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The connection between science and technology in the Basque Country. Analysis of patents in literature.

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Abstract: Citations of non-patent literature contained in patents are widely used as an indicator of the relationship between Science and Technology. From the beginning up to later studies, there could, however, no agreement on their usefulness as robust indicator of the flow of knowledge between Science and Technology be found. Using a sample of 2.438 patents from the Basque Country, this article presents new results in order to evaluate the usefulness of citations in non-patent literature as indicators that show the flow of knowledge between the scientific activity and the technical innovation of the companies in that region.

Keywords: Patents; Innovation management; Citations; Science-technology linkages; Nonpatent references

1. Introduction

The relationship between science and technology is a topic that has become increasingly important in the modern economies in the last few years. In order to increase the competiveness of the industrial sector it is necessary to improve the technology transfer mechanisms between science and industry. The first stage in order to improve these mechanisms is precisely knowing them. During the last decade the usage of citations from patents and non-patent literature as an indicator of innovation has increased rapidly (Carpenter et al. 1983; Narin et al. 1985). Given that these indicate the scientific and technological background of inventions

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they make it possible to follow up the evolution of knowledge. It is possible to identify the influence of certain inventions or groups of inventions and to map their dissemination throughout the economy.

The citations make it also possible to investigate the connections between different technologies, between science and technology or between companies, sectors, countries or regions. These connections can be divided into different types: technological fields, the type of applicant (national or international companies, universities, etc.), inventors etc.

The citations, be it of patents or of non-patent literature, are the references that appear in the search report and that are used to evaluate the patentability of an invention and define the legitimacy of the claims of a new patent application. Given that they function as reference of the state of the technology, they indicate the knowledge previous to the invention and can, as well, be cited in order to justify the lack of novelty of the cited invention. The citations, however, also show the legal limits of the application's claims of the patent in question.

In most cases, the citations are the product of an intense search of the state of the technology, conducted by the examiners with the aim of evaluating the degree of novelty and the inventive activity which is a prerequisite is essential for a certain invention. There are basically two types of citations:
1) The references of patents that are the citations of relevant technology that was previously protected or described in other applications. 2) The References that are classified as non-patent literature (NPL) and that deal with the representation of the possible flow of knowledge between Science and Technology.

The use and application of the indicators of citations are numerous. In the literature about innovation we can find three uses: The measurement of the flow of knowledge (Jaffe et al. 1993). The measurement of patent quality (Harhoff et al. 2002). The strategic conduct of companies (Podolny et al. 1996).

Retrospective citations can be used to find out about the effect of dissemination of knowledge of a technology. The citings can help assess the curve of obsolescence of technologies, the dissemination of knowledge that is triggered by some inventions and thus spreading to institutions, areas, regions etc. The background of these indicators, however, shows that when interpreting the citations of patents and the citations of non-patent literature one has to take certain limitations into consideration:
Various empirical studies (Narin et al 1998; Meyer 2000a) show how the reasons for which examiners, applicants or inventors, incorporate non-patent literature in their citations do not always based on the relation with the patent. The inventor himself is not always aware of the incorporation of new citations, after the search report, that are provided by the examiners or patent lawyers (Jaffe et al. 2000). Nevertheless, this limitation allows considering the citations that are included in patents as less redundant than those of scientific articles and as a result of this, as mentioned before, under better control of the examiners and the possible legal consequences (Verbeek et al. 2002).

Due to this it is possible to find so many authors that are optimistic about considering non-patent literature as a relatively robust indicator of the relationship between Science and Technology (Narin et al. 1997) but there are as well those who think that there is little proof for the before mentioned relationship (Tijssen et al. 2000; Tijssen et al. 2002). Others prefer to speak of interaction instead of relationship (Schmoch 1993).

Taking prior studies into consideration we can conclude that scientific citation in patents is a valid indicator reflecting the relationship between Science and Industrial sectors. This constitutes, however, only a small part of the complex model of the relationship that exists between Science and Technology.

This article provides a different dimension to prior studies, the regional one (Rio-Belver et al, 2008). By adding the contained data to the database of the European Patent Office (EPO) and the one of the Spanish Patent and Trademark Office (OEPM) one can limit the study of patents to those granted to applicants from the Basque Country.

