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Section 5: Behind the data

The impact of science on technology, as measured by patent citations

Steven Scheerooren & Dr. Judith Kamalski

Much has already been written about the linkage between science and technology, and the validity of using (non-patent) citations in patents as a measurement of the bond between them. In this article, Research Trends presents the current thinking on this topic, as well as our own standpoint on the use and limitations of citation data from patents. In addition, we present a case study on Civil Nuclear Energy research and citations in patents for three different countries: UK, US and China.

“Science” & “Technology”

In early citation studies, technological progress was viewed as more or less a direct result of scientific progress. To paraphrase Bassecoulard & Zitt (1), it had been assumed that there is a diachronic relationship in which the science of today is the technology of tomorrow. However, as many authors have since made clear, there are several issues related to using a linear model.

Firstly, the problem of definitions: what is ‘science’, and what sets it apart from ‘technology’? While the two may have been distinct fields in the past (‘science’ being more theoretical and ‘technology’ more practical), over the last decades they have become closely intertwined. In light of this development, Narin & Noma (2) mention Arnold Toynbee’s analogy of a pair of dancers: “...science and technology [are] intimately related as a pair of dancers (...) locked in an embrace from which it is virtually impossible to separate the partners.” After all, university researchers also patent inventions and inventors also publish papers. It is even becoming increasingly common for a researcher to be active in both worlds;

i.e. one may work at a corporate R&D lab, but also hold an academic position (adjunct professorship) or vice versa. Meyer (3) adds to the dancer analogy, by saying that “with dancers dancing an ever closer dance, it also gets increasingly difficult to say who is the partner that determines the direction.” He suggests there may well be technology-pulled science, next to science-pushed technology.

Secondly, we must bear in mind that “citations are not intended to be an indication of technology [or knowledge] flows or spillovers.” (4). Patent applicants cite papers not (just) to show what inspired an invention, but rather to avoid future legal battles over its novelty while at the same time indicating interesting areas for potential licensees. Moreover, citations are added not only by the applicants themselves, but also by the examiners of a patent. Depending on the patent office, it may be in this step that most citations are added. On the one hand this would mean that we cannot regard such citations as a ‘science push’. On the other hand it does point to a link, whether the applicant is aware of the papers or not.

An analogy with citations in scientific literature

Even though many authors admit that for various reasons citations in patents are not very reliable proof of an article’s influence on an applicant’s thought process, the notion nevertheless continues to exist that such non-patent citations are indicators of science’s influence on technology. We wish to argue this is justifiable, within certain limits. The following factors influence the likelihood of whether an applicant has in fact come into contact with the cited literature, which should be taken into account when interpreting bibliometric data.

