Oceanographic research institutes on the World Wide Web: A comparison of websites in developed and developing countries

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Abstract

To date, there are only few webometric studies covering developing countries. This is surprising as the debate on the digital divide has raised attention for the uneven distribution of Internet access around the globe which in turn can be assumed to affect the composition of the World Wide Web.

This exploratory paper seeks to clarify whether web presence and visibility of research institutes varies across developed and developing countries in one specific research field. For a sample of ten small and medium-sized oceanographic research institutes in Germany, India, Kenya, Mauritius, Pakistan, South Africa and the United States page and link counts as well as a set of Web Impact Factors (WIFs) were determined. They were correlated with the United Nations' Human Development Index (HDI) as an indicator for the overall socio-economic situation of the institutes' host countries.

Using Spearman's coefficient, the number of webpages, files and outlinks all showed significant correlations with the HDI, but also with the number of scientific staff. The analysis of the WIFs revealed ambiguous results: While none of the WIFs that were based on the number of webpages correlated with the HDI, four of five staff-based WIFs exhibited a highly significant correlation with the HDI.

To summarise, the visibility of oceanographic research institutes on the Web (in terms of inlinks) matches their website size, but not their real size (in terms of scientific staff). These findings raise doubts about the World Wide Web being a leveller of global inequalities in the scientific information and communication system.

1 Introduction

In a large number of studies, based on co-authorship data, evidence has been found for an internationalisation process within science which has been going on for several decades and which stretches across many scientific disciplines and countries (see e.g. Frame & Carpenter, 1979; Luukkonen et al., 1992; Leclerc & Gagné, 1994; and for a more recent world-wide assessment Wagner & Leydesdorff, 2005). This clear trend is usually explained by political changes and incentives, by economic factors like sinking travelling time and costs, but also by improvements in information and communication technology (ICT). Especially e-mail and the World Wide Web are often considered indispensible instruments for the advancement of connectivity within the international scientific community (e.g., Stichweh, 1996). As the metaphor of the *global research village* (OECD, 1998) indicates, there have been great hopes that distance would not

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matter any longer in the age of modern ICT and that researchers in the whole world would live and work as virtual neighbours.

However, while ICT undoubtedly plays a significant role in the every-day routines of many scientists in developed and emerging countries, the question is whether it holds the same options for colleages in developing countries to gain cheap, fast and comfortable access to new ressources and communication partners. Under the catchword *global digital divide* (Drori & Jang, 2003) it has been argued that so far mainly those world regions have benefitted from the Internet which already had good access to resources and communication technologies before. Consequently, the Internet is said to reinforce rather than to level existing inequalities. This sceptical position is underpinned by the fact that Internet access is distributed unevenly around the globe. However, it is unclear to what extent this holds true for science and academia today. In empirical studies, Internet access at universities in some Asian and African developing countries has been described as limited, slow, unstable, and expensive (e.g. Ynalvez et al., 2005; Uddin, 2003; Ehikhamenor, 2003). Still, the empirical publications on this issue are few, and since most of them build on data collected more than five years ago, they do not allow for definite conclusions on the current situation.

While the digital divide debate is limited to the issue of Internet access, it entails a fundamental question for webometric research on the global scientific community: To what extent is a university's or a research institute's representation on the World Wide Web associated with the development status of the country it is located in? Two webometric properties are most relevant in this context: the *presence* and the *visibility* of academic and research institutions on the Web. [2] Web presence can be assessed by the number of the web pages, other files and outlinks included into a website. Visibility measures are based on the number of external inlinks. Normalised by the number of webpages or staff, these inlink counts are converted into Web Impact Factors (Li 2003).

Webometrics produced numerous new insights during the last decade. Although still struggling with the lack of standardisation and quality control on the Web as well as with shortcomings of the commercial search engines used as data collection tools, it has spawned a wide range of applications (Thelwall, forthcoming). However, comparative international studies covering developing countries are scarce in webometric research. Their results point to significant international differences in the size and the link struktures of academic websites:

An analysis of link patterns on university websites in Asia-Pacific countries by Thelwall and Smith (2002) showed that Japan and Australia clearly were the main sources and targets of links within this region in absolute number. At the same time, developing countries produced and received more links in proportion to the size of their web presences. This finding is plausible as even the smallest websites of academic and research institutes contain institutional or personal homepages and other pages providing basic information which are popular link targets (Bar-Ilan 2005). In contrast, larger websites contain substantial parts with more specific information which can be expected to be a link target as a whole rather than page by page.

