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Linking shallow, linking deep. How scientific intermediaries use the Web for their network of collaborators

Eleftheria Vasileiadou*,*** & Peter van den Besselaar***,**

* Social Sciences Department, NIWI, Royal Netherlands Academy of Arts and Science,
** Rathenau Institute (Science and Technology Assessment)
***Amsterdam School of Communications Research, ASCOR, University of Amsterdam
E-mail: E.Vasileiadou@uva.nl ; P.vandenbesselaar@rathenau.nl

Abstract

In this paper we explore the possibility of using Web links to study collaborations between organisations, combining the results of qualitative analysis of interviews and quantitative analysis of linking patterns. We use case studies of scientific intermediaries, that is, organisations that mediate between the science system and other social actors (the market, the government etc) and argue that it is becoming increasingly important for such intermediaries to use the Web to indicate their strategic alliances. We analyse links between these organisations, together with primary sources such as organisational charts and internal reports, and find that these organisations indeed use outlinks to point to their collaborators and more specifically outlinks from specific depths. This supports our argument that links can be used to study the developments in science and the environment of scientific intermediaries. We discuss these findings in terms of their relevance for science studies and webometrics.

Keywords

Scientific intermediaries, hyperlink analysis, depth of hyperlinks

1. Introduction

The hypertextual character of the World Wide Web (the Web) has allowed the study of links at various contexts and with different conceptualisations. However, the extent to which links indicate practical collaborations, a general interest to specific resources and organisations or even a negative type of relationship is still a matter under investigation. In this study we conceptualise links as relationships; the main questions driving the study are the following: Can we use links to study substantial relationships between organisations online? What kind of links indicates a substantial relationship?

Our point of departure is the study of scientific intermediaries, that is, organisations that link the science system to other social actors (the government, the market, NGOs etc). The literature suggests that the relevant actors in the knowledge production system have multiplied and, thus, the networks created by these organisations are now denser than ever before, including an increasing variety of actors involved in the networks (Gibbons et al. 1994; Rip and van der Meulen 1996; Nowotny et al. 2001). Nevertheless,

how is it possible to study this phenomenon online? What kind of indicators would help us study the actual collaborators of an organisation? Hyperlinks seemed the obvious choice: the way they resemble citations has been studied before (among the first by Rousseau 1997; Ingwersen 1998) and the limitations of this analogy have also been addressed (Egghe 2000; Prime et al. 2002). These limitations led us to explore the depth of the link as a possible indicator of relationships between organisations. Therefore, the current paper is explorative and the main aim is to develop hypotheses for further research.

In what follows, we first describe our conceptual framework for studying the linking behaviour of scientific intermediaries in a changing landscape in science and society. We then move on to explain our methodology, which distinguishes both between links of different depths at an organisational website and between different kinds of relationships between scientific intermediaries and their environment. After a presentation of the statistical analysis we discuss the findings and evaluate the use of webometric approaches for science studies.

2. Theoretical background

In this part we briefly discuss some developments relevant for scientific intermediaries and explain the context in which we have decided to study their linking patterns online. As mentioned before, we conceptualise intermediaries as organisations that mediate between science and other societal sectors and create networks of scientists with other actors, or networks of scientific institutions with other actors. More specifically, we define scientific intermediaries as the organizations whose purpose is to connect scientific output, scientists, or institutions in a meaningful network, linking the science system internally, or externally, that is to other social sectors (e.g. the market, the public sector, NGOs, the general public). The focus of this paper is on a. organizations connecting scientists from different fields and/or different areas with other actors e.g. professional scientific organizations, and b. organizations connecting scientific organizations and representing them in a more formal way, e.g. associations of universities.

There are three main developments in the field of scientific intermediaries summarised here: a. their increasing importance and proliferation (Rip and van der Meulen 1996); b. their need to create a network of alliances more diverse than before; c. their need to operate in the public interface between science and society.