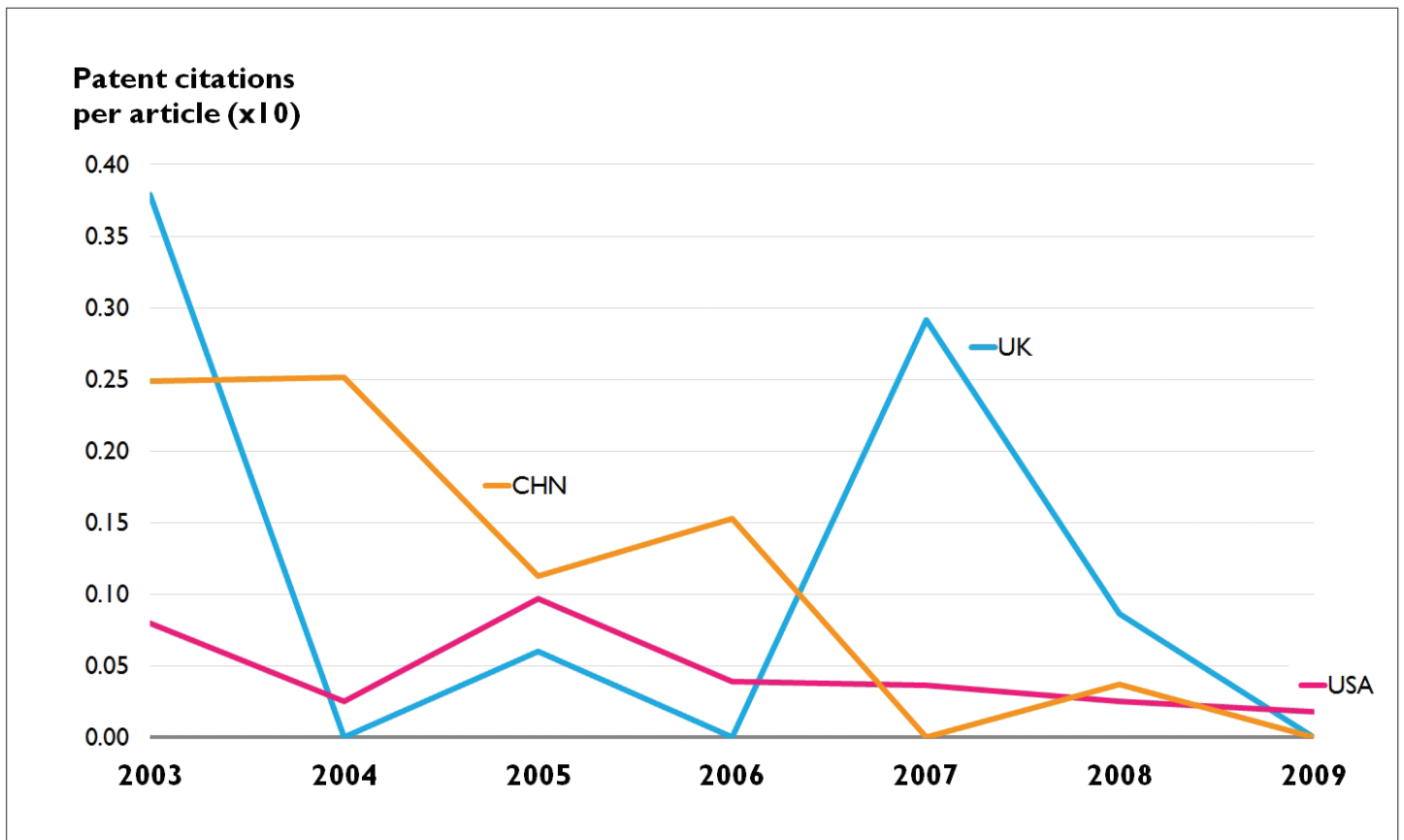


Figure 1: Patent citations per article, multiplied by 10, for UK, China and US. Source: WIPO.

