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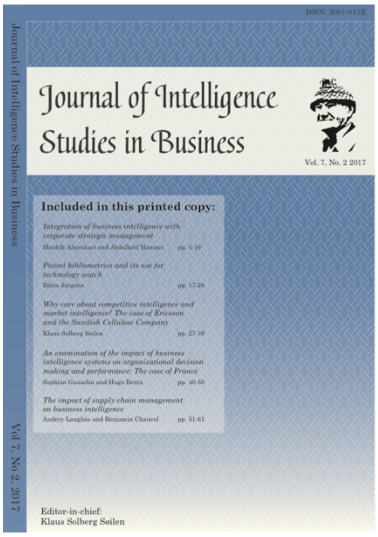


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# Patent bibliometrics and its use for technology watch

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Stevan Dedijer
1911-2004

# Patent bibliometrics and its use for technology watch

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**ABSTRACT** Technology watch is a methodology for organisations to systematically analyze technical information in a continuous way in order to gain insight and competitive advantage in a specific technical domain and is based mainly on statistical analysis of patent information. Patent statistics are commonly based on bibliographic data and generated with bibliometric techniques. In this paper we describe the differences between patent bibliometrics and classic bibliometrics and propose several patent indicators for technology watch activities which we classified into four categories: performance, technology, patent value and collaboration indicators. In a case study we undertook a bibliometric patent analysis using the described groups of indicators in order to generate a technology watch of nanotechnology for the domain of a whole country (Spain) and explained the different data visualizations we used in order to represent the indicators. We conclude that statistical analysis of patent information and its visualization is a powerful methodology for any competitive intelligence activity centred on technology but there are also some limitations to bear in mind when undertaking technology watch activities using patent information discussed in terms of its timeliness, patentability criteria, sector dependence, quantity vs. quality.

**KEYWORDS** Competitive intelligence, nanotechnology, patent bibliometrics, patent indicators, patent information, patent statistics, patents, Spain, technology intelligence, technology monitoring, technology watch

## 1. INTRODUCTION

Technology watch, also known as "technology intelligence", "technology monitoring" or "patent intelligence", is a methodology for organisations to systematically analyze technical information in a continuous way in order to gain insight and competitive advantage in a specific technical domain. Technology watch is a part of the broader concept of "competitive intelligence" (CI) which can be defined as a methodology for gathering, analyzing and managing external information that can affect the organisation's plans, decisions and operations (Negash 2004, Miller 2001). Especially high tech corporations or research intensive companies need to be able to anticipate technology trends, since a wrong choice can result in low profits and obsolete products and can have a major impact on the financial performance for many years (Hodgson 2008).

Technology watch is based mainly on statistical analysis of patent information[1]. Translating patent information into

[1]In fewer cases also other technological sources are included in the technology watch process (like funded R&D project abstracts or profiles from technology transfer platforms) although this data is less structured than patent data and has much lover coverage over countries and/or sectors.

competitive intelligence allows to measure the current technical competitiveness and to forecast technological trends of specific sectors (Fleisher 2003). As an example we can mention the works of Salvador who analyzed the plastics industry (2012) and additive manufacturing technologies (2014), or the study from Deshpande et al. (2016) who looked into relatively new fields with R&D activity like energy efficiency in cloud data centres.

Patents are publicly available documents that describe, in a structured and unified way, a technical invention which, once granted by a government or regional patent office gives the owner the monopoly to commercially exploit the invention in a specific country.

Nowadays, with currently more than 95 million open access patent documents[2], patent information is a powerful source to conduct technology watch of specific technological domains. As patents cover mainly technical inventions, they are a rich source of data reflecting technical change and in technology fields with high research and development activities. Especially in emerging sectors like nanotechnology or biotechnology, patent data can reveal the intermediate stages of innovation activities and can offer a basis for analysis where other data is lacking (Zuniga, 2009).

Patent statistics have been used to monitor and evaluate science and technology activities from the 1960s with the work of Schmookler (1966), who was one of the first to use patent counts as indicators of technological change in particular industries. Taking advantage of its structured format, patent statistics are commonly based on its bibliographic data and therefore generated with bibliometric techniques. This is why it is also known as patent bibliometrics, first introduced by Narin (1994).

