Recent Advances in Patent Analysis Network

Javier Gavilanes-Trapote, Rosa Río-Belver, Ernesto Cilleruelo and Jaso Larruscain

Abstract The databases of patents are considerable, with many authors, as a source of information very valuable within the innovation process. One of the most important methods in patent analysis is based on the citations. The basic concept of patent citation analysis is that there exists a technological linkage between two patents if a patent cites the other. The networks codifying the cited-citing relationship between patents are useful for visualizing the overall status of a given technology and helps the experts in the identification of the technological implications using analysis network techniques. The potential offered by the measuring citations for planning and assessing of policies from Science and Technology is immense. The aim of this paper is to describe the utilities and limitations of the analysis network of patents as well as recent advances.

Keywords Patent citation · Patent citation network · Patent classification · Technological knowledge flow · Citation frequency

J. Gavilanes-Trapote · R. Río-Belver · J. Larruscain
Foresight, Technology and Management (FTM) Group, Department of Industrial Engineering, University of the Basque Country UPV/EHU, Calle Nieves Cano, 12, 01006 Vitoria, Spain
e-mail: javier.gavilanes@ehu.es

R. Río-Belver
e-mail: rosamaria.rio@ehu.es

J. Larruscain
e-mail: jaso.larruscain@ehu.es

E. Cilleruelo (✉)
Foresight, Technology and Management (FTM) Group, Department of Industrial Engineering, University of the Basque Country UPV/EHU, Alameda Urquijo s/n, 48030 Bilbao, Spain
e-mail: ernesto.cilleruelo@ehu.es

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1 Introduction

Many studies have revealed that the patents are more than 90 % of the latest technical information in the world and 80 % of the information in the patents have not been published in any other form (Zha and Chen 2010). In this sense, considering the patent as a substitute of technology, the analysis of the patents has been considered as an analytic tool for forecasting technology.

The first analysis of the patents consisted of counting the patents and making a comparison by nation, company or technological fields (Wartburg and Teichert 2005). The last decade has triggered the use of citations from patents and from non-patent literature. The basic concept of the analysis of the patent citations is that there exists a technological linkage between two patents if one patent cites the other or a knowledge flow if the citation is between one patent and a scientific article.

Besides the simple frequency counts there exists other indicators like technological cumulativeness, citation impact, generality of a patent, technology strength or technology cycle time.

The potential offered by the measuring citations for planning and evaluation of the policies from Science and Technology is immense. Mainly their utilities can be grouped into three: the measurement of knowledge flows, the measurement of patent quality and the strategic behavior of companies (Podolny et al. 1996).

In respect to the measurement of the quality of the patents, the citation analysis is one of the methods most used (Narin 1994). Harhoff et al. (1999) discovered that the American and German patents with high economic value tend to be cited more often. Various studies found a relationship between citation frequency of patents and their market value (Nagaoka 2005). In recent literature we can find numerous studies that try to measure the value of the patents (Breitzman and Narin 2001; Hall et al. 2005; Cheng et al. 2010). However the real value of a patent and its relation to innovation is a complex subject (Meyer 2000; Wang 2007).

The citations as indicators of technology flow have been utilized in numerous studies, for example to identify the core technologies in the telecommunication sector (Lee et al. 2009), discover the knowledge flows among traditional and emerging industries (Han and Park 2006) or identify core and emerging technologies in Taiwan (Cho and Shih 2011).

A form of representation of the technology flows is through the patent networks that allow to visualize the results and simplify the understanding. These networks are based in the co-citation of the documents to discover the bonds of technological knowledge that bind.

The aim of this paper is to describe the contributions and limitations of the patent network analysis as well as recent advances.

2 Patent Citation Network

The analysis of co-citation is one of the most important methods of patent analysis. It goes back to the classic work of Small (1973) where a new form of document coupling called co-citation is defined as the frequency with which two documents are cited together.

Recently this analysis has been used to study the knowledge structure of various technological fields including nanotechnology (Huang et al. 2004; Kostoff et al. 2006). Wallace et al. (2009) took the research further and used the co-citation network to detect clusters based on the topology of the citation-weighted network (Blondel et al. 2008).

Sung et al. (2010) adopted a microscopic approach to measure and evaluate the level of technological convergence through the analysis of patent citation. Yoon and Kim (2011) used SAO-based semantic patent network to identify the rapidly evolving technological trends for R&D planning.

Betweenness centrality is an important measure to take into account in the citation network of patents. It is equal to the number of shortest paths from all vertices to all others that pass through that patent. Betweenness centrality is a more useful measure (than just connectivity) of both the load and importance of a patent.

Recent studies have shown that most of the citations are linked with a small group of patents with a high betweennes centrality. Take into account that measure allowed to detect the key patents in the knowledge diffusion process in a network.

3 Latest Advances

The patents are grouped by technology by way of two classification systems: used the United States Patent and Trademark Office (USPTO) and the International Patent Classification (IPC) developed by the World Intellectual Property Organization (WIPO). These classifications are very hierarchical and can commit errors, hinder the detection of the technological spillovers and not discover emerging technologies.

