Economics Letters 149 (2016) 145–147

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Measuring patent quality in cross-country comparison

Philipp Boeing [a,b,*], Elisabeth Mueller [a,c,d]

[a] Centre for European Economic Research (ZEW), Mannheim, Germany
[b] Research Center for Technological Innovation, Tsinghua University, Beijing, China
[c] German Graduate School of Management and Law, Heilbronn, Germany
[d] Centre for Transformative Innovation, Swinburne University of Technology, Hawthorn, Australia

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.

ARTICLE INFO

Article history:
Received 11 August 2016
Received in revised form
22 September 2016
Accepted 26 October 2016
Available online 28 October 2016

JEL classification:
O32
O34

Keywords:
Patent quality
Cross-country comparison

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.

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).

* Corresponding author. Centre for European Economic Research (ZEW), Research Department for Economics of Innovation and Industrial Dynamics, L7, 1, 68161 Mannheim, Germany. Fax: +49 0 621 1235 170.
E-mail address: boeing@zew.de (P. Boeing).

http://dx.doi.org/10.1016/j.econlet.2016.10.039
0165-1765/

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 $ISR\ index_{\gamma\kappa}$ 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.

$$ISR\ index_{\gamma\kappa} = \frac{\frac{1}{N_{\gamma\kappa}} \sum_{i=1|i\in c=\gamma}^{I} \left(\sum_{j=1}^{I} ISRcites_{ij} \right) * \omega_{i\kappa}}{\frac{1}{N_{\overline{\gamma}\kappa}} \sum_{l=1|l\in c=\overline{\gamma}}^{I} \left(\sum_{j=1}^{I} ISRcites_{lj} \right) * \omega_{l\kappa}}$$

$\omega_{i\kappa}$ is the proportion of patent i within technology class κ. $N_{\gamma\kappa}$ is the sum of $\omega_{i\kappa}$ over all patents of country γ, i.e. $N_{\gamma\kappa} = \sum_{i=1|i\in c=\gamma}^{I} \omega_{i\kappa}$. The comparison group is denoted by $\overline{\gamma}$ and contains all patents that do not belong to country γ. 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 $ISRcites_{ij}$ 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:

$$ISR\ index_{\gamma} = \frac{1}{N_{\gamma}} \sum_{k=1}^{K} N_{\gamma k} * ISR\ index_{\gamma k}$$

N_{γ} is the total number of patents of country γ. 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 (Magerman et al., 2006). 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.

Table 1
ISR Index for major PCT applicant countries.

	China	United States	Republic of Korea	Germany	Japan
Mean of ISR index					
2001	44.9	115.9	74.4	67.1	73.1
2002	34.2	122.7	87.0	72.0	70.1
2003	38.8	113.5	73.9	75.6	66.9
2004	34.4	105.4	89.3	75.9	65.1
2005	41.0	114.4	104.8	72.2	61.1
2006	30.7	116.1	108.5	68.5	57.7
2007	29.0	127.0	105.4	66.5	57.0
2008	29.8	134.9	95.7	73.3	53.4
2009	30.4	158.8	80.4	76.1	49.1
Total	32.1	123.3	93.5	71.9	59.6
Count of PCT applications 2001–2009					
Total	34,738	360,653	44,314	138,212	201,633

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.

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 (71.9%), 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.

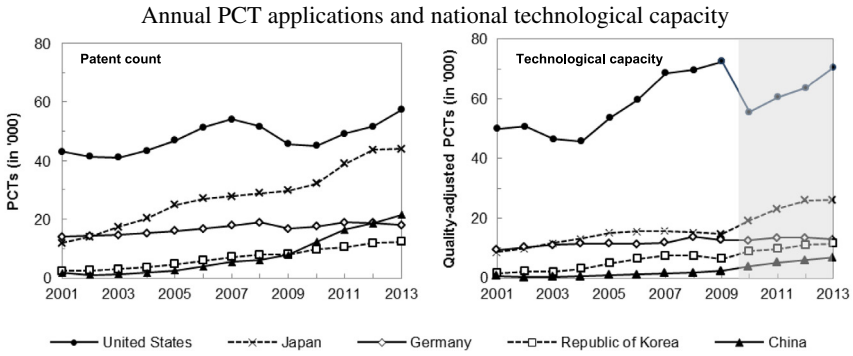

Fig. 1. *Note:* The left figure shows the number of annual PCT applications for the five largest applicant countries between 2001 and 2013, as reported in WIPO (2014a). The right figure shows quality adjusted PCT applications. Numbers for 2010 onwards rely on an extrapolation.

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

Bacchiocchi, E., Montobbio, F., 2010. International knowledge diffusion and home-bias effect: do USPTO and EPO patent citations tell the same story. Scand. J. Econ. 112, 441–470.
Dang, J., Motohashi, K., 2015. Patent statistics: a good indicator for innovation in China? Patent subsidy program impacts on patent quality. China Econ. Rev. 35, 137–155.
De Rassenfosse, G., Schoen, A., Wastyn, A., 2014. Selection bias in innovation studies: A simple test. Technol. Forecast. Soc. 81, 287–299.
Frietsch, R., Schmoch, U., 2010. Transnational patents and international markets. Scientometrics 82, 185–200.
Gambardella, A., Harhoff, D., Verspagen, B., 2008. The value of European patents. Eur. Manage. Rev. 5, 69–84.
Grupp, H., Schmoch, U., 1999. Patent statistics in the age of globalization: new legal procedures, new analytical methods, new economic interpretation. Res. Policy 28, 377–396.
Harhoff, D., Narin, F., Scherer, F., Vopel, K., 1999. Citation frequency and the value of patented inventions. Rev. Econ. Stat. 81, 511–515.
Harhoff, D., Scherer, F., Vopel, K., 2003. Citations, family size, opposition and the value of patent rights. Res. Policy 32, 1343–1363.
Jaffe, A., De Rassenfosse, G., 2016. Patent citation data in social science research: overview and best practices. NBER Working Paper 21868.
Magerman, T., Looy, B., Song, X., 2006. Data production methods for harmonized patent statistics: patentee name harmonization. Eurostat Working Paper and Studies, Luxembourg.
Michel, J., Bettels, B., 2001. Patent citation analysis: a closer look at the basic input data from patent search reports. Scientometrics 51, 185–201.
OECD, 2014. OECD Science, Technology and Industry Outlook 2014. OECD Publishing.
Reitzig, M., 2004. Improving patent valuations for management purposes: validating new indicators by analyzing application rationales. Res. Policy 33, 939–957.
Thoma, G., 2013. Quality and value of Chinese patenting: An international perspective. Seoul J. Econ. 26, 33–72.
Trajtenberg, M., 1990. A penny for your quotes: patent citations and the value of innovations. Rand J. Econ. 21, 172–187.
WIPO, 2014a. Patent cooperation treaty yearly review – the international patent system.
WIPO, 2014b. Patent cooperation treaty – international search and preliminary examination guidelines.
WIPO, 2014c. Regulations under the Patent Cooperation Treaty.