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C. Gay & C. Le Bas (LEFI)

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USES WITHOUT TOO MANY ABUSES OF PATENT CITATIONS OR THE SIMPLE ECONOMICS OF PATENT CITATIONS AS A MEASURE OF VALUE AND FLOWS OF KNOWLEDGE*

C. GAY and C. LE BAS† (LEFI)

Institut des Sciences de l'Homme, 14, Avenue Berthelot, 69363 LYON Cédex 07, France

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Economists recently saw the point in using all the detailed information encompassed in patent documents in order to understand the origin, the nature and the value of technological innovation. Indeed, beside the simple patent count that is the traditional indicator of intensity and rate of innovation, many indicators have been recently elaborated by using information available in patent and/or related with patent: patent citations, non-patent citations, renewal, family size, etc. Among them, we can now highlight numerous and very significant research works using patent citations.[1] Each patent document must contain references to patent and non-patent literature (such as scientific articles, books, any other dated written disclosure). Generally speaking, this information is given in order to circumvent the origins of the invention the applicant wants to protect. Citations made in a patent correspond to the 'prior art' on which an invention is based and on which the applicant cannot have a claim. Beyond this legal dimension, patent citations are used in different ways. Many patent citation analyses use not only backward citations (or references made to prior patents), which are the citations available in patent documents, but also forward citations (or citations received from subsequent patents), which are available after the patent grant in computer readable form.

In this introduction, we will first present the different uses of patent citations; second, we will highlight the limits of their use and we raise different debates concerning their use; third, we will present the papers of this issue of the Journal.

Generally speaking, we can distinguish three main uses of patent citations: (1) Patent citations used as an assessment of the value of technological inventions; (2) Patent citations used

* This opening paper has been specifically written in the memory of Keith Pavitt who was a leader in this field of research (see Pavitt, 1988).

† Corresponding author. E-mail: lebas@univ-lyon2.fr

[1] The arrival of better quality data and the higher capacity to access it (Michel and Bettels, 2001) has enabled the use patent citation at a larger extent. The best example is the database of US patent accessible on internet work out by Jaffe and his colleague from the NBER.

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as a measurement of the origins or the 'knowledge base' of inventions and (3) Patent citations used as an evaluation of technological knowledge flows. Patent citations, mainly forward patent citations, are now largely used in order to approximate the value of inventions and so the value of knowledge contained in patents. The main advantage of this indicator is to overcome the limits of the simple patent count that artificially awards to all inventions the same value in spite of the natural enormous differences in the importance of patents (Trajtenberg, 1987). We can distinguish two different ways of looking at this notion of 'value'. First, value is known as 'technological value' synonymous with technological quality or technological importance. In the same way as bibliometric analyses use references received by a publication to evaluate its impact, citations received by a patent give an idea of its technological importance. The hypothesis is that a patent that is highly cited, i.e. an invention that generates a lot of subsequent inventions, is an invention with a huge technological value (Carpenter *et al.*, 1981; Albert *et al.*, 1991). This hypothesis is tested in some papers thanks to evaluations of technological importance like awards and expert assessments. Second, the 'value' of a patent is assessed in the same way as 'economic value'. The hypothesis is that a patent that is highly cited represents an innovation that has very high economic value since '[the] subsequent patents are the results of costly efforts in the field of innovation undertaken mostly by profit-seeking agents' (Trajtenberg, 1993). One of the very first formal studies of forward citations as a measure of value was carried out by CHI Research under the sponsoring of the Nation Scientific Foundation. The main outcome of this study was that 100 important patents which received awards granted by the journal *Industrial Research & Development* were more highly cited than control patents (Carpenter *et al.*, 1981). One outcome was that patent citation indicators were added to the *Science Indicator Report* (Narin, 2000). Trajtenberg (1990) showed in the case of computer tomography scanner industry that there was a significant link between the social value of the innovation carried out in this technical area and the subsequent citations received by the patent protecting the corresponding innovation. The work by Harhoff *et al.* (1997) issued an interesting result. They surveyed the firms in order to know directly the private value of patent and calculated the subsequent patent citations. The latter were correlated with the former. Nevertheless, the low r^2 (20%) values reveal that the citation/value relationship was rather noisy. Therefore, patent is an extremely noisy measure of the economic value of innovation because a few patents are high value and many patents are very low value ones (Hall *et al.*, 1998). Some studies (see, for instance, Trajtenberg, 1990) have shown that the number of citations received is better correlated to their economic value and that weighting patents by the number of citations seems to be a yardstick that upgrades the measurement of the value of firms' intellectual assets. Studies report that citation-weighted patent stocks give a more accurate measure of innovation than patent counts only (Hall *et al.*, 2001a). Hall *et al.* (2001b) argue that citations-weighted patent stocks are more highly correlated with company value than patent stocks.