*Table 1* Scientific literature vs. patent literature. From Lloyd (2015) and own research.

| | Scientific publications | Patent publications |
|---|---|---|
| Content | Mainly basic research findings | Technical solutions to a problem |
| Access | Paid access or open access or depending on the journal | Open access via public patent databases |
| Quality filter | Peer review | Patent examination process |
| Indexing | Scientific papers can have inconsistent bibliographical details, meaning that they can be hard to index. | Patent publications have a (more or less) standardised numbering system, meaning that it is possible to fully index them. |
| Subject categorization | Core journals by subject field | Patent classifications by technology field |
| Reason to publish | Scientific recognition | Economic (gain commercial monopoly, licensing, etc.) |
| Who publishes | Research entities (mainly universities) | Companies and to a lesser degree research entities and private persons (inventors) |
| Cost | Sometimes fee based and others for free (depending on journal prestige) | Fee based (depending on patent office and coverage) |
| Content duplicity | No (the article can only be published in one single journal) | Yes (as patents are territorial, the same invention can generate several different patent documents for each country) |
| Timeliness | Article publishing depends on the efficiency of the peer review process of the journal | Patent is not published before 18 month after filing |

[2]Source: https://www.epo.org/searching-for-patents/technical/espacenet.html

*Table 2* Performance indicators.

| Indicator | Metrics | Description |
|---|---|---|
| **Top country applicants (per patent family)** | Patent family counts per applicant | Indicate the company/institutions which have most inventions in a field or topic. |
| **Top country applicants (per patent publication)** | Patent document counts (published) per applicant | Indicate the top company/institutions which have most patents in a field or topic. |
| **Patent counts by the applicant over years** | Patents filed (priority) / applicant / year | Measure the level of R&D efforts. A variation can be interpreted as a change in their R&D strategy. |
| **Patent internationalisation rate of applicants** | Patent document counts (published) per applicant / Patent family counts per applicant | Indicate the applicants with the highest ratio of generated patents of their invention portfolio. |
| **Top country inventors (patent family)** | Patent family counts per inventor | Indicate the inventors which have most inventions in a field or topic. |
| **Top country inventors (patent publication)** | Patent document counts (published) per inventor | Indicate the inventors which have most patents in a field or topic. |
| **Patent internationalisation rate of inventors** | Patent document counts (published) per inventor / Patent family counts per inventor | Indicate the inventors with the highest ratio of generated patents of their invention portfolio. |

## 2. PATENT BIBLIOMETRICS VS. CLASSIC BIBLIOMETRICS

Bibliometrics was first mentioned in 1969 by Pritchard, who defined it as "*the application of mathematical and statistical methods to books and other media of communication*" (Pritchard, 1969). The general properties of classic bibliometrics which analyze scientific publications and patent bibliometrics which analyze patent publications are very similar (Narin, 1994) but we have to be careful when comparing both types of analyzed documents since they have some substantial differences. In Table 1 we sum up the main distinctions regarding several aspects such as their content, access, and indexing.

*Table 3* Technology indicators.

| Indicator | Metrics | Description |
|---|---|---|
| **Technology evolution (per patent family)** | Patent family counts in technology field / year | Forecasts the technological trend on the number of inventions. |
| **Technology evolution (per patent publication)** | Patent document counts (published) in technology field / year | Forecasts the technological trend on the number of patents. |
| **Technological distribution** | Patents filed (priority) / Classification | Identifies the core technologies of the analyzed technology. |
| **Technological networks (macro level)** | CPC level 4 / CPC level 4<br>IPC level 4 / IPC level 4 | Relationships between technological domains |
| **Technological networks (micro level)** | CPC level 7 / CPC level 7<br>IPC level 7 / IPC level 7 | Relationships between specific technologies |
| **Applicant technology network** | CPC level 7 / applicant<br>IPC level 7 / applicant | Relationships between company/Institution and technological domains (macro and micro level) |
| **Inventor technology network** | CPC level 7 / inventor<br>IPC level 7 / inventor<br>CPC level 4 / inventor<br>IPC level 4 / inventor | Relationships between inventor/researcher and technological domains (macro and micro level) |

*Table 4* Patent value indicators.