Since the 1980s, there has been a trend among the western states to limit their expenditure on universities and basic research (Culliton 1982) with a parallel push - on the part of the state - for universities to become more socio-economically responsive (van der Meulen and Rip 1994). In other words, universities had to direct themselves towards industry as a funding source. State initiatives to promote this trend include the constitution of specific organisations to help with the transfer of knowledge/ technology from the universities to the industry, with the Offices of Technology Transfer in the USA as one example (Guston 1999). Another such initiative was the precondition for research centres to have industrial representatives in their advisory or governing boards, as a condition of funding from the National Science Foundation in the USA (Etzkowitz and Kemelgor 1998). As a result of such moves and initiatives, intermediary organisations, such as research centres, have proliferated. Etzkowitz and Kemelgor describe research centres as integrating 'university, industry and government into a triadic constellation' (ibid. p. 280) and mention that from the 1980s until 1993, as many centres have been created as in the past 100 years.

Indeed, as back as in 1982 Culliton notes that the corporate investment in the academic science had proliferated, listing as intermediary organisations research centres, institutes where professors worked as consultants, and small biotech companies around major research universities. This can be seen not only as a result of the cuts of governmental funding in almost every sector, but also as a growing belief among all involved that strong academy-industry relations are vital as a means of fully utilising a national research system, so as to improve national innovative capability and therefore increase competitiveness (Müller 1995).

These parallel developments (the pressure on state expenditure to universities and the increasing commercialisation of scientific knowledge) have also been responsible for the transformation of intermediaries. In the Netherlands, science shops were established in universities in the 70s with the ideological aim to promote public access to science. Many have recently turned into consultancy agencies, as more and more clients (companies and NGOs) are ready to pay for the research they require (Wachelder 2003). Others have become public relation tools for the universities they belong to, creating a network of allies in the local region in which they operate.

However, we should not conceptualise the recent developments in science as only creating more alliances with the market sector. Science is becoming more socially accountable in general, so also towards NGOs, the public, the state and individuals (Nowotny et al. 2001). This multiplication of the publics of science has also increased the need for intermediaries to operate at various communication arenas (van Lente 2003). Increasingly, links between basic research and industry, non-profit organisations and social groups are becoming more important in their own right (van der Meulen and Rip 1998), thus creating a diverse audience for scientific intermediaries.

In summary, the relevant literature suggests three parallel trends for scientific intermediaries: a. the increasing importance of their role and their proliferation, b. the increasing diversification of the strategic partnerships and the networks they need to build, and c. the increasing demand to operate in the public sphere. But what is the role of the Web in these developments? How do scientific intermediaries utilise the new information and communication technologies (ICTs) in their strategies? Can we use the Web to study these developments? In order to investigate this we conducted two preliminary interviews with representatives from two intermediary organisations: an applied research and development organization (further mentioned as VOP) and a funding body for biomedical research (HJ). [2]

VOP is a knowledge organisation in the Netherlands used by companies, government bodies and public organisations. It was established to support companies and governments with innovative, practicable knowledge. In the words of their representative, VOP is an 'intermediate organisation in between the world of more fundamental research and the world of the application of knowledge… in fact [they] use knowledge to solve problems for clients and [they] try to pick up new technology developments and make them available for [their] target group'. VOP is responsible for the 'translation' of knowledge produced in the universities, into a market and policy application context. HJ is another Dutch organisation mediating between the public sector and researchers. They are responsible for allocating public funds for biomedical research and organising more general support for these issues; in fact, they call themselves 'a network organisation trying to involve third parties into their activities'. At the time of the interview, the organisation had only been in operation for several months and the development of their website was still under way. These two organisations were chosen because they are typical examples of organisations linking the science system with other sectors. Furthermore, as they are based in the Netherlands, they were easier to contact and conduct interviews.

In these preliminary discussions with the two representatives, our interest was in the ways in which the organisations used the Web and therefore, how we could use Web data to study the developments in the science system related to these organisations. Both of the interviews were conducted in May 2003, lasting approximately an hour. As the purpose of the interviews was a preliminary examination of the general function of the organisations, as well as the use that the organisations made of the Web, we decided to conduct open-ended interviews, that is, not following a predetermined set of questions. The following topics were the basis of the interviews: different functions and audiences of the intermediary, recent developments of the organisation and use and purposes of the Web. Both interviews were tape-recorded and transcribed verbatim.