Backward citations indicate explicitly previously existing codified knowledge embodied in prior patents or in other publications (scientific ones in particular) upon which the invention is built. Therefore, backward patent citations could be used as a tool for investigating the cumulative 'knowledge base' on which a patent is based and, for example, to evaluate the 'shoulders' on which a firm's invention stand.

Backward and/or forward patent citations are also used as an evaluation of the flows of knowledge among firms (or more generally all inventing organizations or individuals), sectors, regions, and nations, etc. The hypothesis, tested by Jaffe *et al.* (1993), is that a patent citation corresponds to a direct or an indirect flow of knowledge, not to say a knowledge spillover, between two agents. In this area, on persuing the seminal work of Jaffe *et al.* (1993) on the geographic location of knowledge spillovers, we find the same way of reasoning in Jaffe and Trajtenberg (1996) on the flows of knowledge from universities to firms, in the study of

Jaffe and Trajtenberg (1998) on cross-country dimensions of spillovers, and in Maurseth and Verspagen (2002) on European regions. Verspagen and Schoenmakers (2002) have recently argued that European patent citations are a useful indicator displaying clusters of technology activity. These approaches begin to bring convenient (or not so inconvenient) solutions to different issues regarding the effects of geographic proximity, the knowledge exchange between organizations, the impact of 'technological relatedness or remoteness'. The dominant feeling is that this tool provides a valid but noisy measure for knowledge spillover (Jaffe *et al.*, 1993).

If we turn now to non-patent citations in the literature, it mainly enables us to show the interaction between science and technology (see the seminal paper by Narin and Noma, 1985, then the documented paper by Narin *et al.*, 1995), or to map or to trace the paths from Science to Technology (Smoch, 1993), and to propose a measurement for the so-called basicness of invention. Harhoff *et al.* (2003) have recently shown that the references of this kind have an impact on the value of patents yet smaller than the impact of backward citations and statistically less significant for the overall sample of patents (nevertheless in pharmaceuticals and in chemicals the coefficients related to this variable is higher). Empirical studies have clearly established the connection between science and technology (Meyer, 2000).

Let us now focus on a different point: instead of emphasizing directly the main drawbacks of patent citation as a measure of value of knowledge[2] and as a tool for mapping its flows, we prefer recording some different problems related to the use of patent citations.[3]

Are international comparisons really feasible? We know that unfortunately the current practices regarding citations differ a lot between the countries, mainly between the United States and Europe. These discrepancies of course make it more difficult to make international comparisons. For instance, Michel and Bettels (2001) argue 'The applicant filling a patent application in the US is requested to supply an exhaustively 'state of the art' list of references, this being a legal requirement and non-compliance by the patent applicant can lead to subsequent revocation of the patent. The applicants . . . rather than running the risk of filling an incomplete list of references, tend to quote each and every reference even if it is only remotely related to what is to be patented'. Moreover, the initial list tends to appear in unmodified form on the front page of most US patents. In contrast, the European Patent Office examiners screen and filter the applications files in a view to select the citations having a direct relevance with respect to patentability. With these conditions, it is not amazing that the average number of citations per US application is three times as high as the European one. This evidence indicates clearly that we have to be cautious in our interpretation of the US data. It is no real obstacle to comparisons on the international level but require to work on the same data for setting up cross-country comparisons.

What sort of knowledge is being transferred behind the citation? Meyer (2000) points out that citation does not mean that citation linkages display a direct link between a cited paper and citing patent. This remark is crucial. He explicitly had in mind the citations to scientific literature and states: 'The inventors interviewed pointed out that their inventions were often based on general experience in research and teaching. General experience can be seen as one component of tacit knowledge, which is conveyed chiefly through personal interaction in

[2] We do not come back to the main limit of patent citation which comes from the fact that we do not know who has put the citation, the applicant or the examiner. Jaffe *et al.* (2000) argue 50% of the citations match flows of knowledge spillovers.