For this reason, some author has created their own patent classification by the co-citation of the IPCs of each patent (Kay et al. 2012; Schoen 2011). This new classification tends to be heterarchy continuously adapting to the technological changes and being more sensitive to the classification errors.

Kay et al. (2012) have been a global patent map developed using the data of the European Patent Office (EPO) between 2000 and 2006. In Fig. 1 the map is represented and through the special positioning of the nodes or categories and the relationship and distance among them. The different colours represent each of the 35 new technological areas and the nodes are the 466 new sectors or technological categories that form the new classification of patents. For proper representation, the correct number of digits was varied in the IPC hierarchy in order to optimize the size of the categories.

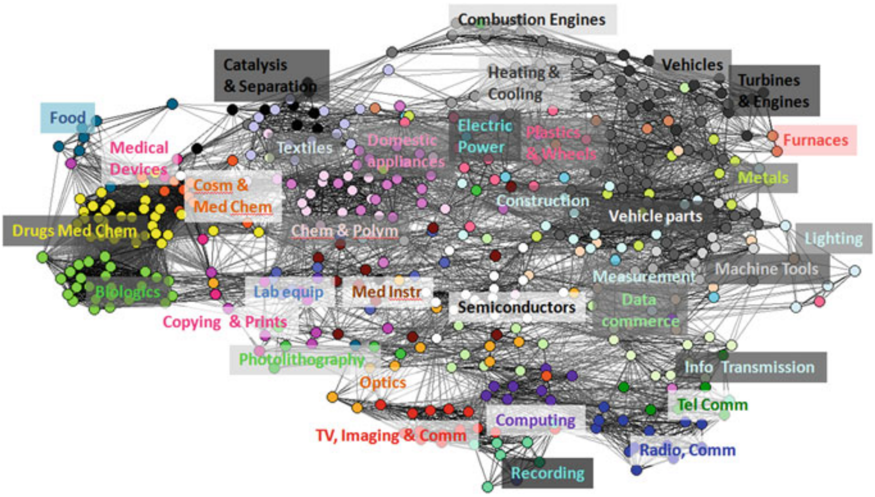

Fig. 1 Full patent map of 466 technology categories and 35 technological areas (Kay et al. 2012)

The subsequent studies such as Leydesdorff et al. (2014) intended to systematize the process more and propose normalizing the categories through the cosine as a similarity measure. Even more some maps can be overlapped in the Google Map for geographic visualization (Leydesdorff and Bornmann 2012).

The patent citation networks or maps based only on the citations have limitations from the richness of information perspective and visualization to represent only static analysis. To overcome these limitations Lee et al. (2011) used the formal concept analysis (FCA) and they modified it for the new algorithm taking into account the time periods and the changes of keywords amongst patents. In this way they were able to design dynamic patent network (Fig. 2).

Figure 2 represents "radial dynamic patent network" for laser technology in lithography for the fabrication of semiconductors between the years 1984 and 2009.

Unlike a conventional patent map that network explains and visualizes the detailed technological changes along a timeline, this permitted the analyst to better understand the technological overview.

Each color of the nodes corresponds with a different technology semiconductor manufacturing. The nodes and arcs differ from one another in the dynamic patent network according to the number of patents in a concept and types of changes of keyword. Finally they identified five types of technology groups and its evolution time.

The technology fusion has recently become the way to achieve innovation by creating new inventions with the convergence of diverse technologies (Jin et al. 2011; Kodama 1986). The technological limits have been blurred because the major inventions do not permit only one technological field but several (Hacklin et al. 2009).