Thus the aim of this article is to evaluate the usefulness of information contained in patents as indicators that show the flow of knowledge between the technological development of industrial sectors and the scientific activity in the Basque Country.

2. Citations in non-patent literature

As mentioned in the previous point there is certain recognition of how references in non-patent literature are useful to investigate the mutual relationship between Science and Technology. The average level of non-patent literature has been used repeatedly as a representative indication to quantify the relationship between a technological field and a scientific field (Narin et al. 1997; Meyer 2000a; Verbeeck el al. 2002). The more scientific references there are in patents the closer one considers the technology of the basic investigation. The analysis of the scientific relationship of patents can be amplified with important topics within technological policy, especially as far as the influence of science on new or emerging technical fields is concerned (Changyong et al. 2012) or the value of Science for industry.

Non-patent literature does not only consist of scientific publications, but also of other types of publications: conference proceedings, references of databases, and other relevant literature.

3. Sample and analysis

The sample (n= 7.815) is made up of all solicited patents between 1929-2010 in the Basque Country. As registering the citing field of non-patent literature in the INVENES of the OEPM started in 1993 it can be assumed that the sample of the study is lower (n=2.438) between the years 1993-2010 in the field "Publication Date of Application".

Of the 2.438 patents a total of 375 cite references of non-patent literature amounting to a total of 744. In the case of the number of patents with citations of patents it increases up to 2.379, which makes a total of 10.786 citations. There is in both cases a significant difference in the proportion of citations per patent (NPL: 0,31; Citation patents: 4,42) but it matches to similar studies on a European level (Callaert 2006).

In Fig.1 one can observe how the number of citations in non-patent literature has increased globally during different years even considering certain years (1996, 2002 y 2005) in which the number of citations seems to have gone down considerably. This can be partly ascribed to the citation intensity in the before mentioned years (number of citations among number of patents that cite) which is below average except in the year 2005 where it is slightly higher. Something similar occurs when looking at the last year where a considerable increase of references can be detected which is a consequence of the higher number of patents and the increase in the intensity of those. This intensity during different years fluctuates between 1 and 2.5, which is considered to be moderately stable taking the extent of the analyzed sample into consideration.

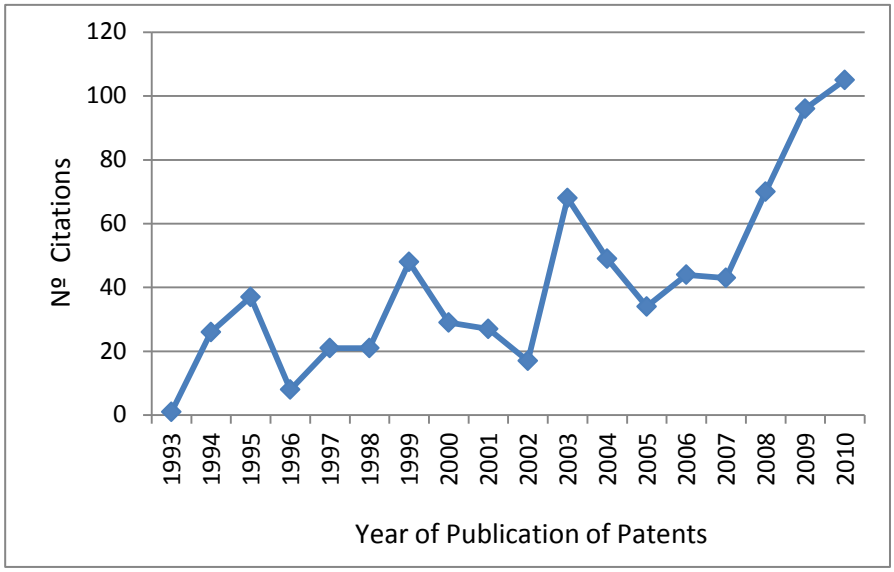

Fig. 1 Total Number of NPL during the period of study (1993-2012)

This longitudinal analysis is differentiated as far as industrial sectors are concerned as can be seen in Fig. 2. The Sectors and industrial groups were divided into groups according to the classification drawn up by Hidalgo Nuchera based on the codes of the International Patent Classification (Hidalgo 2003).