Examining the websites of the psychology history, and chemistry departments of US universities, Tang and Thelwall (2004) found that the lion's share of all international inlinks came from Europe, Asia and Oceania plus Canada, while Central and South America, Africa, the Middle East and the South Pacific only played a marginal role as an inlink source.

Only recently, Onyancha and Ocholla (2007) published the first webometric study on two African countries. Comparing Kenyan and South African university websites, they detected large differences within the sample which they labelled as *content divid*e. This does not refer to qualitative website contents, but to the quantitative website volume in terms of pages and outlinks.

Little effort has been made to relate the magnitude of academic web presences to socio-

[2] These terms were borrowed from the Webometrics Ranking of World Universties; however, the indicators used differ (cf. http://www.webometrics.info/methodology.html, last accessed on 16 July 2008).

economical factors. Interpreting the results of a social network analysis of university websites in 25 countries in Europe and Asia, Park and Thelwall (2006) suggest that wealth rather than geographical location determines a nation's position in the examined link network.

So far, this hypothesis has only been tested at the European level. A comparison of academic websites from countries within and associated with the European Union has revealed considerable inter-country variations in size as well as a correlation of average website size and the national Gross Domestic Product (GDP) per capita (Thelwall et al. 2002). Despite a certain degree of internal variation, the European Union is a rather homogenious part of the world. Comparative information on the web presence and visibility of scientific institutions located in developing, emerging, and developed countries is still lacking.

Therefore, this work-in-progress paper seeks to shed some light on the question how the presence and visibility of research institutes on the Web relate to the development status of their host country. By comparing the virtual representation of a sample of research institutes we will collect some first evidence on whether existing global inequalities are mitigated, reproduced or even reinforced by the World Wide Web – which bears the promise of global communication in its name.

2 Method

A small sample of research institutes, located in different developed and developing countries but being part of the same research field, were examined with regard to their web presence and visibility.

2.1 Assessment of web presence and visibility

Webpage counts, file counts, and outlink counts were used to assess the institutes' web presence. These basic webometric measures were correlated with the institutional size, in terms of scientific staff, and with the Human Development Index (HDI) which served as a proxy for the overall socio-economic situation of the countries hosting the research institutes. A strong correlation with the number of scientific staff would suggest that the institutes are represented on the Web in proportion to their size. A marked correlation with the HDI would indicate that the web presence among these oceanographic research institutes is as unevenly distributed as the overall socio-economic situation.

The main webometric indicator for visibility on the web is the Web Impact Factor (WIF). In early applications, it was defined as the number of external inlinks to a particular webspace divided by the number of its pages. Later, the number of pages in the denominator was often replaced by the number of staff working in the institution which was represented by the examined website (Li 2003).

In this paper we caculated both versions of the WIF to assess the visibility of the sampled research institutes in proportion to their institutional size as well as to their websites' size. Focussing exclusively on inlinks with country-code Top-Level-Domains, four more specific versions of the WIF were built, grouping the inlinks into domestic and international inlinks, into inlinks from developed and from less developed countries (i.e. developing countries, least developed countries, and countries in transition, according to the United Nations classification; see section 4.2 for details).

Again, it was examined whether the websites' visibility was associated with the development status by correlating the each WIF with the HDI.

2.2 Sample

The results presented in this paper are part of a case study on the websites of oceanographic research institutes. Oceanography has been identified as a suitable field for two reasons. First, it is a highly international field in which global research programs, joint use of vessels and other equipment as well as internally co-ordinated data collection are common. While a website is virtually mandatory for reserach institutes in developed countries, this is still not true for those with limited ressources in some developing countries. We assumed that the latter might make the effort to establish and maintain

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a web presence soonest when being part of an international network. We also expected to find a minimum number of international inlinks even for the small websites so that a detailed analysis of inlink sources would be reasonable.

Second, a large share of oceanographic research is conducted at non-university institutes. This is an advantage for webometric analyses as they usually possess a specific domain so their webspace can be deliniated very easily. Moreover, their content can be expected to be comparatively homogenious with educational resources playing a minor role.

Because of the in-depth focus in some parts of this project which also include qualitative analysis the sample is not a random sample, but results from a web-based search for non-university research institutes with a clear oceanographic focus, located in countries in which English or German is an official language. Due the work of the United Nations Intergovernmental Oceanographic Commission, several portals on the Web provide a good overview over the research landspace in this field. Despite the high degree of international connectivity, and in contrast to many oceanographic research institutes existing in developed countries, those in developing countries were mostly rather small in terms of staff and website size. Two of them even had to be discarded since they lacked any institutional web presence at the time of investigation (the National Marine Information and Research Centre of Namibia and the National Oceanographic and Maritime Institute of Bangladesh). To keep the cases somehow comparable, the search was limited to research institutes with small and medium-sized websites even for the developed countries. Since the total number of oceanographic research institutes fulfilling these criteria was very small, all of them were included into the sample.