| Indicator | Metrics | Description |
|---|---|---|
| **Publications per patent office** | Patent application published / patent authority | Indicate which are the most important markets for patents from the analyzed technological domain. |
| **Family size** | Patents application published / family members | Reflects the intention to produce or commercialize globally the products related to the invention. |
| **Top applicants geographic coverage** | Ratio patent application published / family size | Indicates the grade of internationalization of applicants patent portfolio. |
| **Top inventors geographic coverage** | Ratio patent application published / family size | Indicates the grade of internationalization of an inventors patent portfolio. |
| **Family network** | Patent authority / patent authority | Indicates which markets are co-protected and identifies the essential markets where protection is sought together. |
| **Top patents with backward citations** | Number of cited patents / patent | Helps to identify technical complementarities or substitutes or prior art patents. |
| **Top forward cited patents** | Number of citing patents / patent | Reflects the technological impact of the patented invention and helps to identify key patents which influenced other patents. |

## 3. PATENT INDICATORS FOR TECHNOLOGY WATCH

In patent bibliometrics we can distinguish two main types of analysis: single field analysis and multiple field analysis (E-IPR 2013). The single field analysis, widely used also in classic bibliometrics, is a one field analysis based on lists or rankings and is conducted on a set of bibliographic patent references. Multiple field analysis, also known as cross reference analysis, combines different types of bibliographic fields via matrices. This is the basis for data visualization via collaboration networks that can reveal valuable information for a technology watch activity.

With these types of analysis we can generate several patent indicators for technology watch activities which we propose to classify in the following four categories that will be explained subsequently:

- Performance indicators
- Technology indicators
- Patent value indicators
- Collaboration indicators

### 3.1 Performance Indicators

We considered performance indicators to be patent indicators that deal with the patent output of the analysed entities (inventors or applicants) and that are used to monitor the technological performance of company / institutions and inventors / researchers and to track their technological leadership in a given technology over time (Zuniga, 2009).

In Table 2 we describe various typical patent indicators of this type.

### 3.2 Technology indicators

Technology indicators analyze patent classifications and are another very valuable indicator for technology watch activities since every patent is classified with one or more classes according to its technological field. With single and multiple field analysis of the classification we can reveal the technological focal points of an organisation, the research fields of inventors, the evolution of a technology sector and the relationships between technological domains (Table 3).

Macro and micro vision of the technology field can be distinguished in some cases by analyzing the patent classes in different hierarchy levels. For instance a more general vision of the technology landscape (macro vision) can be obtained by aggregating to a 4-digit classification level ("level 4" till subclass hierarchy) and for a more detailed technology perspective (macro vision) the 7-digit classification level ("level 7" till sub group hierarchy) can be used.

### 3.3 Patent value indicators

Patent value indicators can give us an idea about the economical value of a patent by looking at several factors (Table 4). First of all, the size of the patent family and the geographic coverage are important indicators. Patents provide protection on a country level and can be extended to other countries in the 12 months of priority since its first filing. In this sense, the more countries a patent is extended, the broader is their protection and the invention can be considered as economically more promising since the applicant is willing to assume the correspondent high costs of the patent extensions (Hullmann, 2003). In this context another indicator is the ratio of the family size and total invention output compared, which can be used to measure the grade of internationalization of an inventor's or applicant's patent portfolio.

Apart from the quantitative measure of patent families, specific patent types or countries are also used as patent indicators. Patenting in certain countries can be considered as more important than in others (Palmberg, 2009). For example a European Patent (EP) or PCT patent application is considered of special relevance, and if a invention is filed as a Japanese, US and European Patent by the same applicant or inventor the patent is given a special importance since it covers the three most important patenting authorities worldwide (the so called Triadic patent family).

Patent citations are another important indicator related to patent value and to identify knowledge flows from company to company, or from other sectors, e.g. research institutes and academia to companies (Meyer, 2002). Similar to citations in scientific articles, in patents you can distinguish forward and backward citations. Backward citations are the references in a patent document to earlier documents whereas forward citations are more recent documents that cite the patent. As a difference from scientific articles, in patent citation we can distinguish citations from the inventor and citations from the patent examiner. Citations from the inventor are the references that the inventor provides in the patent to describe the state of the art and to give evidence for the novelty of the patent. Citations from the patent examiner on the other hand are the documents that the patent examiner references in the patent examination procedure. In most countries before a patent gets granted, in order to measure the novelty of the invention the patent office appoints an examiner who is ideally an expert in the particular technical field and who searches for documents in the scientific and technical literature that are related to the particular invention and were published before the date of filing of the application.

