Chapter 10

SCIENCE MAPS WITHIN A SCIENCE POLICY CONTEXT

Improving the Utility of Science and Domain Maps Within a Science Policy and Research Management Context

Ed C.M. Noyons

Centre for Science and Technology Studies (CWTS), Leiden University, the Netherlands
E-mail: noyons@cwts.leidenuniv.nl

Abstract: Science mapping within the science policy and research management context has had a promising start during the seventies, but it lasted until the early nineties before useful technology was developed to make it really work. Recently domain visualization seems to have become a mature research area. Therefore, the actual potential of visualization for this particular purpose can be explored in more detail. In this chapter a short history is outlined and the current possibilities and requirements of contributing to a sound evaluation tool in the near future are listed. By using a case study the potential of bibliometric maps is illustrated within a policy context. It shows how these maps may be used to visualize the research focus of actors within one field and to compare them. The main issue raised in this chapter is the requirement of reference points in order to make useful comparisons.

1. INTRODUCTION

Maps of science are an appealing representation of academic knowledge and as such applicable in many contexts. In this chapter I discuss in short the history of science mapping and, in particular, within the science policy and research management context. An obvious link is made to *domain visualization* techniques that have been developed in the past decade.

Since the introduction and hectic starting phase of bibliometric maps as representations of science fields and research areas, there has been a long time with hardly any developments. Only since the availability of graphical user interface techniques in the nineties, has this kind of maps been

H.F. Moed et al. (eds.), Handbook of Quantitative Science and Technology Research, 237-255.

developed further. The appealing aspect of using the map as an interface to find information or investigate the generated structures has contributed to this revival considerably.

It is now time to define for each application area the proper requirements for these interfaces in order to be able to stay on the right track. There is still a lot misunderstanding about the validity and utility of the maps (c.f., Noyons, 1999 and 2001), but with clear guidelines we should be able to make a major progress in the next ten years. In this chapter the focus is on the specific applications of these maps within a science policy and research management context.

2. MAPPING

A science map is two- or three-dimensional representation of a science field, a 'landscape of science', in which the items in the map refer to themes and topics in the mapped field, such as cities on a geographical map. In these maps the items are positioned in relation to each other in such a way that the ones which are cognitively related to each other are positioned in each other's vicinity, whilst the ones that are not or hardly related are distant from each other.

The maps of science considered in this chapter are those based on bibliographical data, the bibliometric maps of science. As scientific literature is assumed to represent scientific activity (Merton, 1942; Ziman, 1984), a map based on scientific publication data within a science field *A* should be able to represent the structure of *A*. It will depend on the information (elements of a bibliographical record) used to construct the map, what kind of structure is generated, where kind of maps refers to aspects like cognitive and social structures.

Most science maps are constructed by the co-occurrence information principle, i.e., the more two elements occur together in one and the same document the sooner they will be identified as being closely related. The science mapping principle dictates that the more related two elements are the closer to each other they are positioned in a map, and the other way around: the less related two elements are the more remote they will be in the map.

Different elements of a bibliographic record may be used to generate a structure. Each element reveals a specific aspect of a publication and can therefore be used to compile a specific kind of structure, unique in a sense, but through the coherence of a publication always related to the structures based on other elements.

A bibliographic record (representing the publication) contains a range of elements. The important ones are:

- Author(s) of a publication;
- Title of a publication;
- Source in which the document is published, e.g., the journal, proceedings or book;
- Year of publication;
- Address(es) of the (first) author(s);
- Abstract of the publication.

In specialized bibliographic databases other information may be included as well:

- Cited references;
- Publisher information of the source;
- Keywords provided by the author or journal editor;
- Classification codes added by the database producer;
- Indexed terms added by the database producer.

In principle all these elements can be used to build a map. As mentioned above, the kind of structure that is generated depends upon the element used. A map based on co-occurrence of *authors* is more likely to unravel a *social* structure (c.f., Peters and Van Raan, 1991) of a science field, describing the relations between people. A map based on co-occurrences of *classification codes* rather describes the relation between content elements and thus reveals a *cognitive* structure.

A map as such has the function of being an aid to help users to explore a publication collection (e.g., search results, a science field). It will depend on the kind of user and the objective as to which map fits best.

In general, all mapping and visualization techniques structure large amounts of data by clustering documents, in our case publications. They may be represented in more than one cluster if the clusters overlap. The clusters are defined by elements taken from the publication data (more accurately, bibliographic data), and depending on the objective of the map a choice for one particular element is made. To provide a better view of the possibilities, I compiled a simple model to represent scholarly communication, as far as relevant for scientometric studies from the point of view in this chapter.

