that an institution is likely to have high values of ResearchGate statistics *because* of its high academic status since unanalysed factors, such as institutional size, may relate to both. In particular, the ResearchGate metrics with the highest correlation with the

existing rankings were all not normalised for institutional size and it seems intuitively that this is unfair.

Another limitation is that the top institutions seem to dominate ResearchGate currently in some ways, and so the findings may not be relevant to typical universities. For example, out of all 10,653 institutions crawled that had a threshold of at least 10 members and 10 publications the ResearchGate sites of the 200 top universities listed in the Times ranking (2%) account for 19% of the members and 31% of the publications. A consequence of this is that high quality papers are probably over-represented on ResearchGate, similar to the case for open access articles in general, mentioned above (Craig et al., 2007).

Although the data shows that institutional success in rankings associates with various ResearchGate statistics, the results do not demonstrate that use of ResearchGate would be advantageous to researchers. Even though the site aims to help researchers communicate with each other and disseminate their publications, the correlations found do not show whether this is successful. In particular, there are no findings about the extent to which ResearchGate helps individual academics or their publications to gain visibility or impact and doubt about the efficacy of open access publication in general (Gaulé & Maystre, 2011; Craig et al., 2007) increase the uncertainty about the value of ResearchGate. Related to this, and in support of ResearchGate acting as a preprint archive, in November 2013 there were a few citations to publications with ResearchGate URLs in both Scopus (50) and Google Scholar (630). This is a tiny number compared to the number of citations to the arXiv.org e-print archive, which has over 25,000 citations from Scopus publications. These figures are not comparable, however, because arXiv.org is older and is explicitly for articles before publication, whereas ResearchGate does not seem to play the role of an accepted preprint archive for any scholarly community. Presumably most articles found in ResearchGate would not be cited with ResearchGate URLs but with post-publication information (e.g., journal or conference name) and so it seems likely that ResearchGate is much more useful for finding publications than the two URL citing statistics suggest.

The six ranking schemes analysed here (i.e., ResearchGate impact points plus the five established rankings) do not attempt to rank institutions based upon the same properties, such as research success, but all have different implicit or explicit goals. Out of all of them, ResearchGate impact points and the CWTS rankings give the purest reflection of research impact, with the latter being size-normalised and field-normalised and hence giving a much fairer research ranking. Nevertheless, these two have the lowest correlation of all of the six ranking schemes. This suggests that the correlation between ResearchGate impact points and the other schemes could be mainly due to factors other than average research performance, such as institutional size. Another factor might be reputation, assuming that universities are more highly ranked by systems other than the CWTS rankings if they publish extensively in high impact areas, such as medicine. For example, the top institution in ResearchGate for impact points, the University of Washington at Seattle (CWTS rank 27), has 13% of its impact points from its Department of Medicine, despite this department containing only 2% of its ResearchGate members.

Conclusion

The comparisons of the rankings between institutions found that total impact points correlated moderately with all of them and whilst it correlated less well, in general, with the other rankings than they did with each other, the difference was not large. If the uptake of ResearchGate increases then it seems likely that the correlation between the ResearchGate

metrics and existing university ranking schemes will increase as ResearchGate becomes more comprehensive. It is not clear what the limit of the correlation will be, however, and in any case the ranking has biases for institutional size and for research in high impact areas. It remains to be seen whether universities will take ResearchGate-based rankings seriously, however, and whether ResearchGate would want this. In addition, if the rankings are taken seriously then there may be attempts to spam or manipulate them in some ways. Nevertheless, the significant positive correlations between the total impact points and other rankings go some way towards validating ResearchGate as a genuine academic web site. Negative or small correlations, in contrast, could have undermined its credibility.

More importantly, the moderate correlations between the various ResearchGate metrics and academic rankings (whatever their limitations and however they should be interpreted) suggest that it is being adopted on a large scale in the world's elite academic institutions and that patterns of use within it reflect traditional academic capital to some extent. This aligns with similar findings from Academia.edu derived with different methods (Thelwall & Kousha, in press). Overall, then, academic social network sites seem likely to reflect traditional academic capital at least to some extent, but it is not clear if there are specific ways in which they can also alter patterns scholarly communication, other than through differing international levels of use.

The substantial international differences in the uptake of ResearchGate suggest that, if it is important for research dissemination, then the research of some nations will be disproportionately be advantaged or disadvantaged. Presumably, the international differences reflect linguistic or cultural norms but since science dissemination is important, it seems that countries like China should take steps to remedy their apparent failings in this regard. Nevertheless, if the low uptake in China reflects more extensive Chinese use of other sites or methods to disseminate articles that are more effective then this advice is not urgent.

Finally, ResearchGate view counts and download counts for individual articles may also prove to be useful indicators of article impact in the future. They were not analysed in the current article because the figures are not embedded in the HTML of the web pages, when crawled, but they may well be useful to give individual authors feedback about which of their articles are proving to be the most popular, especially if this points to articles that are popular despite being uncited. This could occur, for example, for recently-published articles or articles that have value primarily in education or in an applied context.

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