The sample covers ten institutes in the US, Germany, India, South Africa, Pakistan, Kenya and Mauritius (cf. Table 1).

Table 1: Sample of marine research institutes

institute	*acronym*	*country*	*HDI*	*scient. staff*	*website*
Bigelow Laboratory for Ocean Sciences	BLOS	USA	0.951	37	www.bigelow.org
Harbor Branch Oceanographic Institution	HBOI	USA	0.951	69	www.hboi.edu
Leibniz Institute of Marine Sciences	IFM	Germany	0.935	238	www.ifm-geomar.de
Leibniz Institute for Baltic Sea Research	IOW	Germany	0.935	89	www.io-warnemuende.de
Kenya Marine and Fisheries Research Institute	KMFRI	Kenya	0.521	90	www.kmfri.co.ke
Monterey Bay Aquarium Research Institute	MBARI	USA	0.951	99	www.mbari.org
Mauritius Oceanography Institute	MOI	Mauritius	0.804	12	moi.gov.mu
National Institute of Oceanography	NIO	India	0.619	177	www.nio.org
National Institute of Oceanography	NIOPK	Pakistan	0.551	29	www.niopk.gov.pk
Oceanographic Research Institute	ORI	South Africa	0.674	15	www.ori.org.za

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3 Data

This paper draws on two main and two additional data sources.

3.1 website data

All ten websites in the sample were crawled in July 2007 with the SocSciBot[3] in order to obtain the number of webpages and of non-web files, e.g. portable document, text, image, audio, video, data, executable and compressed files. Dynamic pages were included as long as technically possible. The data was manually cleansed of duplicates not identified by the crawler. For each website, the number of distinct outlinks was determined.

3.2 inlink data

Inlink data was collected via Yahoo's API in September 2007, assisted by the LexiURL-Searcher.[4] Our aim was to retrieve as many inlinks as possible and to avoid a regional bias. Combining the "linkdomain:" and "site:" operators with the Internet Assigned Number Authority's list of 270 country code and generic top-level domains (TLDs),[5] we compiled 270 queries for each website. Internal inlinks were excluded. Five TLDs (".ad", ".ax"., ".cat"., ".do", ".name") had to be omitted, since Yahoo obviously treated them as usual key words. The search engine reported hits for 412 out of 2.650 queries. Ten of them resulted in more than 1.000 hits, and thus exceeded Yahoo's output limit. Multiple inlinks from the same domain were removed. Accordingly, the inlink counts in this paper represent the number of inlink domains.

3.3 additional data sources

The number of scientific staff by end of the year 2007 was used as a measure of institutional size when comparing the websites and calculating the WIFs. It was collected from the websites of the oceangraphic research institutes, if there was a complete staff list available. Otherwise, it was requested via e-mail.

[3] freely available at http://socscibot.wlv.ac.uk/

[4] freely available http://lexiurl.wlv.ac.uk/

[5] cf. http://www.iana.org/domains/root/db/

As indicator for the development status of the research institutes host countries the United Nations' Human Development Index (HDI) 2007/2008 was applied.[6] It comprises different indicators of life expectancy, income, and educational enrolment and thus gives a more encompassing picture of the socio-economic situation than the GDP per capita alone.

4 Results

4.1 Small and medium-sized Web presence of oceanographic institutions

The number of webpages shows a medium correlation with the Human Development Index, only significant for Spearman's coefficient, as does the number of non-web files (cf. Table 2).

Table 2: Web presence
(* p<0.05, ** p<0.01)

institute	*webpages*	*files*	*outlinks*[7]
BLOS	972	1378	680
HBOI	905	786	342
IFM	3626	1396	2123
IOW	3960	3248	823
KMFRI	27	1	15
MBARI	5310	13372	2042
MOI	27	13	23
NIO	2915	2150	88
NIOPK	27	11	1
ORI	11	67	38
correlation with HDI			
Spearman	0.573*	0.622*	0.769**
Pearson	0.545	0.429	0.674*
correlation with number of scientific staff			
Spearman	0.718**	0.564*	0.588*
Pearson	0.641*	0.194	0.588*

While the webpage count shows a higher, significant correlation with the number of staff, only Spearman's coefficient is significant for the file count.

[6] cf. http://hdr.undp.org/en/media/hdr_20072008_tables.pdf, last accessed on 30 May 2008.

[7] As specified in the data section, this is the number of distinct outlinks, i.e. multiple outlinks to the same url are counted only once.