The model shows three important elements involved in the entire process of communication, and relevant for scientometric and bibliometric research:

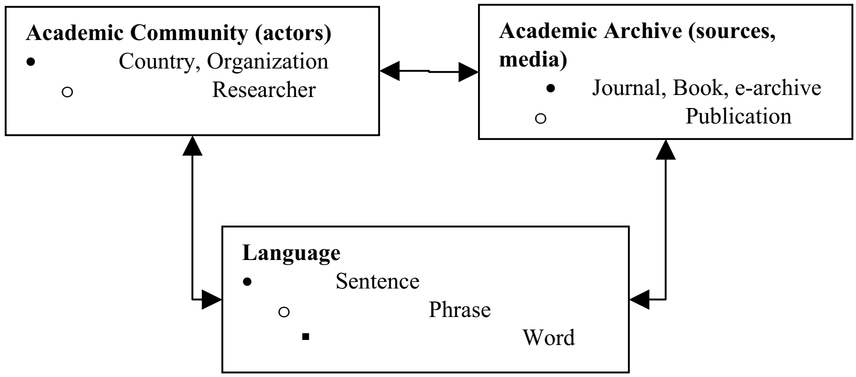


Figure 10.1. Scholarly communication model applicable to scientometrics.

Other elements are involved in the process, e.g., science policy, technology, and societal issues, but I do not take them into consideration here. For a much more complex and broad model in which this may fit I refer to Wouters (1998).

Each of these three elements shows a varying level of aggregation, down to the smallest element applicable to the present research of scientometrics, being the researcher, the publication, and the single word.

Most research performance evaluation studies in which the output and impact of actors (countries, organizations) are evaluated involve *archive* and *community*. Co-word analysis involves *language* and *archive*. Semantic analyses of a scientific author involve *language*, as taken from publications, and linking the other elements (*archive* and *community*). Studies of journals (e.g., journal impact factors) have (parts of) the *archive* as a starting point. Every journal, such as the entire set of publications represented by the *Science Citation Index*, represents, in fact, a sub-collection of the entire archive. Citation data is primarily restricted to the archive, in which one publication refers to an other.

Scientometric and bibliometric research apply to the *archive*, as publication collections are the starting point. Performance analysis concerns the evaluation of entities from the *community*, using the link between *author names* in publications and *researchers* or *affiliations* in publications and *organizations*. In co-citation analysis links within the archive are the basis, whereas author co-citation integrates community entities (*researchers* as *authors*).

Mapping techniques typically structure (parts of) the archive referring to entities from one of these three elements. Subsequently the structure can be linked back to either three, depending on the purpose of the map. For instance, in an actor analysis (at the level of country, organization or author) the activity or performance of a (list of) actor(s) is assessed. An actor (as a part of the academic community) is linked to the archive by looking at the author name or corporate source data in publications. By using the structure of the archive linked to the actor(s) we are able to characterize the actor's activity or performance. The structure we apply to the archive collection may be generated by using language elements, such as words or phrases, extracted from the archive (publications).

3. HISTORY

The history of mapping of science in the context of science policy and research management is relatively short. Moreover, it appears that only a few persons or groups have been engaged with this particular application of bibliometric maps. A highly interesting introduction to the history is found in Small (2003). Small sketches the birth of co-citation within a philosophical context of research paradigms, where the highly cited papers are concept symbols and clusters of these symbols should represent paradigms. With this method it should be possible to map the entire archive of science. The 'war maps of science' to be applied by 'government bureaucrats' were never really established, but the idea of doing so puts it in this particular context of science policy and research management. The development of co-citation analysis was adopted in many studies but the fundaments were only further developed at ISI by Henry Small (Small, 2003).

A spin-off of the co-citation approach is the analysis based on cited author names. This method was developed by White and Griffith (1981) to map the intellectual base of science fields (sub-collections of the archive). This technique uses the co-occurrence of author names in the reference list of articles. The more often two authors are co-cited the closer their intellectual relation. This should reveal the intellectual structure of a field. White and McCain (1998) developed this technique further and Author Co-citation Analysis (ACA) became a very popular technique for mapping an intellectual structure (amongst many others: Persson, 1994 and Persson, 2001).