The views of the two representatives towards the Web and how the organisation used or could use it were quite similar. The idea behind the website planning for HJ was to reflect 'a strong organisation' and that behind the organisation 'there is a whole network of parties building a strong national infrastructure'. As noted by the representative, this network of parties would be presented through, for example, the links of the website. Another

interesting feature of the site would be the content: the plan was to give every activity that HJ was funding a full representation on the Web - all activities would be 'one or two clicks away' from their homepage - but also provide news and content about recent developments in the field of biomedicine. The website was developed so as to mediate information, and also as a public relations instrument for the organisation. Therefore, HJ planned to use the Web partly (but not exclusively) to reflect the developments we described earlier: the increasing demand to operate in the public sphere (as our interviewee put it 'being accountable' through their website was of primary importance) as well as the increasing need to create and sustain strategic partnerships with other organisations (the 'network of parties' mentioned above).

On the other hand, the VOP website was quite developed at the time of the interview. Even though it has subsequently changed, the basic form, the visual lay out and also the structure has remained the same. As our interviewee mentioned, 'It's useful for finding knowledge and expertise within VOP and it's used especially because VOP is such a complex organisation'. Thus, the provision of information is one of the main purposes that the organisation website fulfils. However, the future planning for the website was also 'to make the medium more interactive and more dynamic and more active tool with dealing with your environment'. What the VOP representative was mainly interested in were Web-based tools that would support collaboration environments. As he mentions, 'It would also be interesting to set up stronger relationships with your clients e.g. you can create a virtual environment which you do research with them (sic) and which you can interact on a permanent basis'. Consequently, VOP was using the Web more for the provision of information, but the plan here was also to experiment with ways that would connect the organisation with their partners and clients.

These preliminary interviews suggested that intermediaries may be using the Web to operate in a more public environment and also to link to their strategic partners and clients. Therefore, we decided to use Web data in order to see whether they would reflect the aforementioned recent offline developments in the field of scientific intermediaries. Can we indeed use Web data to study the diverse strategic partnerships and the networks that intermediaries build? Do these data reflect a mediating and networking function? We decided to focus on links between organisations and to examine whether intermediaries use the link facility of the Web to connect to their allies, clients and partners.

Many researchers from information science and internet studies have previously used the hyperlink as an indicator of some type of relationship between the linked and the linking organisation. Some previous studies concentrate on the hyperlink as an analogy of citations, and some (e.g. Thelwall 2002) investigate the relation between links and other variables in the academic context. The basic notion following each of these studies is that in specific contexts, and mainly the academic/ scientific context of electronic journals or universities websites, links could be more codified than in other contexts, and would be similar to citation patterns.

In a different context, Park et al. (2002) use hyperlinks to indicate the trustworthiness of a site as well as its credibility. Their network analysis study of mainly commercial, highly-visited Korean sites conceptualised the number of inlinks to a site as the perceived credibility of the site in the affiliation network, whereas the number of outlinks of a site was used as an indicator of expertise credibility (the site's expansiveness). In this way, they interpret a link as a relationship between organisations, even though there is no actual empirical evidence for the qualitative characterisation of the relationship (trustworthy, credible etc). Davenport and Cronin (2000) also conceptualise links as purveyors of trust.

Based on previous studies, we also start from the conceptualisation of the link as a relationship between the linking and the linked organisations. First, we wanted to see whether hyperlinks indicate a substantial collaboration and whether we can use them for the study of a network of allies, in this case of scientific intermediaries. Studying the hyperlinks of universities, Heimeriks and van den Besselaar (forthcoming) have shown that there is little correlation between the network of a research group's collaborators (project partners and co-authors) and its outlinks. Therefore, our second purpose was whether we could find a more refined distinction among links. The research questions are:

1. Do intermediaries use the Web to position themselves in the network of their collaborators? In other words, are the recent developments of intermediaries reflected in their use of the Web, and more precisely in the links?
2. Can we find a specific subset of links that can be used for the study of collaboration relationships?

The idea was that some of the links from organisational sites would position the organisation with regards to other organisations with whom they collaborated and held a practical relationship (e.g., those with whom they conducted financial transactions). We expected such a position after the VOP and HJ interviews, as well as the emphasis they both put in the website as a tool to demonstrate their network of allies. At the same time, we expected some of the links to point to resources useful to these organisations, or general documents, as information provision was pointed out by both of our interviewees. What would be more important for the intermediary organisations: to link to their collaborators or to provide information and general resources?