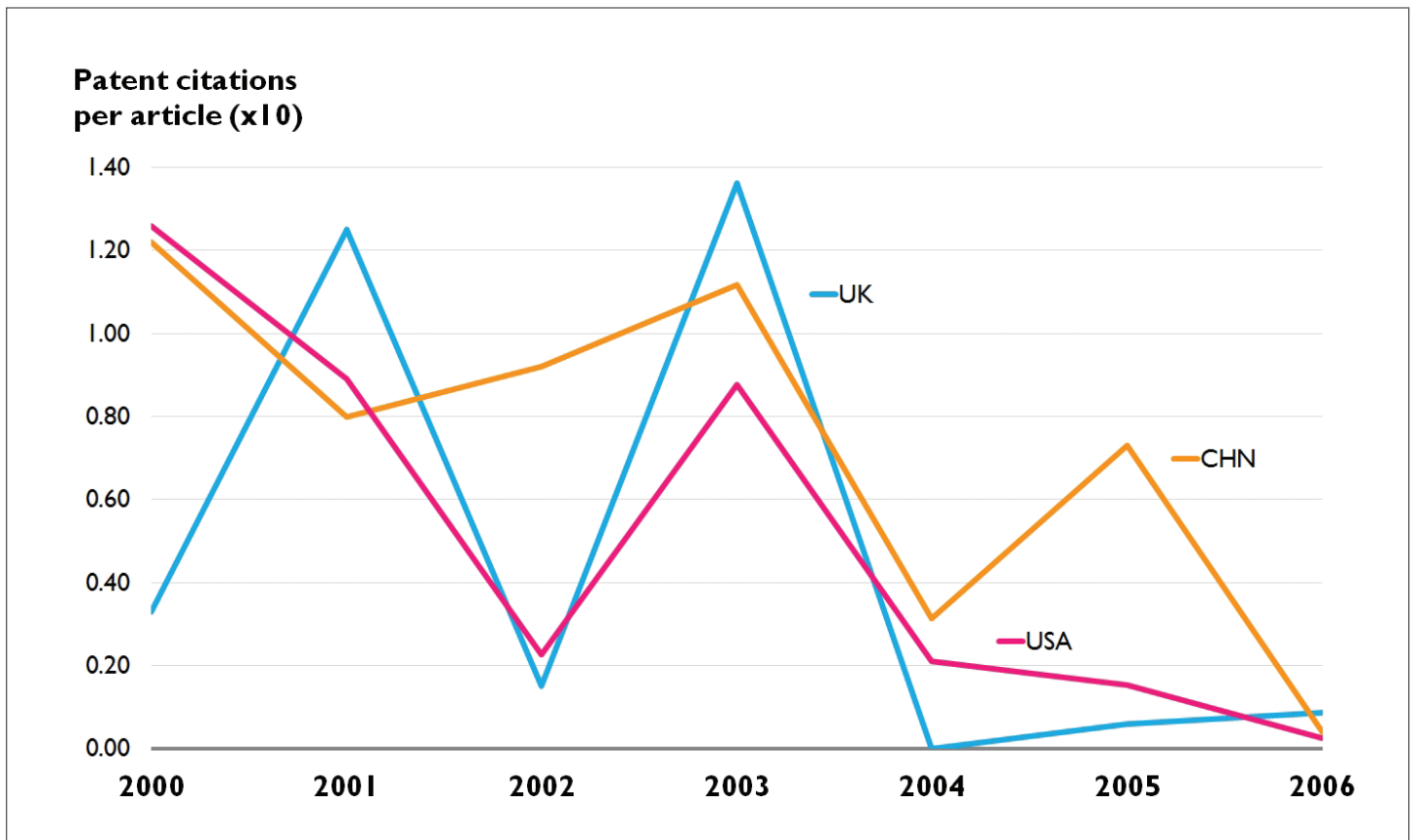


Figure 2: Patent citations per article, multiplied by 10, for UK, China and US. Source: USPTO Office.
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- **Country.** A few authors argue that a so-called 'domestic bias' (i.e. a relatively large share of citations referring to research papers from the same country) indicates localized knowledge flows (5). However, this perceived bias may also stem from the fact that European or American patent offices have different requirements for considering patentability. This results in different citation strategies between countries, with some examiners preferring to cite national papers, and some preferring to cite international ones (4, 3).
- **Field.** Not all technological fields in which inventions are patented use the same citation methods. Some, such as Pharmacology, (Bio)Chemistry or Genetics, tend to cite a much higher number of non-patent documents than fields such as Engineering (3, 6, 7).
- **Journal.** There is a distinct connection between citations in patents and the citation impact of a paper, which relates to the journal in which it is published. Papers, which are cited in patents, are published on average in journals with higher impact than those which are less well cited in patents, or not cited at all. They also tend to receive more citations from other papers. But there is a causality issue here: papers might be more easily cited in papers because they are more visible, or they might readily appear in top journals because they have "broken the technology barrier" (7, 8).

In fact, many of these factors are similar to the use of citations within the scientific literature as a proxy for impact: some subject areas have a tendency to include more references than others; some countries tend to cite articles from their own countries, others are more international. The fact that these statements are true does not mean that we should not use citations as a proxy for impact, or quality. It only means that we should be aware of these issues and try to find the best ways to analyze the data while taking them into account. This also applies to the use of patent citations. We would argue that as long as a comparison is made within a patent office, within a subject area, that the data could yield interesting insights. It is important to keep in mind, as Tijssen puts it, that for the above reasons, "patent-paper citation data are more appropriate for statistics on the interaction between science and technology, rather than the strength of those linkages or the degree of connectedness." (5).

A case study: Civil Nuclear Energy

In this case study, we analyze how often a reference is made in patents to the civil nuclear energy literature from four different countries: the UK, US, France and China. In [Figure 1](#), the counts of patent citations per country have been normalized for country size by taking the number of Civil Nuclear Energy articles published per year by each country and dividing the patent citations by total output, and then finally multiplying by 10.

The fairest comparison between countries can be made by taking patent data from WIPO, the international patent office (9). Selecting the US Patent and Trademark Office may show a bias towards US, and the same applies for the other national patent offices. Still, the results for the US may be disadvantaged because we are not looking at the US patent office data, and this office would contain most of the US patent citations.

[Figure 1](#) focuses on the UK, the US, and China. Per article publication year, it shows how frequently this research was cited in patents. It is clear that UK research from 2007 and 2008 was relatively well-cited in WIPO patents, but that its relative position varies from one year to the next. This variance is due to the low volume involved in this case study. Regardless of the variance, China seems to show a downward trend in terms of patent citations per article, while the US' position is relatively stable.

The same analysis can be repeated for the US Patent Office data, reflected in [Figure 2](#). As the most recent years show little activity, we have selected a time frame further back for the US data. It is clear that even though one can expect this data to be biased towards the US, it still shows meaningful patent citations of for instance UK literature on civil nuclear energy.

The patent citations analysis forms an interesting addition to the more traditional metrics such as output, or field weighted citation impact. For this particular case study, China consistently has the lowest impact, but not the lowest patent citations per article. Depending on the angle chosen, the countries show different strengths and foci. One metric can never provide the whole picture. But we would like to argue that patent citations are a useful addition to the expanding mix of metrics that can be used to assess different aspects of impact.

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