In the early eighties a mapping methodology for a similar objective was developed by the École des Mines in Paris as described in Callon et al. (1983) and Callon, Law, and Rip (1986). They applied co-word analysis rather than co-citation, identifying clusters of words representing research themes. Callon mistrusted the citing behaviour of scientists and therefore considered words as a more appropriate element for creating structures of science. The well-known *Leximappe* software has been used in many studies since then but was not further developed after the early nineties. Based on the work of this French group, Kostoff created his Database Tomography (DT) and applied it in many studies. Unlike most other co-word studies, Kostoff incorporates no visualization techniques.

During the eighties and nineties most developments of the techniques mentioned were put on hold and it was not until the spread of graphical interfaces, such as HTML, Java applets and other Web interface techniques, that the mapping experienced a revival. This particular technology made it possible to use the maps as an interface and to explore the results and underlying data, rather than to look at hard copy structures only. In Lin, White, and Buzydlowski (2003) even a real-time version of the ACA application is presented. But there have been many more similar developments recently (see next section). The graphical user interface has opened doors for the Information Retrievalists and created new opportunities. In particular, the Self-Organizing Maps of Kohonen (1990) are adopted in many visualization tools (e.g., Polanco, François and Lamirel, 2001). Together with the revival of domain visualization, fundamental issues are raised (e.g., Cahlik, 2000; Ahlgren, Jarneving, and Rousseau, 2003; White, 2003).

Despite the revival of visualization techniques in the recent past, an increased application of the resulting maps within a science policy context is still not detectable. It seems that the application of the interfaces is most prominently focused on Information Retrieval; however, often inadvertently. The fundamental difference between these application areas is that an IR user uses the domain map to find an area of interest and zoom-in on a particular sub-area, down to the individual publications. A policy–related user may zoom in into sub-areas but will normally return to the overall view to draw conclusions.

4. CURRENT TECHNIQUES

Börner, Chen and Boyack (2003) — hereafter BCB — provide an excellent overview of the techniques used presently to visualize domains as a follow up of White and McCain (1997). All the techniques discussed could be used as an aid to search for relevant data. But it should be mentioned that most applications are developed to be used in IR, rather than in a science policy context. All discussed techniques are designed to create a domain map, i.e., a two- or three-dimensional representation of information entities to represent the structure of a domain. A domain can be a research field, or any other bibliography, or collection of publication data.

Most domain visualization studies seem to follow a similar path to go from publication data to the actual visualization, the map. In this process flow BCB discern the following steps:

1. Data extraction;
2. Unit of analysis (choice for author, term, document to be used to create the map);
3. Measures (statistics, unit of aggregation, thresholds to decide which items to use, etc.);
4. Similarity method (co-occurrence or other relation, matrix type, correlation measure);
5. Ordination (dimensionality reduction technique, clustering, scaling technique);
6. Display.

Different techniques may use different options at the described stages. And apart from the fundamental discussion about certain steps in a methodology (e.g., Ahlgren, Jarneving, and Rousseau, 2003; White, 2003), the choices to be made at several stages will also depend on the objective of the tool. Author names, in a co-author analysis, reveal a social structure, because they represent persons. This social structure may coincide with a cognitive structure, but that is another issue. Moreover, the interface for displaying the results should be fit to provide relevant answers to the questions at stake. This means that the different present techniques described by BCB may all have their own application area. In most cases they were primarily developed for Information Retrieval. They should be able to visualize a data collection in such a way that the user can zoom in on an appropriate sub-collection. This is an important issue because it means that this application area explicitly requires the entities behind the structure to be individual publications. In some cases the entities on the map are individual publications, in others the entities directly refer to a limited sub-collection of individual publications (co-citation map). But in many cases the entities in the map represent sub-collections of publications. Author co-citation clusters represent a structure of the publication oeuvres of co-cited authors. The research front of a co-citation map represents a structure of the collection of articles citing particular co-citation clusters. Similarly, in co-word maps words, terms, or clusters of words represent publications containing them. The words or terms in the maps do not mean anything as such. In terms of the model in Figure 10.1 an entity in a map always represents a sub-collection of the archive. The labelling of the entities is in most cases a language element or an entity or sub-collection of the community.

BCB explicitly mentions two approaches as being used in a science policy and research management context (Noyons, Moed, and Van Raan, 1999; and Boyack, Wylie, and Davidson, 2002). Still, I think that also the studies of Kostoff (e.g., Kostoff, Eberhart, and Toothman, 1998), Bhattacharya and Basu (1998), Widhalm et al. (2001), Schwechheimer and Winterhager (2000) and Salvador and Lopez-Martinez (2000), to mention a few relatively recent studies, are typically designed to be used in that context. And often they mention this orientation too. It seems, however, that in these cases the analysts did not always adjust the display (the final stage of the process flow) to disclose this option explicitly.