In order to examine the linking patterns of the intermediaries, we decided to distinguish between links from shallow pages, so links, as the HJ representative described 'one or two clicks away' from the homepage of an organisation, and links that can be found deeper in the structure of the website. For the user of a website, there is a distinction between links that can be accessed at the first levels of a site, without going too much into the structure of the site itself. We found it to be pertinent as to what kind of links the intermediary organisation would place in its first and most accessible pages as opposed to what links it would place deeper in the site. With this in mind, our third research question is:

3. What kind of links can we identify at the top levels of an intermediary's site and what kind of links appears deeper in its structure? Do intermediaries find it more important to link in a public and visible way (e.g. so at the top of their site) to their collaborators?

Here, we are interested in identifying practical collaborations between organisations, such as a relationship of working together on one or more projects, of receiving financial support from each other or of being involved in the same delegation process. We decided on these three types of relationships not only because they are of prime importance but also they are easily identifiable. In the remainder of this paper, we use the term collaborators to indicate this type of relationship. In the next section, we explain the process of data gathering and coding, which is then followed by the analysis and the discussion of our findings.

3. Methodology

As this study is exploratory, we decided to analyze the outlink networks of scientific intermediaries, most of them based in the Netherlands, whose primary aim is to connect scientists and scientific institutions, and create networks with other sectors of society. The organizations were: ALLEA, AWT, Chemiewinkel Rijksuniversiteit Groningen, KNAW, the Liaison Office of the University of Amsterdam, NAV-VKGN, Rathenau Institute, and Voeding TNO. These were selected as typical examples of intermediary organizations: ALLEA is the European Federation of National Academies of Sciences and Humanities, linking the science system with the EU public sector. AWT is the Dutch Advisory Council for issues of Science and Technology, linking the science system with the public sector. The Chemiewinkel Rijksuniversiteit Groningen is the Chemistry Science shop of the University of Groningen, linking the science system with the general public and NGOs. KNAW is the Royal Netherlands Academy of Sciences and Humanities, while NAV and VKGN are professional scientific associations (the former of Anthropogenetics and the latter of Clinical Genetics) in the Netherlands. These latter organizations link the science system internally. The Liaison Office of the University of Amsterdam functions as an intermediary insofar as it informs and advises scientists about collaborations with market representatives and third-sector funding opportunities. The Rathenau Institute is responsible for supporting public debates about the role and development of science and technology, linking science and the public. Finally Voeding TNO is a contract research institute linking the science system with the market.

We crawled the websites of these organisations using a tool developed for this purpose; we started from the homepage of the organisations [3] and continued four levels deep [4]. The crawler then provided us with a list of outlinks: the originating URL and the target URL it was pointing to. We only included external outlinks in our analysis, that is, outlinks to domains outside the originating domain. We then coded the depth level of the originating URLs. For that, we used the crawler results, which indicated at which level a specific URL (page) was located, in terms of the homepage of the organisation. So the homepage of an organisation was given the depth 0; then, on the basis of how many steps the crawler moved, the pages were assigned with a depth level of 1, 2, 3 or 4, since we crawled the sites four levels deep [5]. Thus, a page was assigned the value 2 if it belonged to the second depth-level in a structure of a website if the crawler took two steps (two hyperlinks) to go from the homepage of the organization to the page in question.

We then returned to each originating and target URL, and tried to establish whether or not there was a practical collaboration between the two organisations. To do so, we employed information from the organisational charts, the list of partners and other relevant documents we found online as primary sources (Duffy, 1999:108). We had to search for the name of the linked organisations within the documents we found in the website of the linking organisation. In some cases, there was a clear indication whether the two organisations worked together on a project or what type of relationship they had. Other times, we had to go back to the originating URL in order to see how the target URL was labelled (as a 'partner', as 'collaborating organisations' or 'useful resources', etc). Further, we distinguished between collaborations that involved financial transactions (one organisation funding the other, or one as the client of the other), collaborations in the form of delegation (if one organisation represented the other) and collaborations in the form of working together on one or more projects.

After clearing out all invalid or missing links, we obtained a list of 1,525 outlinks in total, 510 of which were manually classified as collaborators and the remaining 1,015 as non- collaborators. In the next section we present the results of our analysis. The research questions we address are:

1. 1. Do intermediaries use Web hyperlinks to connect to their collaborators?
2. Is there a difference between links to collaborators and links to non-collaborators?
3. What kind of links do scientific intermediaries have shallow and deeper on their site? In which position can we find the links to different kinds of collaborators?