[3] We ignored the fact that patent citations are just as limited as patents as an indicator of innovation. It is impossible to assess the value of invention with patent citations for inventions not protected by patent. The other problem is that we are able to trace the knowledge origin of invention only for this kind of new knowledge for which patents are a relevant means of appropriabilty. This entails it should be difficult to obtain the overall map of knowledge flows for all the national system of innovation.

a scientific and/or technological environment'. To what extent could we retain this general conclusion for the citations to other patents? It is acknowledged that citations between patents are a measure of knowledge flows in the sense that a previous knowledge content has been useful for developing a new knowledge content the citing patent protects (Jaffe *et al.*, 1993). Maurseth and Verspagen (2002) mention the precision knowledge spillovers as part of a much broader concepts (rent spillovers are left out). The problem with these flows of knowledge is that we still have difficulties for assessing their size.

Is the number of backward citations a significant measure of the scope of one invention? A patent application seeking to protect a broad scope invention might induce the patent examiners to delineate the patent claims by inserting more references to relevant patents (Harhoff *et al.*, 2003). The main interest of this is that we could use it as a proxy for assessing the scope of the invention in spite of the lack of data on the number of claims.

How can we use self-citations? A self-citation patent highlights a citation that comes from patents granted to the same firm (or more generally to the same institution). In a sense, this tell us that a firm has carried out fruitful research on a mid-term period. It has produced subsequent inventions from one original invention. It is an indication of cumulative or sequential inventions. Jaffe *et al.* (1993) showed that this fraction of citations is higher for firms than for universities. Lanjouw and Schankerman (2001) indicated that there was significantly greater technological similarity between patents and their future self-citations among litigated patents. This shows patentees want to exert a sharp control on their earlier inventions. This could mean that self-citations have a more significant value that we generally expected.

Technological value versus economic value? We have argued (at the outset of this presentation) that citations are more an indicator of 'technological' value than 'economic' value. This opinion relies on the Carpenter *et al.* (1981) conclusions, in particular on the idea that the number of times a patent document is cited – what we call the citation rate – may be a measure of 'technological significance'. According to this opinion, patent citation would give a measure of the technological value of the patent, whereas other direct surveys would approximate private economic value. Of course, the two values calculated for a large sample of patents will be related (the works of Harhoff support it). New surveys in progress will support, we hope, this idea much more forcefully.

How can we map the network communities? It is possible to associate patent citations, used as an indicator of value or as an indicator of knowledge flows, to another information content listed in patent documents to improve our understanding of technological creation. Mainly patent documents contain information concerning the actors implied in the technological creation. Each patent document gives the names and addresses of the unique and/or (multiple) inventor(s) of the innovation and the name and addresses of the unique and/or(multiple) assignee(s) of the invention. In a *knowledge-based economy*, this information is precious because it permits in particular to map the collective dimension of knowledge creation (Gay, 2003). In association with patent citations, this information makes it possible to have a widened representation of technological knowledge creation and diffusion that support technological innovation.

Regarding this present issue, the contributions using the patent citation methods provide useful and significant findings. The paper from Gay *et al.* with US patents data assesses a model showing the main factors explaining the rate of citations. A patent with many citations is a patent that is quickly cited and cited more frequently by patents from other technological fields. These findings confirm the previous findings. Maurseth connects the patent citations and patent renewal behaviour. He issued results highly consistent with the results of the first paper, in particular patents that receive citations across technological fields (having more value) have a longer life span than others patents (see also Maurseth, 2001). The other three papers are basically concerned with patent citations as a tool for measuring and mapping

knowledge flows. Duguet and McGarvie using community innovation survey legitimate the uses of patent citations for mapping knowledge flows. They show that the companies' answers are consistent with the indication given by patents citations in terms of direction of knowledge flows. Brusoni and his colleagues are crucially interested in non-patent document citations (in fact, here, scientific papers) for assessing the scope and the depth of the knowledge bases of the world's largest pharmaceutical firms. Criscuolo *et al.* use patent citations to quantify the relative asset augmenting versus exploiting the characteristics of foreign located R&D. Therefore, this EINT special issue shows the consistence and relevance of patent citations as an useful tool for better understanding the value, the origin and the flows of knowledge.

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