In the BCB review the results of many different techniques (both co-citation and co-word–based) are compared with each other applied to a collection of publications in the field of scientometrics and domains visualization. This collection, named ARIST (after the serial in which the review appeared) is analysed with all techniques available to them (either by software package or expertise) and results are compared. They conclude that every technique has its own special features, advantages, and disadvantages, and that it depends heavily on the objective of which one to use. Moreover they advise exploring results from more than one technique in order to provide insight from different perspectives.

For their study they only included techniques which are typically designed to be used for IR. And although there are obvious possibilities, the techniques are not designed to be used in a science policy context, neither are they reviewed within that context.

5. MAPPING AS A SCIENCE POLICY TOOL

As outlined above, a domain map is often used in contexts other than in the context of science policy/research management. It seems, however, that many issues brought up in domain mapping studies relate to policy–relevant questions. Especially the issues concerning the dynamics of a field under study and the issues concerning the actors (countries, organizations, or authors) relate closely to science policy and research management. Unfortunately, the applied techniques for visualising the issues do not always provide the proper maps or displays to contribute sufficiently to the discussion. In many cases there is a possibility of viewing time series of domains and hence to describe in detail the changes over time, but this approach lacks the means of a comprehensive overview of the relevant changes. These are not the Price's war maps of science on the basis of which science policy can prepare a strategy.

In the process flow of domain visualization (see previous section) there are two stages which seem most important to validate the use of domain maps in a science policy context: the choice for a unit of analysis and the stage of display[1] (more accurately, the design of an interface to use the map). As mentioned before, all techniques cluster publications into sub-collections of the archive, together forming the domain structure (the map). Apart from the specific features of different methodologies, it will depend on the choice of the element to create these clusters (cited references, words or authors), as to what *kind* of structure we will have. In most cases a cognitive structure is preferred over a social structure. For this kind a co-word or co-citation–based structure fits best.

Within a science policy context a landscape is often seen as an interesting representation, but the utility is not always clear. Apart from the user not always understanding the map, he does not know how to interpret the structure as such. Most maps are in a snapshot of a certain moment (year or year block). What the user needs is a reference point in order to be able to see the meaning of this snapshot within a context. A film of the changing landscape with certain reference points enhances these structures seriously. This is what can be termed science dynamics.

But there is another aspect to be taken into consideration. If we are to provide an instrument for monitoring and evaluating scientific research within the science policy context, we should give much attention to the actors. They constitute the only element in the model in Figure 10.1 that may be affected directly by policy. Every strategy or decision will apply to the actors, not to language, nor to the archive. This means that any mapping study in a science policy context should integrate information or linkages to actors, at any desired level of aggregation.

For the objective of a study the stage of display appears also to be very important. Within the science policy context the actual question to be answered should be explicit, so that a proper interface to explore the map and underlying data can be designed. This design may differ considerably from a design of an IR application. Noyons, Moed, and van Raan (2001), Boyack and Börner (2002), and Boyack, Wylie, and Davidson (2002) are the only cases in which the interface is explicitly designed as a science policy or research management tool. It should be mentioned, however, that many

[1] As discussed in detail in De Looze and Lemairie (1997) and Noyons (1999) the stage of field delineation is of course the most important one. We should be confident about what data are going to be used to create the domain map.

applications (c.f., Chen, 2003) do refer to potentials within a policy context, but are not elaborated upon as such. In sum, in policy–related mapping studies the following issues appear important:

- Comprehensive overview;
- Reference to actual/present situation;
- Points of reference to interpret results;
- Dynamics of the structure;
- Actors behind the structure;
- Actors behind dynamics.

As far as the map is concerned we need a limited amount of elements to be plotted in order to be able to provide a comprehensive overview. Most applications discussed in the previous section provide complex networks of many elements. A clustering of elements could in most cases reduce the amount of information in the map considerably. These clusters are referred to as paradigms (Small, 2003) or themes (Callon, 1983). This reduction of items in a map improves the stability and possibility of having points of reference and interpretation.

The reference to the actual situation (the real world) should be covered by the labelling of map elements whilst, of course, these labels should represent the contents of the (clustered) elements. It seems this issue has not had much attention yet, and depends heavily on expert input. For this the expert needs to recognize the structure and needs to be able to understand the individual elements identified.

