# Usage of different Web Impact Factors for Ranking Australian Universities*

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**This study describes how search engines (SE) can be employed for automated, efficient data gathering for Webometric studies using well defined query specfic URLs in SE (predictable URLs). It then compares the usage of staff-related Web Impact Factors (WIFs) to web impact factors for a ranking of Australian universities, showing that rankings based on staff-related WIFs correlate much better with an established ranking from the Melbourne Institute than commonly used WIFs. In fact WIFs do not correlate with the Melbourne ranking at all. It also compares WIF data for Australian Universities provided by Smith [1] for a longitudinal comparison of the WIF of Australian Universities over the last decade. It shows that size-dependent WIF values declined for most Australian universities over the last ten years, while staff-dependent WIFs shows a riding trend.**

## 1. Introduction

This paper explores the application of various forms of web impact factors as a method of ranking Australian universities. Currently assessment of universities is based primarily on citation-related measurements and other panel judgements. As the Internet has changed the way in which academic matters are disseminated among professionals and the wider community, attempts have been made to investigate how universities incorporate the Web to create measures reflecting levels of Web activities. Early moves in this direction were made by

Rousseau [2], Aguillo [3], Chen, et al. [4], and Ingwersen [5]. Since then large scale rankings are published biannually for approximately 15,000 higher education institutions worldwide by Cybermetrics Lab (2008). However, the methodology used to establish the ranking is limited to relatively simple counts which are mainly dependent on the size of an institution – for a description, see Aguillo, et al. [6, 7]. Clearly a major university with a large staff can produce more webpages that are more often linked-to than a smaller institution with far fewer staff. Therefore simple measures based on size are not always appropriate when a more complex comparison of universities of various sizes is required. To overcome size-based comparisons, Ingwersen [5] suggests the use of WIFs for comparing universities on the Web.

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Over the last decade the WIF has become a common measure in Webometrics (Björneborn and Ingwersen [8,9], Ingwersen and Björneborn [10]) to compare the activities of universities on the Web; WIF is the number of links pointing to a specific university's domain divided by the number of pages under this domain (Ingwersen [5]). WIFs were used recently to evaluate universities in Africa (Onyancha and Ocholla [11]). Studies comparing Australian universities using WIF's include Smith [1], and Smith and Thelwall [12] and a critical review of WIFs is provided by Noruzi [13]. There are different ways of calculating WIF's, which use different definitions of the links involved. Thelwall, Vaughan, & Björneborn [14] classify three types of links depending on where links originate and what they point to: inlinks, outlinks and selflinks. Most studies give two values of the WIF based on the number of inlinks and selflinks, which are sometimes combined into an overall WIF. Because a comprehensive coverage of the Web is necessary to obtain correct estimates of the number of links pointing towards a university's homepage, search engines (SE) are used to find all links pointing to a university's domain. However, the use of SE for data gathering places some limitations as they have mainly a commercial interest and the ability to undertake link analysis is merely a by-product and often not supported by all major SE. Some limitations include: incomplete coverage of the web; varying time-outs between queries and therefore fluctuating result numbers for the same query. For a closer look at the limitations faced when using SE, see for example Thelwall [15], Wouters, Hellsten & Leydesdorf [16] and more generally Bar-Ilan [17]. Due to the limitations, Thelwall [18,19]) and Thelwall and Wilkinson [20] use their own crawler for data gathering when comparing UK universities.

Thelwall and Harries [21] restricted their analysis to pages with academic content only after manually classifying all pages into academic and non-academic ones. Using this approach they could show a slight improvement of the correlation between a university's research performance and WIF, as compared to using all content provided under a university's domain. As this approach involves immense manual effort, other approaches seem more promising. For example, the aggregation of links on the directory or domain level rather than the file level has been undertaken by (Thelwall [22]). Also, Thelwall [23], Li, et al. [24] and Thelwall and Harries [25] showed that employing staff numbers rather than the number of pages as a denominator can be successfully used to compare institutions of different sizes. This study takes the approach one step further by examining whether restricting staff to those engaged in teaching and research rather than to all staff can provide even better results.

Sometimes the WIF is compared to Google's PageRank algorithm. However, this comparison fails since PageRank does not give equal weights to each link; it varies depending on where a link is coming from (Page, Brin, Motwani and Winograd [26]). In fact by using PageRank, a web page receiving just one link from a highly linked webpage could rank much higher than a webpage receiving hundreds of links from lesser linked pages. The current study applies this idea to webometrics when comparing universities, thus giving different weights to inlinks depending on where they originate. It also uses the number of links pointing to a university's homepage from academic webpages within Australia and abroad versus links coming from non-academic webpages. The assumptions are that links from academic institutions have greater weight than links from the general Web and that links from academic pages abroad are still more valuable as they are often thought to be harder to receive than those from other national institutions (Bharat et al.[27], Thelwall [28]). Differences in the quality of inlinks have been highlighted before by, for example, Thelwall [29]). This study will investigate if and to what extend weighting links can improve the ranking of webpages.

## 2. Methodology and Data

A list of 39 Australian universities and their URLs was created in 2007. For four institutions which changed their domain name between 1999 and 2007, the former URLs used by Smith [1] were included in addition to the current domain in order to do justice to web content still hosted under the old domain names. For the staff numbers the most recent higher education statistics from Australia (DEST [30]) was used to obtain staff numbers for teaching and research and for overall staff working in each university. The reported numbers of full time equivalent staff were used in order to balance out differences in the share of casual and part time staff at different universities.