In both cases citations in patents can be used to:

- trace the information sources on which the invention was built,
- illustrate the relations with other inventions
- and reveal geographical and technological linkages.

Citation indicators have to be handled with care since one must consider that new patents rarely earn many forward citations because it takes time for a patent to be cited by newer patent documents and therefore a strict forward citation analysis will favour older patents. Furthermore, with the obligation to cite all possible prior art, patent applicants tend to cite many more references than needed, leading to patent references where the cited patent is not of particular relevance. This is the case especially in US patents since, contrary to the European patent system, in the US both the applicant and every other involved party (e.g. the patent attorney), must include any possible prior art of an invention in order to minimize the risk of the application being rejected, which leads to the fact that US patents on average include far more citations than European ones (Azagra-Caro 2009, Alcacer Gittelman 2006).

### 3.4 Collaboration indicators

These type of indicators provide information about collaboration patterns of the entities. They are generated with multiple field analysis and can be visualized with network maps. Similar to traditional bibliometrics, in patent bibliometrics the most important collaboration indicators are related to co-authorship (Glänzel et al., 2003), although their interpretation slightly differs as outlined in Table 5.

## 4. CASE STUDY: TECHNOLOGY WATCH OF NANOTECHNOLOGY IN SPAIN

In the framework of a funded project (see Acknowledgements) a bibliometric patent analysis study was done using the described groups of indicators in order to generate a technology watch of nanotechnology for the country of Spain (Jürgens 2016).

*Table 5* Collaboration indicators.

| Indicator | Metrics | Description |
|---|---|---|
| **Applicant collaboration network** | Applicant / applicant | Collaboration between organisations: Connect entities that share the ownership of a patent and contrary to co-inventions can point to a shared interest in utilising a patented invention. |
| **Inventor co-authorship collaboration network** | Inventor / inventor | Research collaborations: Identifies individuals (inventors or researchers) who generated the technology in a common undertaking and can be considerate as most closely related to the co-authorships in scientific publications. |
| **Applicant collaboration by country** | Applicant country / applicant country | Identifies international collaboration on an institutional level. |
| **Inventor co-authorship by country** | Inventor country / inventor country | Identifies international collaboration on a research level. |

In Spain competitive intelligence and technology watch as a discipline was first brought to a wider audience by the work from Palop & Vicente (1999). Nowadays, it is an established methodology for fostering the competitiveness of organisations and even has its own certification scheme within the Spanish certification entity AENOR (García & Velasco 2006). Although it is applied by many Spanish multinational companies from a diversity of sectors, e.g. Telefónica and Repsol, there is still a knowledge gap amongst the small and medium enterprises which is why many regional development agencies have initiated it to provide technology watch services to fill this gap (Jürgens, Herrero-Solana, 2011).

In the case of nanotechnology in Spain only one study was identified (Andaluz & Sanchez, 2006) centred more in information analysis of the R&D output than patents. This apparent lack of patent analysis in this sector in Spain led to the project of this case study where we analyzed the nanotechnology patent publications of Spanish applicants of the years 2004 till 2014.

Regarding the search strategy, relevant nanotechnology patent classifications were identified (Jürgens, Herrero-Solana, 2016) and combined with an established lexical query for nanotechnology (Magrebi et al 2010). As a data source the database *Espacenet-Worldwide* from the European Patent Office was used since it provided the best data coverage for the purpose of the study (Jürgens, Herrero-Solana 2015).

The search process retrieved more than 3400 patent records with Spanish authorship and after an exhaustive data harmonization process a bibliometric patent analysis was performed using the software tool *Matheo Patent*. For a patent/paper comparison, furthermore, scientific article data was retrieved from the database *Scopus*.

Subsequently several indicators were generated according to the groups described earlier and were presented via data visualization techniques.

Apart from graph and pie charts, which were used for many single field indicators (e.g. numbers of nanotech patent publications over time), we used choropleth maps containing patent data aggregated over predefined regions with colour ranges representing the data ranges in order to visualize the geographical "hot spots" of nanotechnology patenting in Spain (Figure 1).