Moreover, there are points of reference needed in order to interpret results. In the case in which we use a map to characterize the activity or impact of an actor, we need to know how this outcome relates to some point of reference, e.g., a world average, a similar actor or different period in time.

With respect to the dynamics it should be possible to visualize the changing landscape. This should, however, be established in such a way that changes can be monitored and interpreted easily. This means that for every change there should be a point of reference. This could be the starting or final point of a time series. In Noyons and Van Raan (1998) a method is outlined to deal with this.

As the elements in the map represent publication collections, and as actor data is in the author and affiliation fields of these publications, we are able to use the maps to distribute activity (numbers of publications per map element) and performance (activity and impact) over the landscape. Moreover, we should be able to integrate additional author information into the maps, such as funding and grants (c.f., Boyack and Börner, 2003). The interface should be able to enhance the map with this information, depending upon the question the user (science policy user) would like to have an answer to. Typical policy–related questions are:

– What does this domain look like?
– Who are the main actors in this domain?
– What is their particular expertise?
– How does this expertise relate to that of others?
– What are the main developments in a certain period of time?
– Which actors contribute to these developments?
– Who may be responsible for a particular change?

With these requirements in mind, many years were needed to develop at CWTS an interface that should be able to serve as a tool to provide possible answers to this kind of questions. In an example of a dedicated publication collection it will be shown how this interface works. And I will show how this approach provides possibilities to deal with the requirements as mentioned for a domain map as a tool for science policy or research management.

6. A CASE STUDY

In this section I will take the case of our own field as defined by a collection of relevant publications. The collection of publications is based on suggestions in Börner, Chen, and Boyack (2003). The collection is referred to as the ARIST collection or domain, after the serial in which this field delineation was used. It covers all core publications in scientometrics, bibliometrics, and domain visualization. The search strategy used is in Table 10.1. Data are retrieved from the ISI databases (*Web of Science*) in the years 1996–2002. I realize that a significant part of research is published outside the scope of the *Web of Science*, but for the main points I wish to make in this contribution the results are considered illustrative rather than complete.

Table 10.1. Search string for the ARIST data collection

citation analys* or
cocitation or co-citation or
(co occurrence and (word or term)) or
co term or co word or coword or coterm or
science map* or mapping science (map* of science) or
semantic analys* or semantic index* or semantic map or
bibliometric* or scientometric* or
data visualization or (visualization of data) or
information visualization or (visualization of information) or scientific visualization

An asterisk (*) indicates a right-hand truncation

With this delineation, the number of 1913 publications is covered. The distribution over years in the period 1996–2002 is in the Table 10.2.

Table 10.2. Numbers of publications in the ARIST collection

Year	*Number of publications*
1996	234
1997	223
1998	233
1999	270
2000	310
2001	307
2002	336

With the methodology described in Noyons (1999), I selected 237 keywords to be used to create the structure of the field (or domain). The cluster analysis yielded 12 keyword clusters as a good solution to represent the structure. These clusters are defined for the entire period of time and the evolution of the clusters (sub-domains) are presented in Table 10.3. The names of the sub-domains (labels) are set by the most frequent keyword. In other words, a sub-domain may be defined by a collection of keywords, but is represented in the table and map by only one.

Table 10.3. Numbers of publications per ARIST sub-domain, by year

Sub-domain	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*
1— impact	55	40	44	59	56	66	68
2— visualization tool	11	11	13	12	17	13	16
3— semantic analysis	17	11	19	23	20	24	17
4— information visualization	25	33	31	44	63	68	50
5— cluster analysis	7	3	5	4	6	9	7
6— information retrieval	5	5	8	7	15	8	13
7— journal	39	28	33	47	43	47	43
8— patent citation analysis	1	2	2	3	6	3	1
9— latent semantic analysis	4	2	7	6	7	8	4
10— bibliometric indicator	25	22	22	26	34	24	22
11— data visualization	12	14	12	14	18	16	33
12— citation analysis	26	21	20	30	24	28	26

It appears that in Table 10.3 most sub-domains remain at a similar level of activity during the entire period. In all sub-domains there is an increase of activity but it never exceeds the 20% growth on average during the entire period.

The overlap between the clusters (or sub-domains) is used as input to draw the map. In this map (Figure 10.2) we see 12 sub-domains with a wide range of sizes. The label of each sub-domain is represented by the most frequent keywords. The most prominent sub-domains are *semantic analysis* (which contains a substantial portion of general research as well) *citation analysis* (amongst which are co-citation studies), *journal* (representing all journal based studies), and *information visualization* and bibliometric indicator (containing performance evaluation studies). The other sub-domains represent more specific work. This map shows much overlap with the Kohonen map (ET-Map) presented in Börner, Chen, and Boyack (2003).