4. Results

We used SPSS and Excel to analyse the data. As mentioned, we obtained a list of 1,525 outlinks in total, 510 of which were classified as collaborators and the remaining 1,015 as non-collaborators. Approximately 63% of the collaborators were identified as having a financial relationship, 8% as delegation collaborations and 45% as co-working relationships. [6] We merged the category of delegation together with the co-working relation, since we can safely assume that there is some kind of co-working collaboration between organisations that represent each other. In the two following figures we present the distribution of the depth of originating URL (level), and the distribution of the links among the eight organisations.
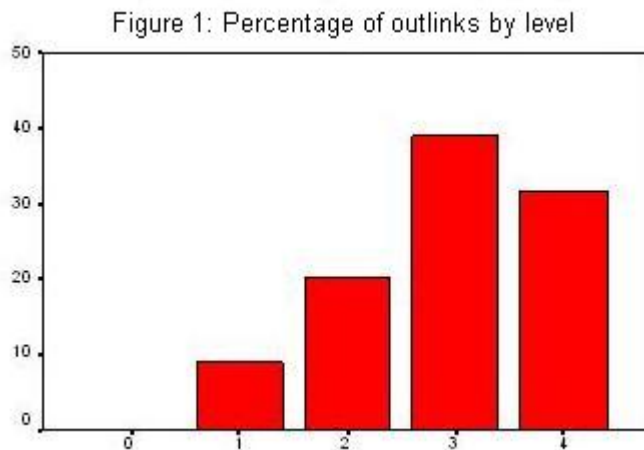
Figure 1: Distribution of the depth of originating URL
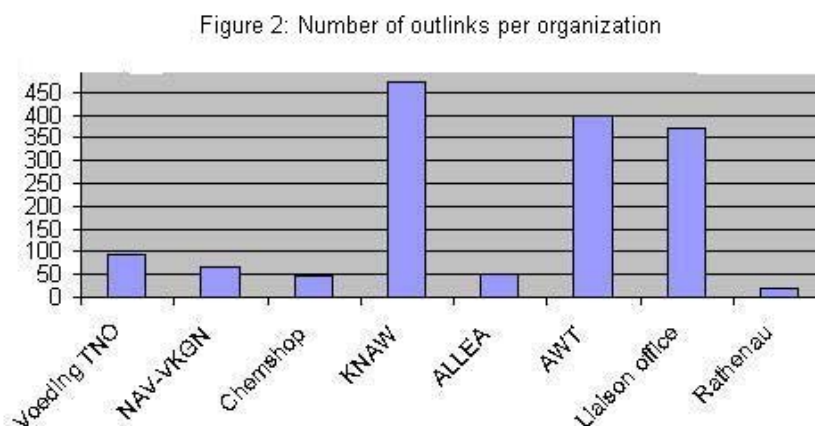
Figure 2: Distribution of outlinks among case studies

In the first figure we can see that there are only two outlinks from depth level 0 (so from the homepage of our case studies). To simplify the analysis we therefore decided to combine them with the links from the 1st level. The second figure shows large discrepancies among the different intermediaries as to the number of links to outside domains. This could indicate different web design choices of organizations.

In regard to our first research question, we tried to see whether intermediaries did indeed link to their collaborators. Generally, they do, as approximately 33% of the coded links were to collaborating organisations. However, we wanted to establish whether all of our case studies actually linked to collaborators, or whether there were discrepancies. In the following figure we show the distribution of links to collaborators and to non-collaborators for each scientific intermediary under study.
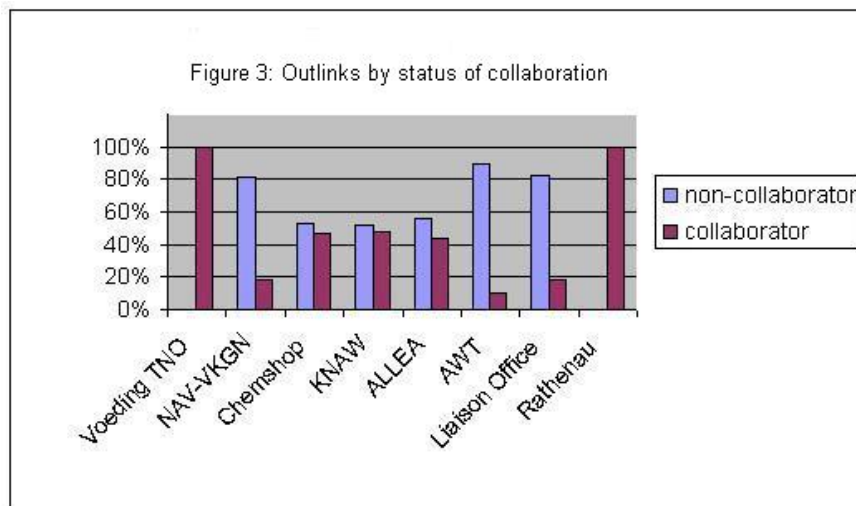
Figure 3: Distribution of types of links for each organization