Scattergraphs were used in the study to compare the patent and scientific publication outputs of the most important nanotechnology players in Spain, segmented in colour by their type of institution (e.g. company, university) (Figure 2).

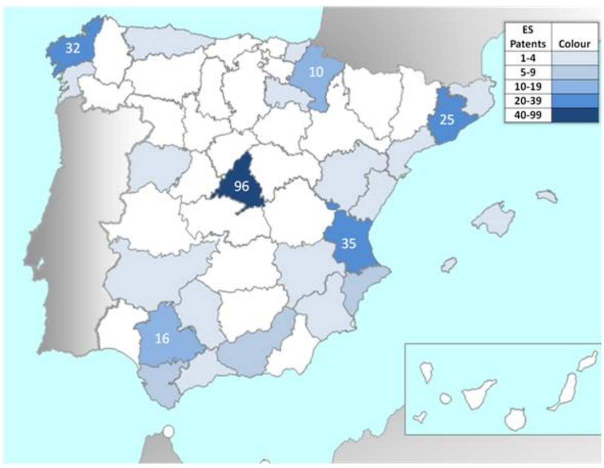


*Figure 1* Geographical patent hotspot map (the darker the more nanotech patents were published).

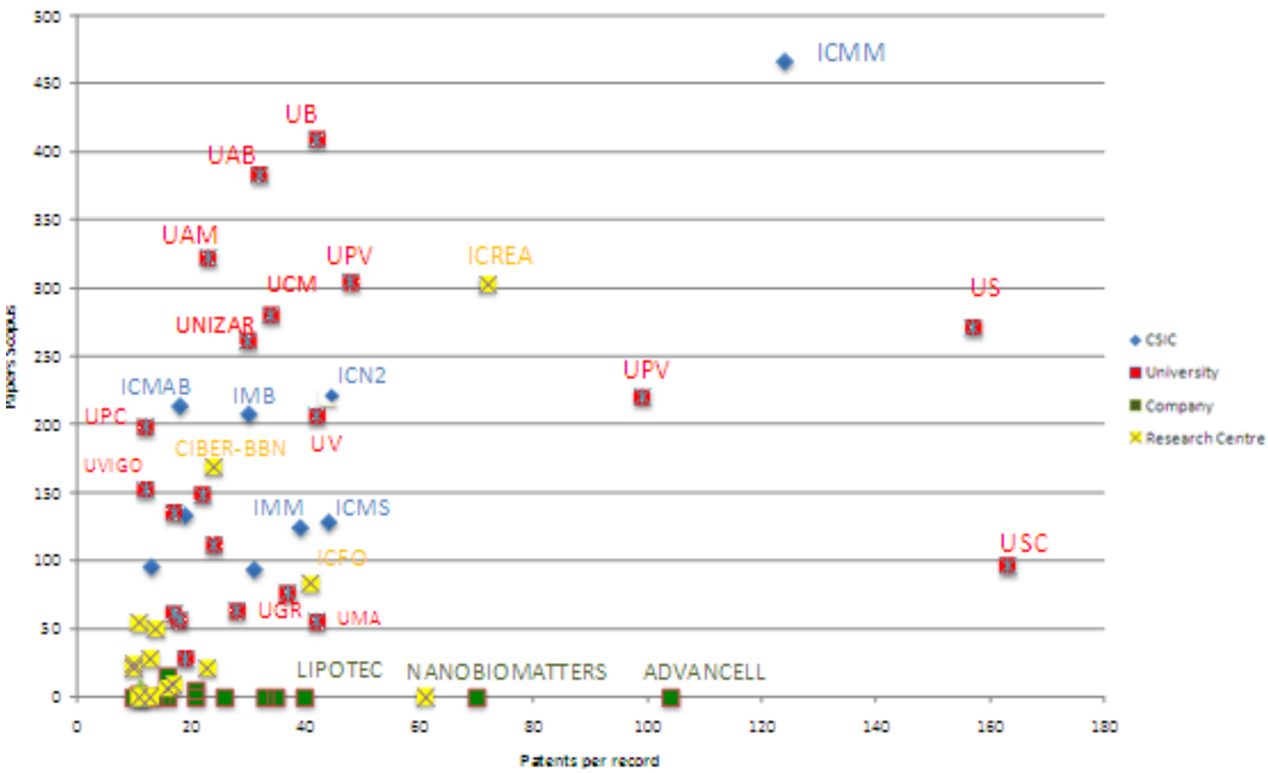


*Figure 2* Comparison of patent and scientific papers output revealing which institution/company has more focus on basic (papers => Y axis) or aplied research (patents => X axis).