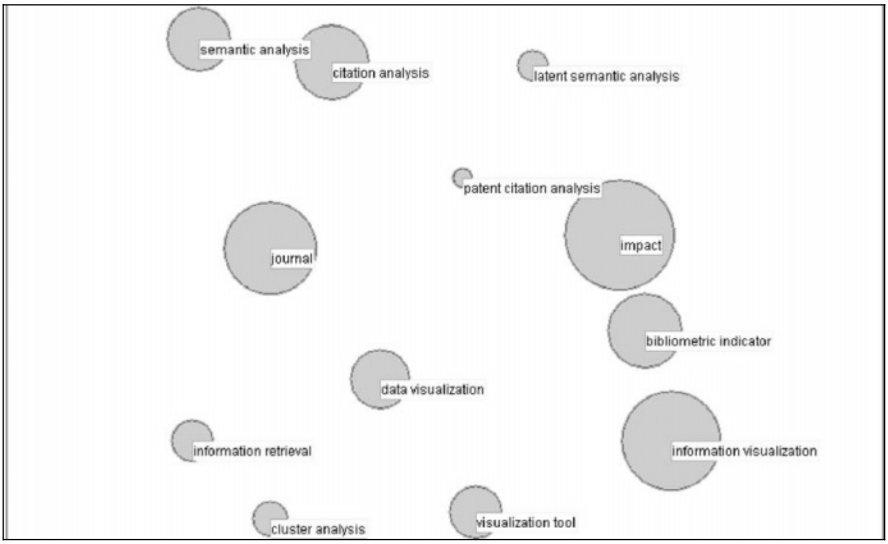


Figure 10.2. Map of the ARIST domain based on keywords co-occurrence

Separately we compiled a list of most active countries in the ARIST domain in the period 1996–2002. For these countries I also calculated the standard CWTS indicators, described in Moed, De Bruin, and Van Leeuwen (1995). The impact figures were at the time of the analysis available only for the period 1996–1998. The indicators show the profile per country for the entire field but in certain cases it may be interesting to see in which themes these countries are actually working on.

In other words, if we take the landscape as shown in the map, it would be interesting to know where the activity of these countries is located? I will illustrate how this information can be used to underpin these overall indicators. We take the example of the European Union (EU15, here considered as a country while all individual EU15 countries are included in the list as well) and compare it to the results for the United States (US). The US and EU15 have a similar production in this period but show some differences with respect to the other indicators. These differences may be due to the fact that they focus on different areas in the map. I will not elaborate on these differences here.

Table 10.4. List of most active organizations identified in the ARIST domain (1995–2002)

Country	*P*	*CX*	*CPP*	*PS*	*PN*	*CPP/FCSm*
USA	904	1,097	4.12	21%	8%	1.7
EU15	824	678	2.59	31%	12%	1.0
UNITED KINGDOM	193	187	3.53	32%	9%	1.3
GERMANY	185	92	1.70	30%	13%	0.6
NETHERLANDS	127	195	4.43	25%	5%	2.5
SPAIN	79	45	1.61	28%	17%	0.3
FRANCE	78	47	1.47	45%	20%	0.7
CANADA	76	46	1.64	36%	18%	0.7
JAPAN	63	38	1.73	38%	20%	0.6
ITALY	48	19	1.36	44%	14%	0.6

Country	Country or EU.
P	Number of publications.
Cx	Number of citations, self-citations excluded.
CPP	Average number of citations per publication (impact).
PS	Percentage of self-citations.
PN	Percentage of non-cited publications.
CPP/FCSm	Impact normalized by world average.

The map in Figure 10.3 below shows the distribution of the US over the ARIST domain. The shading of sub-domains is based on the relative contribution of the actor. Dark grey sub-domains are those with a high US contribution relative to their average contribution to the field. It appears that the US is present in all sub-domains, but with a clear focus on the upper (semantics) and lower part (visualization and IR) of the map.

The map in Figure 10.4 below shows the activity distribution of the EU15 in the ARIST Domain. Their cognitive orientation differs from that of the US, in the sense that the EU countries appear to focus more on the middle area of the map (journal studies and research evaluation). Apart from the fact that with these major actors (US and EU) we may expect that they are counterparts of each other with respect to activity in different sub-domains, we discern this clear difference of focus. From the literature in the field it is known for a fact that in Europe there is a major interest in the research evaluation component of bibliometrics.