Table 1: List of Australian Universities

| *University* | *URL* |
|---|---|
| Australian Catholic U | www.acu.edu.au |
| Australian National U[1] | www.anu.edu.au |
| Bond U[2] | www.bond.edu.au |
| Central Queensland U | www.cqu.edu.au |
| Charles Darwin U | www.cdu.edu.au<br>www.ntu.edu.au[3] |
| Charles Sturt U | www.csu.edu.au |
| Curtin U of Technology | www.curtin.edu.au |
| Deakin U | www.deakin.edu.au |
| Edith Cowan U | www.ec.edu.au<br>www.cowan.edu.au[3] |
| Flinders U of South Australia | www.flinders.edu.au |
| Griffith U | www.griffith.edu.au<br>www.gu.edu.au[3] |
| James Cook U | www.jc.edu.au |
| La Trobe U | www.latrobe.edu.au |
| Macquarie U | www.mq.edu.au |
| Monash U[1] | www.monash.edu.au |
| Murdoch U | www.murdoch.edu.au |
| Queensland U of Technology | www.qut.edu.au |
| RMIT U | www.rmit.edu.au |
| Southern Cross U | www.sc.edu.au |
| Swinburne U of Technology | www.swinburne.edu.au<br>www.swin.edu.au[3] |
| U of Adelaide[1] | www.adelaide.edu.au |
| U of Ballarat | www.ballarat.edu.au |
| U of Canberra | www.canberra.edu.au |
| U of Melbourne[1] | www.unimelb.edu.au |
| U of New England | www.une.edu.au |
| U of New South Wales[1] | www.unsw.edu.au |
| U of Newcastle | www.newcastle.edu.au |
| U of Notre Dame | www.nd.edu.au |
| U of Queensland[1] | www.uq.edu.au |
| U of South Australia | www.unisa.edu.au |
| U of Southern Queensland | www.usq.edu.au |
| U of Sydney[1] | www.usyd.edu.au |
| U of Tasmania | www.utas.edu.au |
| U of Tech. Sydney | www.uts.edu.au |
| U of the Sunshine Coast | www.usc.edu.au |
| U of Western Australia[1] | www.uwa.edu.au |
| U of Western Sydney | www.uws.edu.au |
| U of Wollongong | www.uow.edu.au |
| Victoria U | www.vu.edu.au |

[1]University is part of the G8 universities (http://www.go8.edu.au); [2]University is not included in this study, see text; [3]Former domain of university.

For *Bond University*, a private funded, profit oriented organization, no staff numbers were reported in the higher education statistics, therefore it was excluded from further analysis, leaving 38 Australian universities. This exclusion is in line with other comparative studies of Australian universities (e.g. Williams [31]). Table 1 lists the 39 Australian universities and their URLs.

The search engine *Exalead.com* was used to obtain the number of inlinks pointing to each university's homepage. Unlike Google, *Exalead* allows searching for inlinks to a web page on a domain-wide basis, a necessary requirement for this research; in contrast Google can only approximate the number of links pointing to individual pages, but not to all the pages within a university's domain. Noruzi [13] points out the coverage bias of search engines favouring pages under certain Top Level Domains (TLD), thus making Web Impact Factor (WIF) comparisons among different countries problematic. However, it is assumed that *Exalead's* coverage of Australian webpages is not biased towards any one of the Australian universities as they all share the same country TLD; hence allowing unbiased comparisons. *Exalead* has also been used by other projects for data gathering (Cybermetics Lab [32]).

Searches in *Exalead* were executed using 'predictable' URLs; these include the commonly used search strategies in the URLs. These search strategies permit efficient execution of a large number of internet searches within a short time frame to ensure that results are not affected by time lags between searches. An example of a predictable URL used to gather the number of webpages indexed by *Exalead* for the *Australian National University* is: *http://www.exalead.com/search/results?q=site%3Aanu.edu.au*. To get the numbers for other universities their domain names are used: '*anu.edu.au*' is replaced by, for example, '*usyd.edu.au*' for *University of Sydney*. Predictable URLs generated this way were used for all 38 universities. The same technique using predictable URLs to obtain the total number of inlinks to and selflinks from each Australian university was used to obtain the numbers of inlinks from other academic institutions in the UK (ac.uk) and the US (edu). Table 2 provides the general queries used.

Table 2: Predictable URL's used for Exalead

| *Query to get the no of ...* | *Predictable URL embedding the necessary query*[1] |
|---|---|
| ... files under a university's domain indexed by Exalead | http://www.exalead.com/search/results?q=site%3AXXX |
| ... links pointing to a university's domain (including selflinks) | http://www.exalead.com/search/results?q=link%3AXXX |
| ... links pointing to a university's domain from the domain itself (selflinks) | http://www.exalead.com/search/results?q=link%3AXXX+site%3AXXX<br>-OR WITH REVERSED ORDER OF THE SEARCH TERMS-<br>http://www.exalead.com/search/results?q=site%3AXXX+link%3AXXX |
| ... links pointing to a university's domain excluding selflinks (inlinks) | http://www.exalead.com/search/results?q=link%3AXXX+-site%3AXXX<br>-OR WITH REVERSED ORDER OF THE SEARCH TERMS-<br>http://www.exalead.com/search/results?q=-site%3AXXX+link%3AXXX |
| ... links pointing to a university's domain from academic domains in Australia (incl. selflinks) | http://www.exalead.com/search/results?q=link%3AXXX+site %3Aedu.au<br>-OR WITH REVERSED ORDER OF THE SEARCH TERMS-<br>http://www.exalead.com/search/results?q=site%3Aedu.au+link |
| ... links pointing to a university's domain from academic sites in the UK | http://www.exalead.com/search/results?q=link%3AXXX+site%3Aac.uk<br>-OR WITH REVERSED ORDER OF THE SEARCH TERMS-<br>http://www.exalead.com/search/results?q=site%3Aac.uk+link%3AXXX |
| ... links pointing to a university's domain from academic sites in the US | http://www.exalead.com/search/results?q=link%3AXXX+site%3Aedu<br>-OR WITH REVERSED ORDER OF THE SEARCH TERMS-<br>http://www.exalead.com/search/results?q=site%3Aedu+link%3AXXX |

[1]In all queries XXX has to be replaced with the domain of each university.