Furthermore, network maps were used extensively as they are intuitive to read since entities are connected to each other in the form of a node and link diagram. In the case study we used network maps to visualize several types of indicators, as shown in the examples in Figures 3-5.

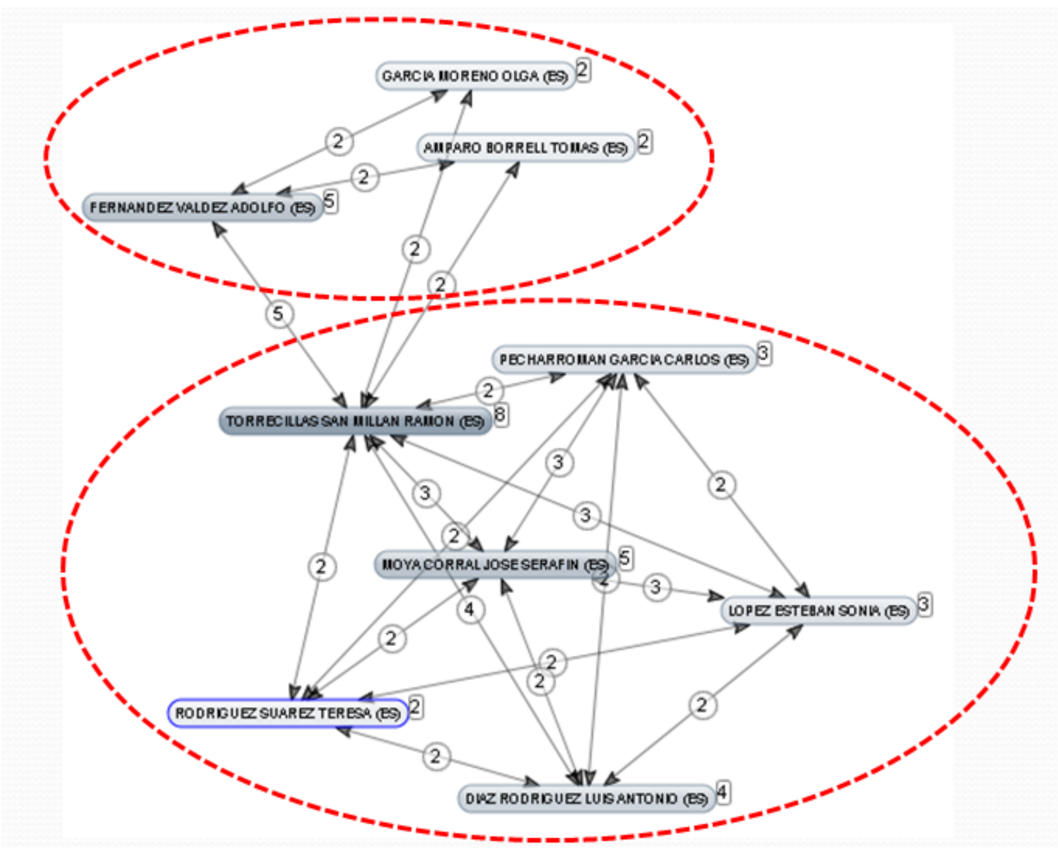


*Figure 3* Coauthorship network revealing collaboration patterns of two research groups (red circles) and showing their leaders in terms of publications (in dark grey).