Figure 3 shows that Voeding TNO and the Rathenau Institute have all their links to organisations they collaborate with; NAV-VKGN, AWT and the Liaison Office have between 10 and 18.5% of links to their collaborators; collaborators hold between 40% and 50% of links on the Chemshop, KNAW and ALLEA websites. So, all of our case studies link to their collaborators to a greater or lesser degree. Even though the number of our case studies here is small, they can be distinguished, according to their linking patterns, in three groups. But what do these groups reflect? We will discuss this grouping in the following section.

Our second research question was whether there is a finer distinction among links that we can use in the study of collaborators. That is, we wanted to see whether there is a difference between links to collaborators and links to non-collaborators. In order to explore this, we first examined whether there is a relationship between the depth of the link and the existence of collaborators. We used one-way ANOVA to analyse the relationship between the status of collaboration and the depth of the link. The average depth of links to collaborators is 2.8 whereas the average depth of links to non-collaborators is 3. The difference is small but significant (0.000); in other words, the collaborators are slightly more visible.

At the second stage, in order to find out whether there are differences between the various kinds of collaborators, we used the distinction between co-working (combining co-working and delegation processes) and financing and analysed, through one way ANOVA, their relationship with the variable 'level out'. Again, we find a significant (0.000) difference between the two means: the average outlink level to co-working organizations is 2.3 and the average outlink level to non-co-working organizations is 3.1, making the former much more visible than the latter. As the depth of the link increases, the probability that the link indicates a co-worker decreases. The differences between the two groups are relatively large: almost a whole level. Links to co-working organizations, therefore, tend to be higher up in an intermediary's site, that is, in a more visible position.

The same, however, does not hold for organizations that have a financial relationship. A one way ANOVA between the outlink level and financial collaborators showed that financial collaborators tend to be on average linked from a slightly deeper level, even though the difference is not that big (less than 0,2 degrees). Again, the difference between the two means is significant (0,002). So, it seems that a different relationship between organisations tends to be indicated by links at different depth levels of a site. It seems more important for intermediaries to link to the organisations they work together with (e.g. in a project) than to organisations that they receive or give financial support. Based on these results, we can safely argue that there is a finer distinction among links, namely the depth of the links, which can help us study collaboration relationships online. In general, there is a significant difference between links to collaborators and links to non-collaborators. Links to collaborators tend to be more visible than links to non-collaborators. More specifically, links to co-workers tend to be substantially more visible, while links to financial collaborators tend to be slightly less visible.

Our third research question leads us to describe what kind of organisations scientific intermediaries link to at each level. What kinds of links do intermediaries have shallow and deeper in their site? In order to find this out we use an Excel chart (figure 4) to show the distribution of each type of link at each level.
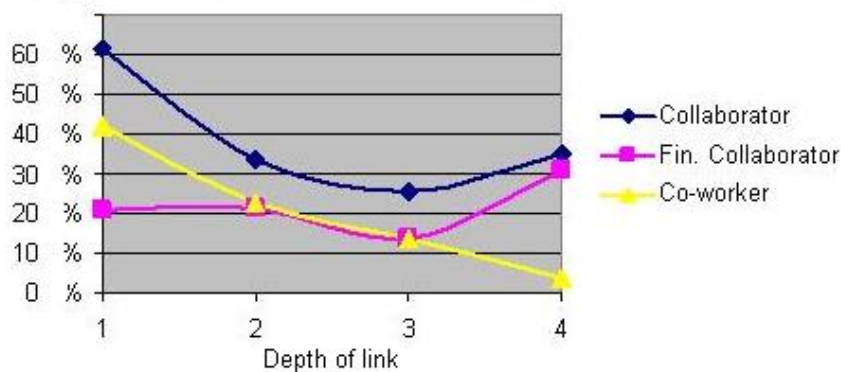