The syntax of search engines generally allows only direct searching for the number of pages under a domain and the total number of links pointing to a site with the operators *site:* and *link:* respectively. As the *link:* operator combines selflinks and inlinks into one value, boolean logic is used in formulating search strategies for queries returning the number of selflinks and the number of links from the .ac.uk; .edu; and .edu.au domains. However, the use of boolean queries in search engines can be problematic; Ingwersen [5] and Smith [1] have pointed out that the order in which terms are combined using the boolean 'and' influences the number of sites retrieved, even though this should not be the case when boolean logic is strictly applied. Smith [1] posits a reason for this behaviour: the variation of time-outs is dependent on the search engine's workload at the time of a search. In order to uncover the extent to which the inconsistencies affect the results, our study used alternative search strategies with alternating order of the boolean operators for all searches using more than one operator. All boolean identical searches are listed in Table 2.

For downloading the searches '*wget*', a command line download client and mirroring tool for different platforms, was used (http://www.gnu.org/ software/wget/ wget.html). Downloading the result pages for all searches allowed storage for further off-line analysis after completion of all searches. The use of predictable URLs along with *wget* ensured timely execution of all searches. After all searches were downloaded a combination of four freely available unix command line tools were used to extract the number of hits from the html files for each search: *cat*, *grep*, *sed* and *cut*. *Cat* was used to display all html files as a continuous line by line stream, from which *grep* extracted just the lines containing the number of search results using pattern matching. *Sed* then eliminated from each line all characters preceding the result numbers and *cut* eliminated all trailing characters. The 'cleaned' output was written into a text file containing just the result numbers in separate lines for each search. This text file was then imported into Excel. The combination of these programs enabled convenient and quick execution of numerous searches and preparation of the data for further analysis. As all programs are freely available and no programming skills are required to use them, this methodology allows automated data gathering and extraction for future Webometric studies. After looking at the result numbers retrieved for each search from a test run, it was evident that for some searches results were incomplete. This occurred in searches where varying the order of search terms gave different result numbers. Inconsistencies appeared infrequently and in a second test run, we concluded that the differences were caused by varying time-outs of the search engine, depending on the workload of the search engine at the point of each search (Smith [1]). In order to minimise the effect of time-outs the whole search was repeated ten times within 24 hours. Then the maximum value for each search was taken. As incomplete number of search results occurred only in some searches, using the average would affect the number of results for incomplete searches more than for others; therefore, the maximum value was used. This is also in line with the assumption that the highest number of results will be retrieved at the point of the search engine's lowest workload. Additionally, comparing the differences for the number of results for Boolean-equivalent searches using the maximum values shows clearly a decreasing effect on Boolean inconsistencies. That is, the numeric differences between identical queries are much smaller when the maximum values of all ten instances are compared with each other as opposed to the two values retrieved during just one instance.

The size-dependent WIF is calculated by dividing the number of inlinks to a university's domain by the number of websites at that Domain (1). The staff-dependent sWIF is likewise calculated by dividing the number of inlinks to a university's domain by the number of Full Time Equivalent (FTE) staff of the University (2).

$$WIF = \frac{\text{Number of Inlinks}}{\text{Number of Web Site}} \qquad (1)$$

$$sWIF = \frac{\text{Number of Inlinks}}{\text{Number of Staff}} \qquad (2)$$

Table 3: Comparison Size, Inlinks and external Web Impact Factor in 1999 to 2008 – in decreasing order by the overall size in 2008. sWIF is used for 'Staff WIF'.