The outlink counts shows a medium significant association with the number of staff and a somewhat higher correlation with the HDI.

4.2 International visibility of small and medium-sized oceanographic institutions on the Web

Five different Web Impact Factors were built to obtain some information about the international visibility of the sample websites, each with the number of web pages and with the number of staff as denominators (Table 3 and 4).

The inlinks from all country-code and generic TLDs were included into the *general WIF*. For the *domestic WIF*, only inlinks featuring the country-code TLD (ccTLD) of an institute's host country were counted. For the US institutes, besides ".us" the generic TLDs ".edu", ".mil", and ".gov" were adopted as domestic. Other generic TLDs were not included in the calculations except for the general WIF.

Table 3: A set of Web Impact Factors, based on the number of webpages (* $p<0.05$, ** $p<0.01$)

	general WIF	*domestic WIF*	*international WIF*	*developed countries' WIF*	*less developed countries' WIF*
BLOS	1.38	0.35	0.27	0.56	0.06
HBOI	1.57	0.30	0.24	0.46	0.07
IFM	0.78	0.20	0.22	0.35	0.07
IOW	0.27	0.12	0.07	0.17	0.01
KMFRI	1.19	0.00	0.48	0.48	0.00
MBARI	0.54	0.12	0.12	0.21	0.03
MOI	1.26	0.04	0.37	0.30	0.11
NIO	0.24	0.02	0.08	0.06	0.03
NIOPK	2.85	0.85	0.56	0.41	1.00
ORI	7.27	2.09	1.73	1.55	2.27
correlation with HDI					
Spearman	-0.068	0.277	-0.455	0.037	0.018
Pearson	-0.336	-0.266	-0.408	-0.201	-0.391

Table 4: A set of Web Impact Factors, based on the number of scientific staff (* $p<0.05$, ** $p<0.01$)

	general WIF	*domestic WIF*	*international WIF*	*developed countries' WIF*	*less developed countries' WIF*
BLOS	36.32	9.08	7.22	14.76	1.54
HBOI	20.59	3.88	3.13	6.07	0.93
IFM	11.90	3.03	3.30	5.33	0.99
IOW	12.01	5.20	3.04	7.72	0.51
KMFRI	0.36	0.00	0.14	0.14	0.00
MBARI	32.66	7.27	7.45	12.68	2.05
MOI	2.62	0.08	0.77	0.62	0.23
NIO	3.95	0.27	1.31	1.05	0.53
NIOPK	2.57	0.77	0.50	0.37	0.90
ORI	6.67	1.92	1.58	1.42	2.08
correlation with HDI					
Spearman	0.948**	0.868**	0.917**	0.917**	0.523
Pearson	0.761**	0.777**	0.766**	0.795**	0.350

The *international WIF* is built complementarily, drawing on inlinks from all TLDs except for the domestic ones. The *developed countries' WIF* includes links from all TLDs standing for countries categorised as developed countries by the United Nations taxonomy.[8] Analogously, the *less developed countries' WIF* comprises the TLDs of nations labelled as developing or least developed countries, together with countries in transition.

These indicators have to be interpreted very cautiously since most country-code TLDs are not limited to users from the country they represent. Some ccTLDs, like ".tv", or ".fm", are systematically used by organisations abroad. In some countries the majority of websites is set up in domains with generic TLDs instead of national ccTLD, because the latter is administrated restrictively or because it is considered provincial (Wass, 2003). Moreover, as the difference between the general WIFs and the sum of domestic and international WIFs in Table 3 shows, generic TLDs with no country specification have a strong weight. Accordingly, the WIFs will not be discussed in detail, but as an approximation to the visibility on the Web.

Table 3 shows the WIFs based on the number of webpages. It can be noted that the institute with the smallest website, ORI, is a clear outlier, having the highest values for all page-based WIFs. Apart from this, the effect of small web presences attracting more inlinks in proportion to their number of webpages, as discovered by Thelwall and Smith (2002), is not very pronounced in this sample. There are neither positive or negative correlations of significance between the HDI and any WIF based on the number of webpages.

There is no general dominance of international over domestic WIFs or vice versa. But most websites attract more inlinks from developed countries' than from developing countries' TLDs, except for South Africa's ORI and Pakistan's NIOPK which both have a strong domestic WIF.

As a next step, the five WIFs were recalculated with the number of staff as denominator (Table 4). Overall, two US institutes, MBARI and BLOS, attract most inlinks per staff member. All staff-based WIFs correlate highly significantly with the HDI, expect for less developed countries' WIF.