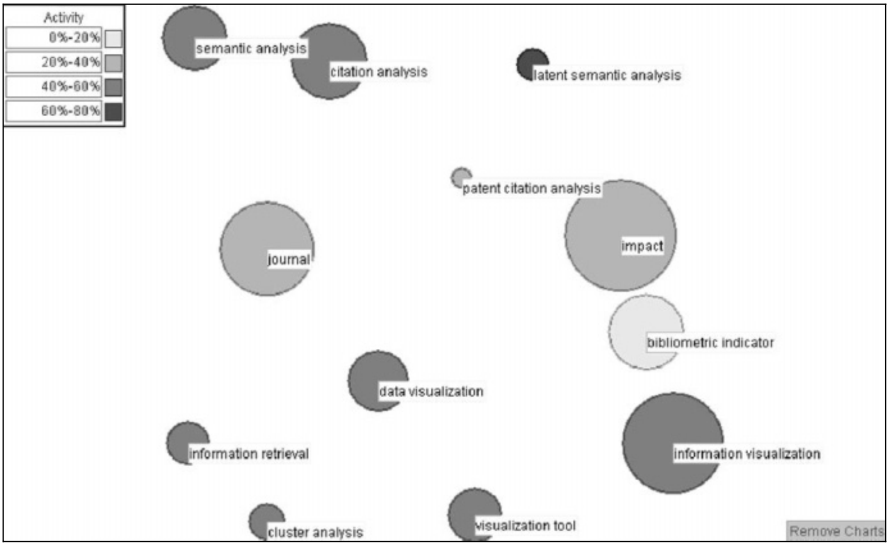


Figure 10.3. Activity profile of the US in the ARIST domain

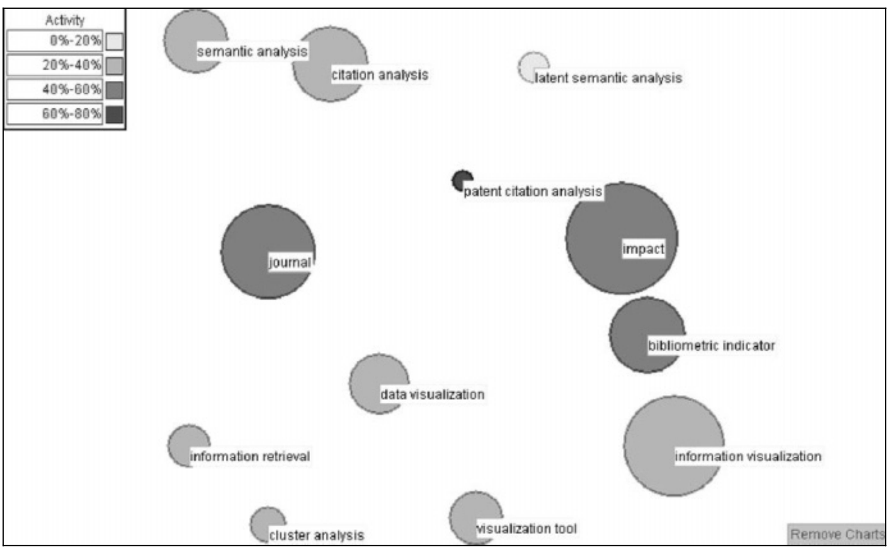
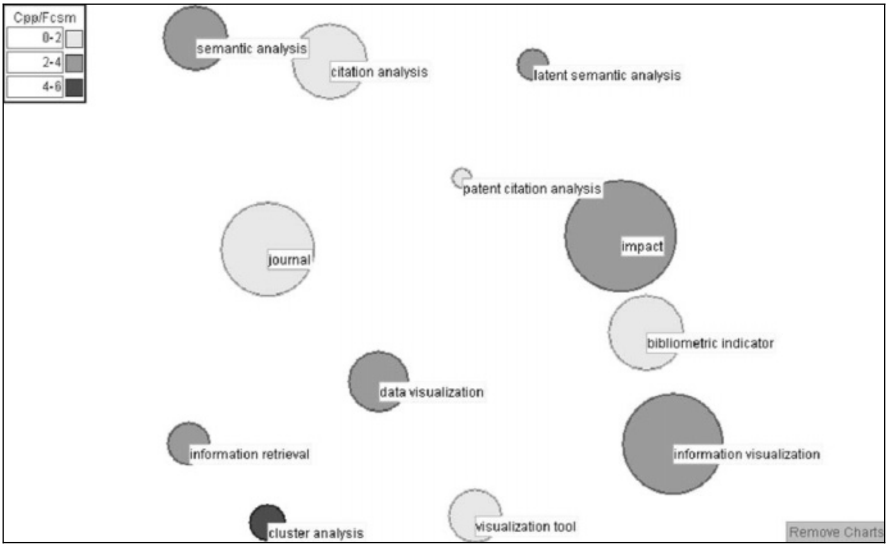
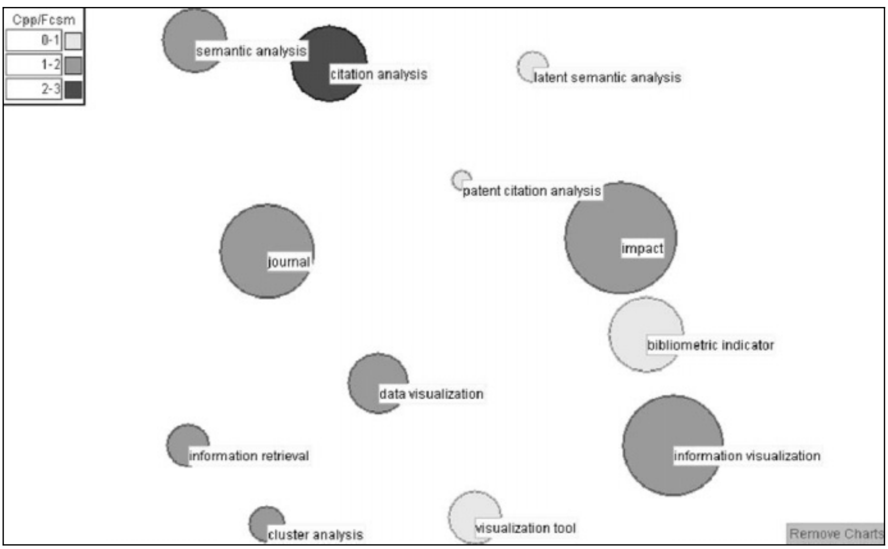