| *University* | *Size 2008* | *Size 1999*[1] | *Inlinks 2008* | *Inlinks 1999*[1] | *WIF 2008* | *WIF 1999*[1] | *sWIF 2008* | *sWIF 1999* |
|---|---|---|---|---|---|---|---|---|
| U of New South Wales | 294,324 | 26,586 | 93,841↑ | *16,483* | 0.32 | 0.62 | 22.4 | 4.2 |
| Australian National U | 169,680 | 45,526 | 277,682 | *75,118* | 1.64 | 1.65 | 78.9 | 25.9 |
| U of Melbourne | 154,393 | 66,944 | 104,153 | *64,266* | 0.67 | 0.96 | 18.0 | 14.1 |
| RMIT U | 139,636 | 17,178 | 47,835 | *18,380* | 0.34 | 1.07 | 21.0 | 8.9 |
| Swinburne U of Tech.[3] | 136,603↑ | 12,750 | 23,253↑ | *5,610* | 0.17 | 0.44 | 24.4 | 6.7 |
| U of Queensland | 105,889 | 24,994 | 76,849 | *34,992* | 0.73 | 1.40 | 14.0 | 7.8 |
| U of Sydney | 97,653 | 33,277 | 89,892 | *31,280* | 0.92 | 0.94 | 16.9 | 6.6 |
| Monash U | 88,287 | 38,653 | 164,993 | *47,543* | 1.87 | 1.23 | 29.3 | 11.2 |
| Murdoch U | 82,081 | 13,247 | 27,573↑ | *7,683* | 0.34 | 0.58 | 22.3 | 7.3 |
| Macquarie U | 60,462 | 16,606 | 41,200 | *13,949* | 0.68 | 0.84 | 23.4 | 9.8 |
| U of Adelaide[2] | 46,269 | - | 55,870 | - | 1.21 | - | 23.1 | - |
| U of Western Australia | 45,195 | 20,950 | 47,562 | *21,369* | 1.05 | 1.02 | 16.1 | 9.0 |
| U of Technology Sydney | 43,682 | 15,749 | 26,147 | *12,442* | 0.60 | 0.79 | 12.8 | 7.5 |
| Charles Sturt U | 39,499 | 10,684 | 31,194 | *18,483* | 0.79 | 1.73 | 19.9 | 12.9 |
| Curtin U of Technology | 37,137□ | 7,398 | 24,796 | *9,987* | 0.67 | 1.35 | 9.7 | 4.6 |
| James Cook U | 37,005 | 13,363 | 13,967 | *6,949* | 0.38 | 0.52 | 9.1 | 6.7 |
| U of Tasmania | 36,964 | 10,955 | 30,389 | *10,955* | 0.82 | 1.00 | 17.8 | 8.0 |
| U of South Australia | 31,154 | 10,533 | 17,151 | *8,321* | 0.55 | 0.79 | 7.9 | 4.6 |
| Queensland U of Tech. | 29,194↓ | 13,715 | 31,740 | *10,012* | 1.09 | 0.73 | 10.3 | 3.7 |
| Deakin U | 27,058 | 8,323 | 13,763 | *5,909* | 0.51 | 0.71 | 6.2 | 3.2 |
| U of Newcastle | 26,870 | 8,892 | 18,492 | *9,603* | 0.69 | 1.08 | 9.5 | 4.8 |
| Griffith U[3] | 24,304 | 10,890 | 20,655□ | *17,533* | 0.85 | 1.61 | **7.1** | 8.2 |
| U of Southern Queensland | 21,298□ | 2,097 | 7,439 | *3,376* | 0.35 | 1.61 | 6.1 | 3.4 |
| U of Wollongong | 20,193 | 8,601 | 18,534 | *6,451* | 0.92 | 0.75 | 12.4 | 5.2 |
| La Trobe U | 19,690↓ | 11,405 | 23,925 | *13,002* | 1.22 | 1.14 | 10.1 | 6.3 |
| Central Queensland U | 17,574 | 8,264 | 9,908↓ | *6,033* | 0.56 | 0.73 | 8.7 | 6.6 |
| Southern Cross U | 17,496 | 6,255 | 12,461 | *5,942* | 0.71 | 0.95 | 17.2 | 10.0 |
| Flinders U of SA | 17,318 | 7,646 | 16,330 | *7,646* | 0.94 | 1.00 | 10.7 | 5.4 |
| U of Canberra | 16,536↓ | 10,201 | 10,698□ | *9,895* | 0.65 | 0.97 | 13.0 | 12.4 |
| U of New England | 13,249 | 5,291 | 16,483↑ | *5,132* | 1.24 | 0.97 | 13.9 | 4.1 |
| Edith Cowan U[3] | 11,945 | 3,358 | 10,242 | *4,567* | 0.86 | 1.36 | 6.8 | 3.2 |
| Charles Darwin U[3] | 11,465 | 3,507 | 14,773↑ | *2,350* | 1.29 | 0.67 | 34.3 | 5.6 |
| U of Western Sydney | 10,792□ | 9,449 | 9,736□ | *8,882* | 0.90 | 0.94 | 5.0 | 4.2 |
| Victoria U[3] | 9,274 | 4,608 | 12,127 | *3,594* | 1.31 | 0.78 | 8.9 | 3.2 |
| U of Ballarat | 5,740 | 2,195 | 2,993 | *1,317* | 0.52 | 0.60 | 5.8 | 3.2 |
| U of the Sunshine Coast[2] | 4,011 | - | 1,764 | - | 0.44 | - | 4.8 | - |
| Australian Catholic U[2] | 2,048 | - | 4,645 | - | 2.27 | - | 5.3 | - |
| U of Notre Dame[2] | 1,102 | - | 1,110 | - | 1.01 | - | 3.8 | - |
| Total/Average | 1,953,070 | 510,090 | 1,452,161 | 525,056 | 0.84 | 0.99 | 15.45 | 7.31 |

↑/↓= Rank changed by more then 5; □/□=Rank changed by more than 10; [1]Size and WIF for 1999 were taken from Smith (1999), The number of Inlinks for 1999 were calculated using size and WIF for 1999; [2]University was not included by Smith (1999); [3]URLchanged between 1999 and 2007, for details see Table 1.

## 3. Results and Discussion

Table 3 gives a comparison of the 2008 data for this study with that of Smith's [1]. Overall the results show clear progress in terms of the visibility and links to Australian universities on the Web. The number of individual sites indexed by *Exalead* in early 2008 that are related to Australian universities has increased nearly four-fold (383%) in less than a decade. The growth rates for individual universities show that all but three universities have at least doubled the number of pages indexed and seven universities show growth rates above the national average – up to eleven times the size reported by Smith [1]. This means that the growth of indexed web pages for each university is not equally distributed over all universities, with the mode of 295% being vastly different from the mean of 383%. Looking at the ranking of universities by the number of Web pages indexed (size) and comparing the rankings for 1999 with 2008 show that ranking positions do not change dramatically for most universities. However, three universities changed their rank position by more than ten and seven by more than five. It is important to point out that even though the ranking for 2008 includes four more universities than the ranking for 1999, this had no dramatic effect on the total rank position of the other universities as three of the four universities were ranked last.