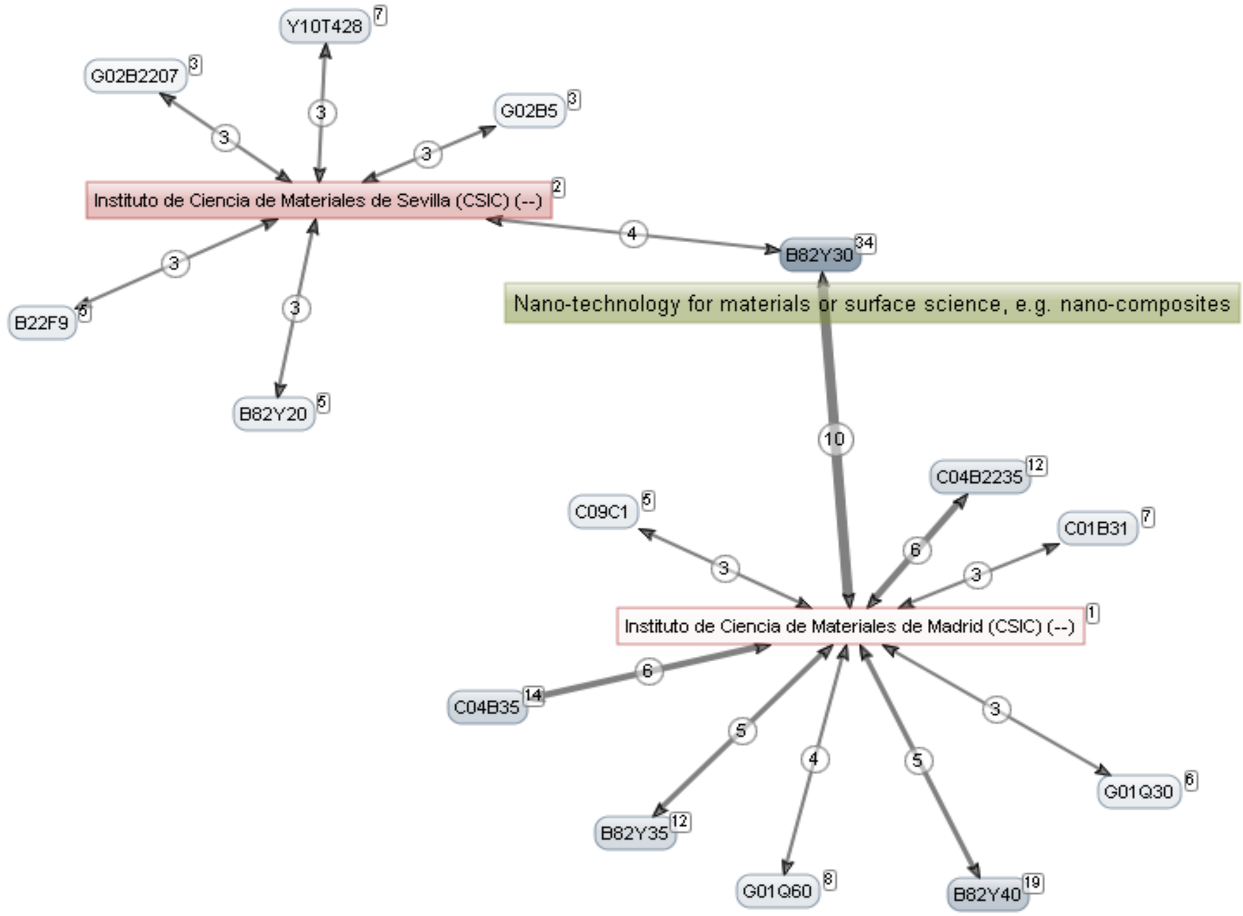


*Figure 4* Technology network map revealing a common technology focus (in green) of two Spanish nanotech institutions (in red and light red).

## 5. LIMITATIONS OF PATENT BIBLIOMETRICS AND CONCLUSIONS

There are also some limitations to take in mind when undertaking technology watch activities using patent information. First of all, the timeliness. The patent system of most patent offices worldwide establishes that a patent is not divulged by the patent office until 18 months have passed. Only then the patent office publishes the application via its patents office bulletins and patent databases. This means that patent indicators have a considerable delay of a minimum 18 months.

Second, not all innovative activity is patented or even patentable and therefore cannot be captured in a patent analysis. This can be due to the following reasons:

- the costs a patent process incurs are too high for the inventor/researcher
- the necessary public disclosure of the invention is not wanted by the inventor/researcher and it is preferred to keep the invention secret instead of patenting
- the invention itself is not patentable because it does not fulfil the patentability criteria (e.g. in most countries scientific theories, mathematical methods, plant or animal varieties or commercial methods are not patentable)
- the invention is not patented due to strategic decisions

Third, when comparing patent data between technological sectors it has to be taken in mind that patenting activity tends to vary significantly across different industries (Pavitt, 1985).

