Measuring patent quality in cross-country comparison

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**Highlights**

- Novel quality index allows for cross-country comparison of patent quality.
- The ISR index relies only on citations from international search reports.
- The ISR index is exogenous with respect to national policy.
- China’s recent patent expansion has taken place to the detriment of patent quality.
- Widening gap between the technological capacities of China and the leading USA.

**Abstract**

Our novel quality index is based on citations from international search reports and provides internationally comparable, quality-adjusted figures for applications made under the Patent Cooperation Treaty (PCT). We show that China’s recent patent expansion has taken place to the detriment of patent quality. Weighting national PCT counts with our index reveals a widening gap between the technological capacities of China and the leading USA.

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1. Introduction

Patent applications are a leading indicator of emerging technological prowess and indicate a global shift from the West to the East in recent years. Stimulated by policies, in 2011 China surpassed the USA as the greatest global source of patent applications (OECD, 2014). Since 2013, China has ranked third in terms of applications made under the Patent Cooperation Treaty (PCT), which typically precede the international commercialization of valuable inventions (WIPO, 2014a; Grupp and Schmoch, 1999). However, without comparable information on patent quality it remains questionable whether China’s rapid expansion in applications constitutes the rise of a new technological superpower.

A challenge in assessing patents is that patents vary in their commercial value and technological impact. Although there is a consensus that frequent citations by subsequent patents indicate higher quality (Jaffe and De Rassenfosse, 2016; Harhoff et al., 1999; Trajtenberg, 1990) and provide the best approximation of patent quality (Gambardella et al., 2008; Reitzig, 2004), the comparability of citation counts has several limitations in cross-country comparison. First, as applicants only select more valuable patents for protection abroad a direct comparison of domestic and foreign applications is hardly informative (Harhoff et al., 2003). Second, heterogeneous examination practices lead to significant variation in citation counts generated across national patent offices (Michel and Bettels, 2001). Third, patent examiners are biased towards citing domestic patents from their home country (Bacchiocchi and Montobbio, 2010).
Due to the aforementioned difficulties, cross-country quality comparisons are not yet based on citations but count patents that fulfill minimum requirements with regard to geographic coverage. For example, Frietsch and Schmoch (2010) introduce transnational patents, which are defined as patent families with at least a PCT application or an application at the European Patent Office (EPO).

2. Measurement of patent quality

We ensure comparability by exclusively relying on citations generated by international search reports (ISRs) during the international phase of PCT applications. Under the PCT system, applicants can simultaneously seek protection in up to 148 countries. A search for prior art occurs in the international phase within 30 months after filing the application. National patent offices act as international search authorities (ISAs) where all examiners follow the same strict examination rules from the World Intellectual Property Organization (WIPO) when drafting an ISR (WIPO, 2014b).

Our quality measure allows for technology-specific cross-country comparisons. The ISR index \( \gamma_{x,k} \) defines the quality level of PCT applications, where the home country of the first applicant \( c = \gamma \) and technology class \( k = \kappa \). The index is calculated at the annual level but we omit time indices to simplify notation.

\[
ISR index_{\gamma,k} = \frac{\frac{1}{N_{\gamma}} \sum_{i=1}^{l} \left( \sum_{j=1}^{l} ISRcites_{ij} \right) \ast \omega_{\kappa}}{\frac{1}{N_{\gamma}} \sum_{i=1}^{l} \sum_{k=1}^{K} ISRcites_{ik} \ast \omega_{\kappa}}
\]

\( \omega_{\kappa} \) is the proportion of patent \( i \) within technology class \( \kappa \). \( N_{\gamma,k} \) is the sum of \( \omega_{\kappa} \) over all patents of country \( \gamma \), i.e. \( N_{\gamma,k} = \sum_{i=1}^{l} \{ISRcites_{ij} \ast \omega_{\kappa} \} \). The comparison group is denoted by \( \gamma \) and contains all patents that do not belong to country \( \gamma \). The indicator function \( ISRcites_{ij} \) equals one if application \( i \) is cited by application \( j \) within the defined time window and zero otherwise. \( I \) is the upper limit of the population of PCT applications. The indicator function \( ISRcites_{ik} \) only considers non-self-citations received by foreign countries, i.e. from countries other than the applicant country. Note that relying only on citations generated outside of national boundaries makes the index invariant with respect to national policy.

The country-level index is obtained by averaging ISR indices across technology classes:

\[
ISR index_{\gamma} = \frac{1}{N_{\gamma}} \sum_{k=1}^{K} N_{\gamma,k} \ast ISR index_{\gamma,k}
\]

\( N_{\gamma} \) is the total number of patents of country \( \gamma \). A value of the ISR index of larger (smaller) than 100% signifies quality above (below) the comparison group.

3. Empirical analysis

3.1. Data

Covering the start of China’s patent expansion in 2001, we consider the population of PCT applications with priority years 2001–2009. The priority year indicates the year in which the first patent application for a specific invention was filed, irrespective of the chosen patent offices. Country allocations of applications are based on the address of the first applicant and only citations from distinct pairs of citing and cited patent families are considered. Self-citations are identified on the basis of DOCDB standard names from PATSTAT and EEE-PPAT applicant name harmonization.