In terms of links pointing to content provided on the Web by Australian universities the increase was not as drastic as for the increase in the number of indexed Web pages. Still in links to Australian universities show an increase of 277% over the last nine years with 26 out of the 34 universities (with 1999 values) at least doubling the number of links pointing to them. In contrast to the number of indexed pages for each university the growth rates for the number of in links seem to be more balanced among all universities with a mode of 230% not being vastly different from the mean of 277%. Comparing the rankings of universities by the number of in links between 1999 and 2008 again shows no large fluctuations in the ranking positions of the universities. Just two universities changed positions by more than ten while nine universities changed by more than five positions. Similar to the ranking of universities by the number of indexed pages, the additional four universities in the ranking for 2008 (but not for 1999) had little effect on the ranking of the other universities as (once again) three of the four were found among the four lowest ranking positions.

The imbalance in the increase of the number of content (higher) and the number of links pointing towards that content indicates a marked decrease in the average and overall WIFs of Australian Universities as defined by Ingwersen [5]. This means that all but six of the universities (for which comparison of the WIF is possible) showed a decrease of their impact on the web. This is, however, counterintuitive to the fact that the overall presence of Australian universities on the Web, as represented in the index of search engines and the number of links to that content, has improved vastly over the last nine years. However, the biggest problem of the original definition of the WIF seems to be that universities putting up more content on the web are disadvantaged by their WIFs as more content means a wider spread of the number of links received. This shortcoming of the WIF has been pointed out by Thelwall [33,22] and previously hinted earlier by Ingwersen [5]. Thelwall [22] therefore suggests using the number of full-time equivalent staff working at each university to calculate WIFs. This method of calculating the WIF still pays tribute to the fact that universities of different sizes can produce different amount of content, but does not disadvantage universities that encourage their staff to put up more content on the web which is not likely to receive many links; one example is large amounts of raw data. Using the staff numbers for 1999 (DEST [34]) and Smith's [1] data allowed the calculation of staff-related WIF (sWIF) for 1999 and comparing them with the 2008 data. Even though the staff numbers increased for almost all Universities, the number of Inlinks were increasing at a higher rate; therefore; the sWIF improved for all universities except *Griffith University*, (see Table 3). The decrease for *Griffith University* may be due to a substantial increase in staff from 2,138 to 2,914 and the change of the domain name from *gu.edu.au* to *griffith.edu.au*. The latter may lead to a number of dead links form other Web pages pointing to sites on the university's old domain no longer in existence or have been removed from the database. The staff-related WIF seems therefore more promising than the domain size-related, as it does not disadvantage web pages with more content and furthermore, shows growth characteristics more closely related to the growth of a university's internet site.

The next step in our analysis looked at the origins of the top level domains links to Australian universities. As links from other academic sites are of special interest, the analysis looked at the number of links coming to each university from three academic top level domains: links from academic web pages from the UK under the top level domain (TLD) *ac.uk*; links from academic web pages mainly from the USA under the TLD *edu* and links from other Australian academic web pages (including other universities) coming from web pages under the TLD *edu.au*. The results are displayed in Table 4 and show that most of the links were coming from the general web for all of the universities, with an average of 86%. Not surprisingly, for the academic domains there seems to be a clear trend for links from other Australian universities with an average of 7% inlinks, followed by the US (5%), and a few from the UK (2%). However, the difference between the UK and the US is perhaps due to the overall greater number of academic websites in the US.

Looking closely at the results for the UK reveal that the percentage of links coming from the UK is well above the average of 1.9% for *Central Queensland University* (14.2%), the *University of South Australia* (9.9%), *RMIT* (8.0) and *Charles Sturt University* (5.3%). A closer look at the links pointing to these four universities from the TLD *ac.uk* showed that in all four, the web pages were heavily linked by the same source in the UK, making up at least 50% of all incoming links from *ac.uk* for each university. Six universities had a high percentage of inlinks from other Australian academic sites, for three of them the reason for this seems to be not a high number of links, but a very small number of overall inlinks pointing to them (<3000), therefore enabling a relatively low number of links reaching a high percentage. In the other three cases it is explained by being abnormally heavily linked by one other university. In the four cases of universities heavily linked from the edu TLD (>5000), no irregularities in common could be found after browsing the top 1000 results.

For the comparison of different possible rankings of Australian universities by the number of inlinks per staff, irregularities for the number of inlinks as described in the previous paragraph were corrected. Four different ways of calculating the staff-related WIF were applied: using all staff members or just the teaching and research related staff members as the denominator, non-weighted and weighted number of inlinks as the numerator. The notion of weighting inlinks arises from the assumption that links from other academic web pages are more indicative of the high status of universities than links from the general web. Furthermore it was assumed that attracting international academic links is more prestigious than national academic links. Therefore, inlinks from other Australian web pages were given twice the weight of links from the general web and inlinks from academic related web pages overseas were weighted four times. The numbers of inlinks and weighted inlinks achieved per staff member are displayed in Table 5. All four ranking methods achieved similar results with ranking positions not deviating more than 1 among all ranks for 49% of the universities and not more than 3 for 82% of the universities.