Finally, most patent indicators are quantity based and do not measure quality of the patents. It has to be taken in mind that not every patent has the same value and the distribution of the value of patents is skewed as only a few patents turn out to be commercially successful (and therefore are of substantial value) whereas many patents do not reach the market. Further research in this specific aspect would be of interest.

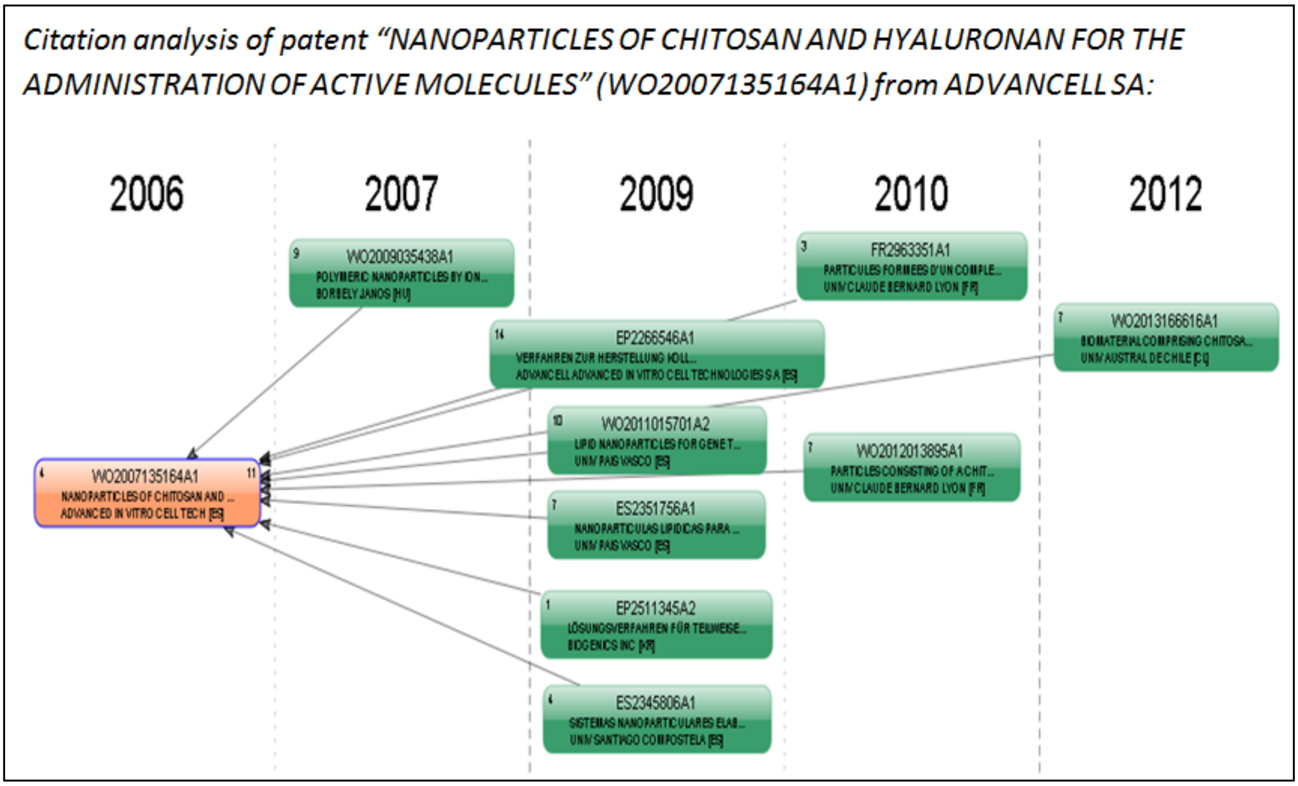


*Figure 5* Citation node map of a Spanish nanotech patent (orange box) reveals who was influenced by the technology (green boxes).

Nevertheless, we can conclude that statistical analysis of patent information and its visualization is a powerful and successful methodology for any competitive intelligence activity centred on technology, since it can be effectively used to monitor and evaluate technology activities. This can be observed by the increasing numbers of studies which use this type of analysis, although we would recommend to take in mind the afore mentioned limitations when doing this kind of analysis.


## ACKNOWLEDGMENTS

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