Figure 4: Type of outlinks by level, all organizations

Figure 4: Distribution of kind of links at each level

	Collaborator	Fin. Collaborator	Co-worker
Level 1	61,4%	20,7%	42,1%
Level 2	33,8%	21,1%	22,7%
Level 3	25,5%	13,6%	13,8%
Level 4	34,9%	30,7%	3,9%

Table 1: Distribution of kind of links at each level

The table above reads as follows: at the 1st level, 61,3% of the links are to collaborators, with 20,7% of links indicating financial collaborators and 42,1% indicate co-workers [7]; at the second level, 33,8% of links point to collaborators, 21,1% of links point to financial collaborators and 22,7% to co-workers. As the links go deeper, the majority of links are to non-collaborators. More specifically, the links to co-workers decrease as the links go deeper, whereas for financial collaborators, they decrease up to level 3; they then begin to increase. This is also the tendency for general collaborators. We can also see that the distinction between the two different kinds of collaborators actually exists only at the first level, where we find a majority of co-workers, and at the fourth level, where we find a majority of financial collaborators. The placement of financial collaborators therefore tends to be deeper in a site, whereas the placement of co-workers tends to be in a more shallow position, thus resulting in more visibility.

Therefore, answering our third research question, intermediaries tend to link to their collaborators from more or less specific levels of their websites. At the first level, which is the most transparent for their users, the majority of links (61,4%) point to collaborators and more specifically most of them are to co-working organisations. At the second and third levels, a minority of links indicate collaborators, with co-working organisations and financial collaborators being distributed almost equally. At the fourth level, again the minority of links point to collaborators, although more that at the previous two levels, with a majority pointing to financial collaborators. We can therefore contend that links to collaborators tend to be 'one or two clicks away' in an intermediary's website, thus, shallow within a site. Links to the financial collaborators of an intermediary tend to come deeper in the website (levels 2, 3 and 4) whereas links to co-working organisations have the opposite pattern, decreasing as the links go deeper in a site.

In the following section we attempt to explain our findings and discuss them in relation to the recent developments in the field of scientific intermediaries.

5. Conclusions and Discussion

In this paper, we studied the linking patterns of scientific intermediaries, starting from the recent discussion about their changing role and then examining whether this role would be reflected online. In this section we will discuss the insights but also the limitations of this study and reflect on our results in terms of their relevance for two different, but at times convergent fields: science studies and science policy, on the one hand, and webometrics on the other.

The first conclusion from our analysis is that scientific intermediaries do indeed use Web hyperlinks to connect to organizations that they maintain practical collaborations with. This means that to an extent, their function offline is reflected by their online behaviour. With the changes in the knowledge production system and in society, scientific intermediaries play an increasingly important role, linking different social actors with the science system and creating a network of allies/ collaborators. However, to them it is also becoming important to show these partnerships online, and gain from the transparency in their positioning. This became obvious not only from our preliminary interviews but also from the subsequent analysis of the links. Certainly for our case intermediaries around one third of their outlinks pointed to organisations with whom they collaborate. Even though we found different groups of intermediaries based on the extent to which they linked to collaborators, all intermediaries did link to their collaborators to some extent.

From our analysis three types emerged: one that links only to collaborators, that is the Voeding TNO and the Rathenau Institute; one that links mostly to general resources and organisations they do not collaborate with, providing information to the visitors, the Liaison Office, AWT and NAV-VKGN; and one that provides links that are more or less equally distributed to collaborators and non-collaborators: KNAW, ALLEA and the Chemistry Shop. These types may reflect different website design ideas, such as the use of website as a public relations tool, as a navigation tool for the user or something in between. They could also reflect different perceptions about their role as a scientific intermediary, indicating different types of intermediaries, or different levels of maturity in web use. We would however need a bigger sample of scientific intermediaries to understand this more in depth; this could therefore become a point for subsequent study.