Though the results seem plausible for most of the universities, there were some notable exceptions; for example, *Charles Darwin University* at Rank 2 throughout just behind *Australian National University*. To further test if sWIF based rankings of Australian universities are a valid method of ranking presence on the web, the results of all four ranking methods were compared to the 2007 ranking of Australian Universities by the Melbourne Institute (Williams [31]). The assumption here is that sWIF based rankings should not be significantly different from the Melbourne Institute ranking if they are valid methods for ranking Australian universities. That is, in spite of the different results in the ranking methods, there should be a general tendency for universities to cluster in the top, middle or bottom rankings in both. To test this assumption Spearman's correlation coefficients were calculated between the Melbourne Institute ranking and each of the four sWIF based ranking methods. All rankings correlate significantly (at the 0.05% level) with the Melbourne Institute Ranking; however, looking at the correlation coefficients in Table 6 indicate that using total staff

Table 4: Number and Percentage of Links for each University for ac.uk; edu; edu.au and other Pages in 2008 – In decreasing order of the total number of Inlinks.

| *University* | *ac.uk* | *edu* | *edu.au* | *other web* | *Inlinks (Total)* | *% ac.uk* | *% edu* | *% edu.au* | *% other* |
|---|---|---|---|---|---|---|---|---|---|
| Australian National U | 2110 | 13977 | 5858 | 255738 | 277682 | 0.8 | 5.0 | 2.1 | 92.1 |
| Monash U | 1004 | 8478 | 20831 | 134681 | 164993 | 0.6 | 5.1 | 12.6 | 81.6 |
| U of Melbourne | 652 | 3664 | 14368 | 85470 | 104153 | 0.6 | 3.5 | 13.8 | 82.1 |
| U of New South Wales | 811 | 4377 | 4856 | 83798 | 93841 | 0.9 | 4.7 | 5.2 | 89.3 |
| U of Sydney | 845 | 4358 | 5292 | 79398 | 89892 | 0.9 | 4.8 | 5.9 | 88.3 |
| U of Queensland | 812 | 3708 | 3823 | 68507 | 76849 | 1.1 | 4.8 | 5.0 | 89.1 |
| U of Adelaide | 467 | 10506 | 1995 | 42903 | 55870 | 0.8 | 18.8 | 3.6 | 76.8 |
| RMIT U | 3833 | 1929 | 948 | 41125 | 47835 | 8.0 | 4.0 | 2.0 | 86.0 |
| U of Western Australia | 439 | 5301 | 2059 | 39763 | 47562 | 0.9 | 11.1 | 4.3 | 83.6 |
| Macquarie U | 846 | 3601 | 1618 | 35135 | 41200 | 2.1 | 8.7 | 3.9 | 85.3 |
| Queensland U of Tech. | 189 | 1034 | 1429 | 29089 | 31740 | 0.6 | 3.3 | 4.5 | 91.6 |
| Charles Sturt U | 1668 | 1437 | 2237 | 25852 | 31194 | 5.3 | 4.6 | 7.2 | 82.9 |
| U of Tasmania | 228 | 1357 | 1685 | 27120 | 30389 | 0.8 | 4.5 | 5.5 | 89.2 |
| Murdoch U | 337 | 1082 | 1247 | 24908 | 27573 | 1.2 | 3.9 | 4.5 | 90.3 |
| U of Technology Sydney | 468 | 846 | 2085 | 22749 | 26147 | 1.8 | 3.2 | 8.0 | 87.0 |
| Curtin U of Technology | 249 | 1279 | 1420 | 21849 | 24796 | 1.0 | 5.2 | 5.7 | 88.1 |
| La Trobe U | 244 | 2333 | 1457 | 19893 | 23925 | 1.0 | 9.7 | 6.1 | 83.1 |
| Swinburne U of Tech. | 169 | 1078 | 1066 | 20941 | 23253 | 0.7 | 4.6 | 4.6 | 90.1 |
| Griffith U | 334 | 1069 | 1355 | 17899 | 20655 | 1.6 | 5.2 | 6.6 | 86.7 |
| U of Wollongong | 161 | 1142 | 1187 | 16044 | 18534 | 0.9 | 6.2 | 6.4 | 86.6 |
| U of Newcastle | 160 | 1137 | 1032 | 16164 | 18492 | 0.9 | 6.1 | 5.6 | 87.4 |
| U of South Australia | 1702 | 507 | 1400 | 13543 | 17151 | 9.9 | 3.0 | 8.2 | 79.0 |
| U of New England | 108 | 597 | 999 | 14780 | 16483 | 0.7 | 3.6 | 6.1 | 89.7 |
| Flinders U of SA | 141 | 708 | 1335 | 14146 | 16330 | 0.9 | 4.3 | 8.2 | 86.6 |
| Charles Darwin U | 356 | 1142 | 675 | 12601 | 14773 | 2.4 | 7.7 | 4.6 | 85.3 |
| James Cook U | 203 | 639 | 936 | 12190 | 13967 | 1.4 | 4.6 | 6.7 | 87.3 |
| Deakin U | 447 | 567 | 923 | 11827 | 13763 | 3.2 | 4.1 | 6.7 | 85.9 |
| Southern Cross U | 110 | 663 | 759 | 10929 | 12461 | 0.9 | 5.3 | 6.1 | 87.7 |
| Victoria U | 82 | 211 | 560 | 11275 | 12127 | 0.7 | 1.7 | 4.6 | 93.0 |
| U of Canberra | 118 | 717 | 975 | 8889 | 10698 | 1.1 | 6.7 | 9.1 | 83.1 |
| Edith Cowan U | 44 | 247 | 918 | 9033 | 10242 | 0.4 | 2.4 | 9.0 | 88.2 |
| Central Queensland U | 1404 | 490 | 703 | 7312 | 9908 | 14.2 | 4.9 | 7.1 | 73.8 |
| U of Western Sydney | 71 | 428 | 1279 | 7959 | 9736 | 0.7 | 4.4 | 13.1 | 81.7 |
| U of Southern Queensland | 112 | 428 | 551 | 6348 | 7439 | 1.5 | 5.8 | 7.4 | 85.3 |
| Australian Catholic U | 9 | 106 | 401 | 4130 | 4645 | 0.2 | 2.3 | 8.6 | 88.9 |
| U of Ballarat | 26 | 65 | 423 | 2480 | 2993 | 0.9 | 2.2 | 14.1 | 82.8 |
| U of the Sunshine Coast | 5 | 46 | 207 | 1506 | 1764 | 0.3 | 2.6 | 11.7 | 85.4 |
| U of Notre Dame | 1 | 20 | 142 | 948 | 1110 | 0.1 | 1.8 | 12.7 | 85.4 |