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>United States</th>
<th>Republic of Korea</th>
<th>Germany</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>44.9</td>
<td>115.9</td>
<td>74.4</td>
<td>67.1</td>
<td>73.1</td>
</tr>
<tr>
<td>2002</td>
<td>34.2</td>
<td>122.7</td>
<td>87.0</td>
<td>72.0</td>
<td>70.1</td>
</tr>
<tr>
<td>2003</td>
<td>38.8</td>
<td>113.5</td>
<td>73.9</td>
<td>75.6</td>
<td>66.9</td>
</tr>
<tr>
<td>2004</td>
<td>34.4</td>
<td>105.4</td>
<td>89.3</td>
<td>75.9</td>
<td>65.1</td>
</tr>
<tr>
<td>2005</td>
<td>41.0</td>
<td>114.4</td>
<td>104.8</td>
<td>72.2</td>
<td>61.1</td>
</tr>
<tr>
<td>2006</td>
<td>30.7</td>
<td>116.1</td>
<td>108.5</td>
<td>68.5</td>
<td>57.7</td>
</tr>
<tr>
<td>2007</td>
<td>29.0</td>
<td>127.0</td>
<td>105.4</td>
<td>66.5</td>
<td>57.0</td>
</tr>
<tr>
<td>2008</td>
<td>29.8</td>
<td>134.9</td>
<td>95.7</td>
<td>73.3</td>
<td>53.4</td>
</tr>
<tr>
<td>2009</td>
<td>30.4</td>
<td>158.8</td>
<td>80.4</td>
<td>76.1</td>
<td>49.1</td>
</tr>
<tr>
<td>Total</td>
<td>32.1</td>
<td>123.3</td>
<td>93.5</td>
<td>71.9</td>
<td>59.6</td>
</tr>
</tbody>
</table>

Note: Annual mean values for ISR index displayed as percentages for the five largest PCT applicant countries between 2001 and 2009. The respective comparison group includes the PCT population from all other countries.

We use the 3-digit level of the IPC classification (technology class) to categorize patents and apply fractional counting to apportion patents that belong to more than one technology class. Given the trade-off between precision and timeliness, we limit the citation window to a still informative three years.

3.2. Quality index

With a mean value of 32.1%, our ISR index shows that China’s patent quality is significantly below that of the comparison group, which consists mainly of high-income countries (Table 1). Between 2001 and 2009, the decline of the ISR index, from 44.9% to 30.4%, is a result of the decrease in the average number of citations obtained by Chinese PCT applications; whereas the citations received by the comparison group remain relatively stable. In global perspective, the USA leads with an average value of 123.3%, followed by Korea (93.5%), Germany (71.5%), Japan (59.6%), and China (32.1%). The respective comparison groups include all countries except the country of interest.

Although the core elements of PCT applications are published in English—i.e. abstract, title, search report, and text of drawings—other elements may only be available in the applicant’s language. Because PCT applications of Chinese origin are typically either published in Chinese or English, we calculate a correction factor for the language bias. To do so, we compare the share of foreign citations in total citations before and after an English equivalent publication is available for PCT applications originally published in Chinese. Taking the share of applications in Chinese and in English as well as the average time lag until an English equivalent is available into account, we obtain a correction factor of 1.11 for the index. After correcting for the language bias, China’s ISR index increases modestly from 32.1% to 35.6%.

We multiply the year- and country-specific mean value of the ISR index with PCT counts to measure national technological capacity. Fig. 1 shows the development of PCT applications with and without quality adjustment for the five largest applicant countries. Where exclusively patent counts are considered, the USA takes the leading position. This lead is increased when moving to the quality-adjusted PCT applications—highlighting the technological influence of the USA. Due to the 3-year citation window, we can only calculate the index up to 2009. However, extrapolating the quality-adjusted count by multiplying the patent counts with the average value of the index for the time period 2001–2009 enables us to obtain the quality-adjusted count up to 2013. Without quality adjustment, China takes the third position, thereby overtaking Germany and Korea. If quality adjustment is applied, China remains in the fifth position.
Annual PCT applications and national technological capacity

Fig. 1. Note: The left figure shows the number of annual PCT applications for the five largest applicant countries between 2001 and 2013, as reported in WIPO (2014a). The right figure shows quality adjusted PCT applications. Numbers for 2010 onwards rely on an extrapolation.

4. Discussion

The expansion of Chinese PCT applications has occurred to the detriment of quality. Although China has undergone an unforeseen increase in patent applications, its technological capacity has increased less than would be expected if one considers only the number of patent applications. From a global perspective, our analysis shows that Eastern technological capacity is not yet dominating, but the West’s leading position largely depends on the performance of the USA.

Finding a quality decrease for Chinese PCT applications is in line with prior literature. According to Thoma (2013), differences in quality indicators of EPO patents suggest a lower quality for patents with Chinese inventors and Chinese applicants compared to patents without Chinese involvement. Dang and Motohashi (2015) find a decrease in Chinese patent quality in response to the introduction of grant-based patent subsidies using claim scope as quality measure.

The focus on PCT applications could be seen as a limitation of the current application of the index. For example, De Rassenfosse et al. (2014) point out that the focus on a single patent office can lead to selection bias. However, the applicability of the ISR index is not restricted to PCT applications. In fact, it can be applied to the national applications of any country whose patents are included in the minimum documentation required for the prior art search during the international phase of PCT applications (see Rule 34 of WIPO, 2014c for a country list). Furthermore, depending on the area of interest, it is possible to extend the considered citations to ISR citations from the country of the applicant and to self-citations.

References