5 Discussion

Both the institutional size in terms of scientific staff and the Human Development Index show a medium, partly significant correlation with the number of webpages, files and outlinks. While the staff count is slightly stronger associated with the website size, the HDI has higher Pearson and Spearman values for files and outlinks. Although not correlated themselves (Pearson's coefficient 0.153, n.s.), neither HDI nor number of staff exhibit a unique association with the website measures. However, these findings are limited to the sample. Since oceanographic institutes with large websites from developed countries were deliberately excluded during the selection process, as have two institutes from developing countries which lacked any web presence (cf. section 2.2), a stronger overall association of development status and website size and outlinks can be assumed for the field of oceanography.

The analysis of the visibility of the websites produces diverging results: No significant correlation between any page-based WIF and the HDI is found. Both Pearson's and Spearman's coefficients return small, partly negative values. In contrast, four of the five staff-based WIFs are strongly, and with high significance, associated with the HDI.

The sampled oceanographic research institutes located in developing countries are as visible on the Web as the institutes in developed countries in proportion to their website size. In proportion to their number of scientific staff, however, they receive less inlinks than institutes in Germany or the US. Their visibility on the Web (in terms of external inlinks) matches their virtual size (in terms of webpages), but not their real size (in terms of man-power).

In a way, this can also be interpreted as a chance: Overall, those institutes in developed countries which have made an effort to set up at least a minimal website are internationally visible, and by extending the website contents

[8] http://milleniumindicators.un.org/unsd/methods/m49/m49regin.htm#developed, last accessed on 30 May 2008.

strategically the number of inlinks might still increase. However, it is a long way to raise the number of inlinks per staff member to the current level of the US and German institutes. This is probably less an issue of strategy than of resources and of centrality in the world-wide scientific community. Altogether, our findings do not corroborate the optimistic view on the World Wide Web reducing global inequalities in the scientific information and communication system.

The exceptional, non-significant result for the less developed countries' WIF, based on the number of staff, can be explained by some institutes in developing countries having a high proportion of domestic inlinks. In fact, both coefficients increase notably (Pearson 0.766**, Spearman 0.905**) when excluding domestic inlinks from the calculation of the developing countries' WIFs. In contrast, the developed countries' WIFs decrease slightly when omitting the domestic inlinks for the institutes located in developed countries (Pearson 0.662*, Spearman 0.751*). We conclude that for the staff-based WIFs the sampled institutes' domestic and international visibility on the Web is strongly associated with the development status of their host countries. In detail, this is even more true for the visibility in (other) developing countries and countries in transition than for the visibility in (other) developed countries.

Despite the limited scope of this study, this might be taken as a vague hint at geographical proximity playing a minor role in the international link structures of developing countries than in those of developed countries. This would be consistent with the conclusions of Park and Thelwall (2006). A systematic examination of international link networks including more world regions is needed to test this hypothesis.

One aspect that deserves a closer look, is the definition of visibility as the number of inlinks to a particular webspace. Search engines do not cover all websites evenly. Accordingly, the visibility of a webpage depends directly on the existing inlinks' source pages being coverd by the major search engines. It is possible that the proportion of inlinks from developing countries is underestimated. There is empirical evidence for the uneven coverage of national webspaces. Barjak and Thelwall (2008) reported major differences in the inlinks counts of Google and MSN for some European nations. Moreover, Vaughan and Thelwall (2004) found that search engine coverage is higher for older parts of the Web. This is highly relevant in this context, since the older parts of the Web are concentrated in developed countries, while link networks in and between developing countries are often created more recently. This is not necessarily a problem for the assessment of visibility, but for the of the concept of visibility: What do we want to survey: Visibility as the sum of inlinks with each link from any part of the world having the same weight? In this case, Web crawler data would be more useful. Or visibility as produced by the major search engines? As search engines play a key role in channeling the web users' attention it is absolutely legimitate to examine the latter. But in this case, future research on variations in national coverage and on discrepancies between search engines is urgently needed. The same is true for information on the coherence of ccTLDs and the denominated country.

An obvious limitation of the data presented in this paper is the small number of cases and countries included. A larger sample would allow for more complex statistical analyses and thus give more significant insights. But in contrast, it can also be fruitful to look more into depth. By focussing on the individual profiles of research institutes and by including qualitative data on the website contents, we can obtain new insights about the nature and the reasons of international disparities. The next questions that will be addressed in this case study on oceanographic research institutes are the following:

Which international differences can be detected in the website contents? How does the actual website usage, in terms of hits, correspond to the inlink profiles of the websites? How does the web presence and visibility relate to publication output and to the coverage in the Web of Science?

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