Table 5: Inlinks to Australien Universitis, for Weighted and Non-Weighted Links and for all Staff and Teaching and Research Staff only – Sorted by rank for all Staff weighted.

| University | *All Staff* | # | *All Staff weighted* | # | *T&R Staff* | # | *T&R Staff weighted* | # |
|---|---|---|---|---|---|---|---|---|
| Australian National U. | 78.9 | 1 | 94.3 | 1 | 145.4 | 1 | 173.7 | 1 |
| Charles Darwin U. | 34.3 | 2 | 46.3 | 2 | 76.9 | 2 | 103.9 | 2 |
| U. of Adelaide | 23.1 | 6 | 37.6 | 3 | 42.1 | 10 | 68.4 | 3 |
| Monash U. | 26.5 | 3 | 32.4 | 4 | 54.3 | 3 | 66.4 | 5 |
| Macquarie U. | 23.4 | 5 | 31.9 | 5 | 47.9 | 7 | 65.2 | 6 |
| Swinburne U. of Tech. | 24.4 | 4 | 29.4 | 6 | 49.7 | 6 | 60.0 | 8 |
| U. of New South Wales | 22.4 | 7 | 27.2 | 7 | 46.2 | 9 | 56.2 | 10 |
| Murdoch U. | 22.3 | 8 | 26.7 | 8 | 52.2 | 4 | 62.6 | 7 |
| Charles Sturt U. | 19.3 | 10 | 25.0 | 9 | 51.5 | 5 | 66.4 | 4 |
| RMIT U. | 19.5 | 9 | 23.2 | 10 | 42.0 | 11 | 49.9 | 11 |
| U. of Western Australia | 16.1 | 15 | 22.7 | 11 | 33.8 | 15 | 47.5 | 13 |
| U. of Tasmania | 17.8 | 11 | 21.6 | 12 | 40.6 | 12 | 49.2 | 12 |
| Southern Cross U. | 17.2 | 12 | 21.4 | 13 | 46.5 | 8 | 58.0 | 9 |
| U. of Sydney | 16.9 | 13 | 20.8 | 14 | 35.5 | 13 | 43.8 | 14 |
| U. of Melbourne | 16.8 | 14 | 20.4 | 15 | 35.4 | 14 | 42.9 | 16 |
| U. of Queensland | 14.0 | 16 | 17.2 | 16 | 27.6 | 19 | 33.9 | 19 |
| U. of Canberra | 13.0 | 18 | 17.2 | 17 | 32.6 | 17 | 43.2 | 15 |
| U. of New England | 13.9 | 17 | 16.5 | 18 | 32.6 | 16 | 38.8 | 17 |
| U. of Wollongong | 12.4 | 20 | 15.8 | 19 | 25.0 | 21 | 31.8 | 20 |
| U. of Technology Sydney | 12.8 | 19 | 15.8 | 20 | 29.9 | 18 | 36.8 | 18 |
| La Trobe U. | 10.1 | 23 | 14.0 | 21 | 22.3 | 24 | 30.8 | 22 |
| Flinders U. of SA | 10.7 | 21 | 13.3 | 22 | 23.1 | 23 | 28.6 | 25 |
| Curtin U. of Technology | 9.7 | 24 | 12.0 | 23 | 23.5 | 22 | 29.1 | 24 |
| Queensland U. of Tech. | 10.3 | 22 | 12.0 | 24 | 27.1 | 20 | 31.5 | 21 |
| U. of Newcastle | 9.5 | 25 | 12.0 | 25 | 21.3 | 26 | 26.9 | 26 |
| James Cook U. | 9.1 | 26 | 11.3 | 26 | 20.2 | 28 | 25.2 | 27 |
| Central Queensland U. | 7.8 | 28 | 10.8 | 27 | 21.4 | 25 | 29.5 | 23 |
| Victoria U. | 8.9 | 27 | 10.0 | 28 | 20.7 | 27 | 23.1 | 28 |
| U. of South Australia | 7.4 | 29 | 9.3 | 29 | 16.4 | 32 | 20.9 | 32 |
| Griffith U. | 7.1 | 30 | 9.0 | 30 | 17.4 | 30 | 22.1 | 29 |
| Edith Cowan U. | 6.8 | 31 | 8.0 | 31 | 18.3 | 29 | 21.5 | 30 |
| Deakin U. | 6.2 | 32 | 8.0 | 32 | 15.2 | 33 | 19.6 | 33 |
| U. of Southern Queensland | 6.1 | 33 | 7.8 | 33 | 16.5 | 31 | 21.4 | 31 |
| U. of Ballarat | 5.6 | 34 | 6.8 | 34 | 13.8 | 35 | 16.6 | 35 |
| Australian Catholic U. | 5.3 | 35 | 6.1 | 35 | 12.5 | 37 | 14.5 | 37 |
| U. of Western Sydney | 4.8 | 36 | 6.0 | 36 | 12.5 | 36 | 15.7 | 36 |
| U. of the Sunshine Coast | 4.7 | 37 | 5.5 | 37 | 14.2 | 34 | 16.7 | 34 |
| U. of Notre Dame | 3.8 | 38 | 4.5 | 38 | 9.7 | 38 | 11.4 | 38 |