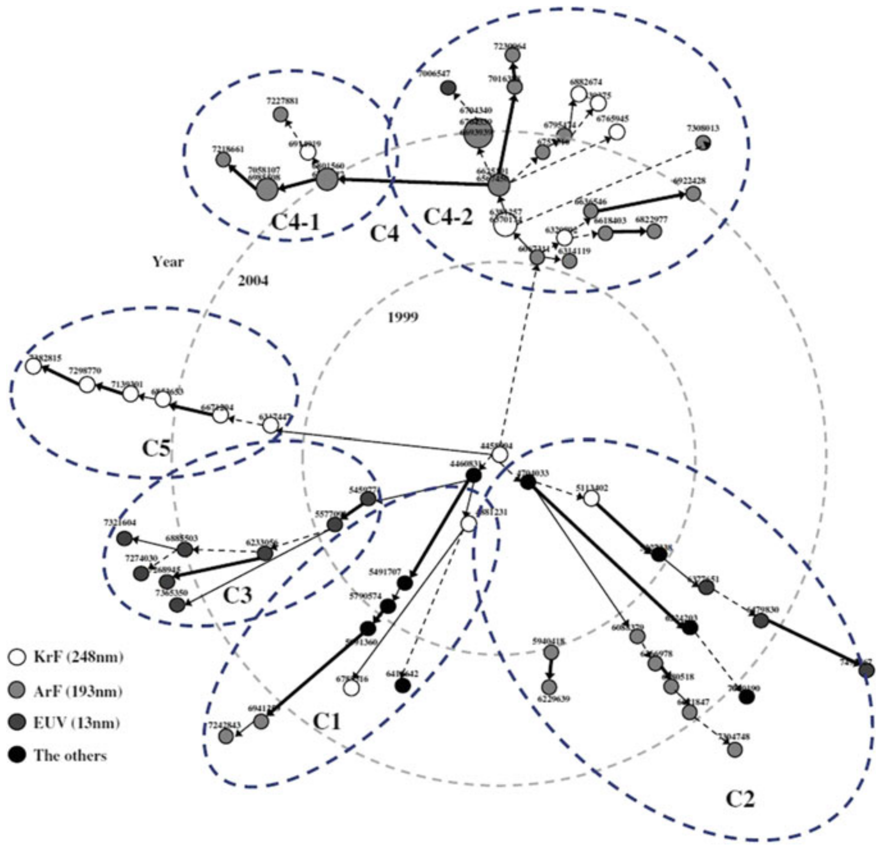

Fig. 2 Radial dynamic patent network for laser technology in lithography (Lee et al. 2011)

This is the reason they require the analysis not only one technology group but all of them. Therefore Ko et al. (2014) presented a method to analyzing dynamic trends of technology fusion industry-wide by the measurement of knowledge flows from patents (Fig. 3).

Figure 3 graphically represents every step of the investigation process. It mainly consist of three steps: constructing a knowledge flow matrix by extracting the classification codes and citation information from patent data; generating a knowledge flow map from and industry by associating the classification codes with industrial sector; and constructing a technology fusion map using assessment indicators for analyzing industry-wide knowledge flows.

This work attempts to develope a systematic method on how to analyze the interdisciplinary trends about different technologies. These technological convergences are analyzed from a global perspective industry-wide measuring knowledge spillover.

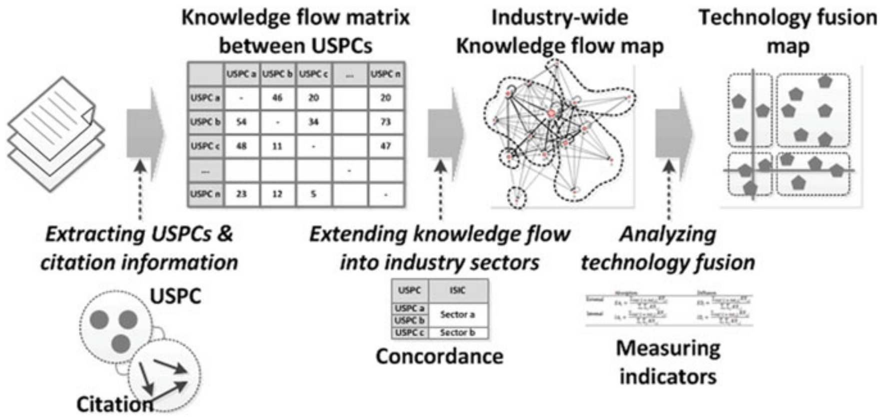

Fig. 3 Overall procedure of this research (Ko et al. 2014)

4 Discussion and Conclusions

In the last decade there has been a skyrocket in the use of patent citations as an innovation indicator. The analysis have become more complex and have evolved from a simple count of citations to determining the quality of a patent or the knowledge flow between a group of patents to complex algorithms taking into account the coreness and intermediarity of the technological sectors (Park and Yoon 2014) or the time periods and the keywords amongst patents (Lee et al. 2011).

Even so, there are still biases and limitations that introduce an important quantity of noise in the results. Bacchiocchi and Montobbio (2010) discovered that the different legal rules and procedure of patent examination and approval in the national offices produced a clear bias. Even more, it has to be taken into account the self-citation bias and the tendency to cite patents from the same nationality (Jaffe and Trajtenberg 1999).

On the other hand, it has to be remembered that the latest patents have less opportunity to be cited from other subsequent patents, because the citation analysis may not function well to reflect the most recent technological tendencies. In the case of the Korean and Japanese patents the problem is bigger because the citations are largely omitted and are not mandatory in its inclusion (Yoon and Kim 2011).

There are other methods not based on citations to determine the similarity between patents such as text mining (Kostoff et al. 2006), keywords analysis (Huang et al. 2004), and the word co-ocurrence analysis (Garechana et al. 2012). Even so, the unexpected scientific discoveries, the changes in the patent laws or the habits of the patent examiners continue to be factors that influence the development of technology and are not part of the patent analysis.

In general, one can not say that patent citation analysis is the final solution to direct the policies of R+D but observe that most traditional methods of analysis of the patent paths and the new methods that are converging (Fontana et al. 2009).

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