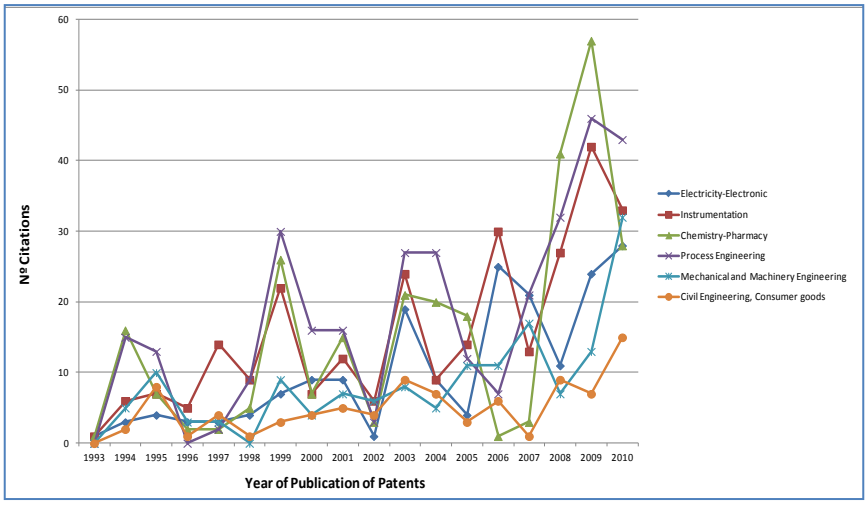

Fig. 2 Total number of citations per industrial sector during the period of the study.

One can observe how all the industrial sectors are following the same pattern of an increase in the average. "Process Engeneering", "Instrumentation" and "Chemistry-Pharmacy" are the sectors that are above average as far as the number of citings is concerned, 25%, 22% and 21% respectively. The groups with the most citations within each sector would be "Machinery and devices for food and agriculture", "Control technology, analysis and measurement", and "Agriculture and food" respectively for each sector.

In order to distinguish between the intensity of citation of the sectors, so to say, the number of citations within the total number of patents of the sector within the period of study, we have to compare the figures in relative terms.

In this case there are four sectors that are above average (0,18): "Chemistry-Pharmacy" (0,51), "Instrumentation" (0,38), "Electricity-Electronic" (0,28) and "Process Engineering" (0,20).

Finally there is another aspect that one has to analyze, the nature of citations in non-patent literature. In table 1 the different groups are illustrated.

Table 1 Classification of the different types of citations. (Callaert 2006)

Nature	References	%
Reference Books/Databases	425	57,1%
Journals	223	30,0%
Conference Proceedings	39	5,2%
Books	24	3,2%
Newspapers/Magazines	13	1,7%
Industry/Company related documents	5	0,7%
Research/Technical Reports	9	1,2%
Unclear/Others	6	0,8%
Total	744	100,0%

The data shows that the type of citations that is used most widely is "Reference Books/Databases" followed by "Journals".
This data contrasts other studies carried out with references by the USPO and the EPO (Van Vianen et al. 1990; Harhoff et al. 2002; Callaert et al. 2006) where the type of reference used most widely was "Journals".

4. Conclusion

The obtained results confirm the link between the achievements obtained by Science and Technical innovation in industry in the Basque Country between 1993-2010. It is possible to make out the before mentioned connection between citations in non-patent literature that contain the application of the register of industrial property.

In the same way one has to indicate that this relation is not very consistent due to the low percentage of scientific articles that make up non-patent literature (30%). The extension of these results to a non-regional area would therefore improve its representativity due to the increase in the extent of the sample.

The industrial sectors where non-patent literature is cited most often in absolute terms are "Process Engineering", "Instrumentation" and "Chemistry-Pharmacy". If we, however, take the citation intensity of the sectors into consideration there is a fourth sector that is above average: "Electricity-Electronic". What is most notable is that "Chemistry-Pharmacy" has the third highest score in absolute terms and is thus the most important in relative terms. Consequently the necessity of using the term Citation Intensity is justified in order to identify the three industrial sectors that have the strongest link to Science.

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