Table 6: Spearman correlations between sWIF rankings, the size based WIF and Melbourne Institute 2007 Ranking

| *Model* | *Correlation* |
|---|---|
| Inlinks for all Staff* | 0.478 |
| Inlinks for all Staff (Weighted)* | 0.485 |
| Inlinks for T&R Staff* | 0.400 |
| Inlinks for T&R Staff (Weighted)* | 0.403 |
| Size based WIF | 0.228 |

*Correlation is significant on the 0.05 level.

numbers seem to give better results than limiting the staff numbers to teaching and research staff only. Using total staff numbers might also pay better tribute to variety of staff are involved in creating a university's web content. The higher value for both correlation coefficients based on weighted inlink counts over the non-weighted counterparts also indicate a slight advantage of weighted link counts over simple inlink counts.

In order to confirm the general advantage of the sWIF over the WIF, the correlation between the Melbourne Institute ranking and the WIF was tested using Spearman's ranking correlation coefficient. The result show no significant correlation for the WIF with the Melbourne Institute ranking. This confirms the earlier impression that the classic WIF as suggested by Ingwersen [5] seems to be a poor measure for ranking universities based on the quality of their research and teaching .

## 4. Conclusion

The study introduced a succinct description of the methodology and necessary software tools used for efficient data gathering for Webometric studies. All of the necessary software is freely available on the Internet and steps given in this paper allow other researchers to perform similar Webometric studies. It is, however, important to recognize the limitations when using search engines (SE) for data gathering in Webometric studies. Generally all studies using SE are affected by incomplete coverage of the Web and non-indexable content. More specific for this study is that search engines cover the Web differently and therefore the longitudinal comparison with Smith [1] could be affected: Smith used *AltaVista* for his searches rather than *Exalead*. However, the technology used by SE has changed dramatically over the last ten years and one can argue that even using *AltaVista* today would be like using an entirely different SE. Another limitation specific to this study is that it does not distinguish between different kinds of academic institutions within a specific top level domain (TLD). Therefore links coming, for example, from the *.edu* TLD encompass other academic pages and not just those from universities.

Some of the findings from previous research are confirmed in our study as under :

(1) The *Exalead* search engine appears to have overcome boolean retrieval inconsistencies; that is, retrieval results are not dependent on the order of terms entered in a search. However, it is important to execute multiple instances for each search in order to obtain results not affected by outliers for individual queries.
(2) The tendency for geographical proximity to influence links received was also found: Australian universities received the most links from other Australian academic institutions, rather than from the US or UK, despite the fact that academic institutions in the two countries outnumber those in Australia. Some further findings of our study include: WIFs based on staff numbers correlate significantly better with a classic ranking of the research performance of Australian universities than WIFs based on the number of webpages; and giving a higher weight to links from other academic institutions can improve the quality of the ranking. However, using only teaching and research related staff as the denominator for each university did not help to improve the ranking quality. This result indicates that weighted inlink counts based on a university's total staff might be the most favourable model when using staff-related WIFs for ranking universities.

It is important to keep in mind that Web based indicators like WIFs are just one set of indicators that can be used to evaluate institutions. For detailed comparisons of academic institutions, several methods should be combined including, for example, citation based measures, publication counts, and expert reviews. Therefore this study, based on webometric methods, is investigating just one aspect of academic institutional rankings. There is also a need to understand more fully what WIFs are measuring as they seem to introduce a new aspect into university rankings that differs from the classic rankings mainly based on research quality; WIFs produce slightly different results. WIFs might be sensitive to providing better and more information for prospective and current students and other researchers, in that WIFs reflect the extent to which universities are 'linked' to by the general public, industry, other institutions and researchers nationally and internationally. Clearly it seems a promising path to include some indicator based on the general web presence of universities into rankings schemes. However, as long as it is not clearly understood what WIFs are measuring, the weight given to them should not be equal to those of classic ranking methods. The study shows that if measured appropriately, Web-based indicators can be a part of a multi-criteria based ranking of higher education institutions.

## Addendum

Based on questions raised by the audience of the Fourth International Conference on Webometrics, Informetrics and Scientometrics & Ninth COLLNET Meeting on the 28 July – 1 August, 2008, Berlin, Germany we would like to make some additional comments on our research. Possibly the most important outcome of this research is the clear result showing that the use of a university's staff number as denominator when calculating WIFs generates university rankings which correlate significantly (0.05 level) to other well established rankings for the same universites. Whereas WIFs using the number of webpages do not correlate with other rankings at all. This provides a clear case for future researchers to base WIFs on staff numbers rather than the number of webpages. Also while WIFs based on staff numbers correlate significantly with other university rankings they produce different results and therefore seem to add an additional dimension to the comparison of universities. This additional dimension might reflect the different level of activity universities show on the net. Even though the ranking of Australian universities presented here seems plausible, it is only based on the representation of the Internet by the search engine *Exalead*. This means other search engines will represent the net differently and might therefore produce other results. Future research should therefore investigate how results obtained using *Exalead* differ from results based on other search engines, for example, *Alta Vista*.

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