Furthermore, for intermediaries it seems important to operate in a public interface of science, which is here translated on the Web and in their linking behaviour. The more prominent the links on a website, and the easier it is for the user to find them and the more importance the organisation tends to give to them. More specifically, for the case of the organisations our intermediaries worked with, there was a substantial difference in the depth that the links were placed. The general placement of the links to collaborators tends to come more prominently in a site than to other organisations or general resources. On the contrary, links to organisations with a purely financial relationship tended to be placed deeper in the website, indicating that relations with these organizations are not as important for our cases to demonstrate as opposed to the co-working organisations.

In this context, the linking patterns revealed more collaborators at the shallow levels than at deeper levels. A more refined distinction between links, on the basis of their depth, seems to clarify the relationship between the linked organisations. Moreover, the importance that intermediaries give to their co-working organisations seems to be greater than that to their financial collaborators. Perhaps they gain in importance by clearly indicating the organisations that they actually worked with in their website, rather than the ones they merely provide or take money from.

Methodologically, the results presented here suggest the use of the depth of links as a possible indicator of a certain type of relationship between the linked and the linking organisations. Generally speaking, we would expect links from shallow URLs to indicate the relationships that organisations consider as the most important (here, the actual co-working relationships), whereas links from deeper URLs would not be as important, which could indicate a different relationship between organisations (here, a financial transaction). Of course this also depends on the organisational policy for the website, if such a policy exists: as we found out from our interviews and also from the link analysis, organisations may use their website for purposes other than that of a public relations and general placement tool. However, to an extent in all of our cases, online patterns reflected the offline mediating

function. We need to remember that all of these cases were scientific intermediaries, connecting networks, scientists and scientific organisations.

We believe that the study of scientific intermediaries and their developments can reveal simultaneous changes in both the science system and other social systems, and can clarify their relationships and their increasing intermingling. In a way, this study justifies the use of Web data for the study of these developments. With the advent of the internet it has become easier to obtain large amounts of Web data that can be analysed in an automatic way. However, a great deal of further work is needed not only to develop the relevant methods and approaches but also to interpret the results in terms of concepts and phenomena in the offline world. This study contributes to this agenda as it clarifies how linking patterns can be mapped in a more detailed way and what they actually mean in the context of scientific intermediaries.

The limitations of this study are, nevertheless, not trivial. We only studied the linking patterns from a limited number of scientific intermediaries, without considering whether these patterns are specific for these organisations. In other words, are the results we obtained typical for the context of scientific intermediaries, or do they reflect general linking behaviour of organisational websites? For example, another study indicated a lack of collaborators in the outlinks of a university department (Heimeriks and van den Besselaar, forthcoming). More exploratory research is needed to identify the role that different depths of links may play in different contexts. The current study is a first step in showing how depths of links matter, and how online relations reflect offline functions.

In a strictly academic/ scientific environment, the outlinks could show more similar patterns than that of intermediary organisations. There, the results may even show stronger correlations because the environment is more codified. For example, the hierarchy of a department could be reflected in the depth of links (we would find the personal homepages of scientists working in that department at a deeper level). At the same time, links to articles of interest in online journals (non-collaborators) would be expected to have a stricter codification in terms of their depth.

However, in comparison with the academic/ scientific environment, scientific intermediaries have not used the print medium in a standardized way to indicate co-working relationships. Scientists have utilised print journals and books to indicate their collaborations, which is not the case for intermediaries. In this well-codified scientific setting, the addition of a new communication medium (the Web) would create a different balance, and may appropriate different interactional settings (Vasileiadou and van den Besselaar, 2004) than in an environment that did not use the print medium in a codified way. Further research could establish these different new balances of media and interactional settings in different environments with relation to the introduction of the Web. Scientific intermediaries may have just found a new medium with which to indicate their collaborations, but does this also hold for universities, which already have a medium for this purpose?

Acknowledgements

Notes

2. To ensure confidentiality, we use fictitious names for both organizations.

3. The crawling was performed on the 17th of November 2004

4. The crawler operates in a Linux environment and was built by Manolis Mavrikakis, in the University of Patras, as part of the EICSTES project (see **www.eicstes.org**).

5. The choice of the depth level was based on the expectation that we would

not find many outlinks at deeper levels, following Cothey (2004) who reported the results of a similar study of distribution of outlinks at the different depths of websites.

6. The categories were not exclusive, as some organizations had e.g. both co-working relationship and also financial transactions.

7. We repeat that the two categories (financial collaborator and co-worker) were not exclusive.

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DISCUSSION

Linking shallow, linking deep
Anne Beaulieu