Figure 10.4. Activity profile of the EU-15 in the ARIST domain



United States



EU 15

Figure 10.5. Impact profiles of the US and EU-15 in the ARIST domain

The maps above (Figure 10.5) show that the impact distribution for both US and EU differs from their activity profile.

From a science policy perspective this distribution reveals the scope of activity of these two major actors. It would also be interesting to show their contribution to the field in terms of their impact. To investigate this I calculated the normalized impact (CPP/FCSm) of the publications for these two organizations and plotted them in the same map. This distribution shows where the impact of their work is located. Activity and orientation is one, the location of their impact is another. In this study I confine myself to showing the results. The number of publications in some cases is so low that it would be inappropriate to draw serious conclusions.

Because this small study is performed to illustrate the issues raised in this chapter, I left out detailed information about the analysis and results. More details are available via the author. This simple example illustrates how we can use the map and the actor information (organization names in publications) to characterize in more detail the activity and impact of actors and to relate it to an overall view of the domain (the map). This kind of displays provides a point of reference which makes it easier to interpret the results, because the same structure is used to characterize the performance of two different actors. In addition we could do these analyses using different time periods or additional indicators.

7. CONCLUSIONS AND PERSPECTIVES

In this chapter an overview is given of the history and present state of the mapping of science techniques, in particular those used within a science policy or research management context. The development of new techniques in the emerging field of *domain visualization* provides new opportunities. The idea of generating overviews of fields (or domains) is becoming more important in a time where fields become more interdisciplinary and where experts seem to have more problems maintaining this helicopter view.

As the domain visualizations (maps) and interfaces are dedicated mostly to IR objectives, the specific requirements for science policy and research management use should become explicit. Hence, we will be able to develop the proper maps and interfaces.

In view of the utility for science policy, the visualization techniques should provide points of reference to interpret the results more accurately. These reference points should apply to all elements at stake in such studies: structure; actors; and indicators.

The case study based on the technique developed and used at CWTS is used to illustrate the present situation and discuss the issues put forward in her. We hope to be able to join forces with many other domain visualization techniques to make serious progress in the analytical stages of the bibliometric mapping studies. We believe that the design of the user interface is of crucial importance to the applicability and utility for specific purposes, such as science policy and research management support.

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