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HIGHER SCHOOL OF ECONOMICS

Ekaterina Khramova, Dirk Meissner, Galina Sagieva

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Ekaterina Khramova[1], Dirk Meissner[2], Galina Sagieva[3]

STATISTICAL PATENT ANALYSIS INDICATORS AS A MEANS OF DETERMINING COUNTRY TECHNOLOGICAL SPECIALISATION

Patent data provide a rich set of information which can be used for comparative studies and trend analysis. The paper presents a systematic overview of the most appropriate tools methodologies that are available for determining the technological specialization of countries. Such analysis includes a discussion of databases, approaches, and indexes appropriate for this kind of analysis. This paper discusses different indicators of technological specialisation, concentration, and patent quality are analysed, including Revealed Technological Advantage (RTA) index, patent share, C20 concentration index, and Gini concentration index. the main available patent databases, especially those with open access, and summarizes arguments for the study of technological specialisation based on assignee and inventor patent data. Also the limits and potentials of the statistics on resident / nonresident patenting on internal and external markets are discussed in the paper.

Keywords: Revealed Technological Advantage (RTA) index, patent share, C20 concentration index, Gini concentration index, country technological position
JEL classification: O31, O32, O33, O34, O47, O57, L24

[1] Research Fellow, Institute for Statistical Studies and Economics of Knowledge, katia.khramova@gmail.com
[2] PhD, Deputy Head, Laboratory for Science and Technology Studies, Institute for Statistical Studies and Economics of Knowledge, National Research University Higher School of Economics, dmeissner@hse.ru
[3] Senior Research Fellow, Institute for Statistical Studies and Economics of Knowledge; Department Head, Department for Research of Intellectual Property and Technology Transfer, sagieva@hse.ru

Introduction

Patent data have been intensively used by scholars aiming at measurement of the national technological specialisation, changes in national technological activities, and innovation performances (Patel, P., Pavitt K. 1987; Patel P., Pavitt K., 1991; Griliches Z., 1990; Acs Z. J., Audretsch, D. B., 1989; Comanor W.S., Scherer F.M. 1969). Patent statistics contain detailed information about technology areas, assignees and inventors personal information (e.g. name, country, city, address, etc.), as well as specific information about inventions (e.g. claims, filing date, issuing date, etc.), are widely available over long time periods for many countries. Patent documentation is considered to be a comprehensive resource for characterising inventions and generating appropriate patent indicators. The resulting analysis serves multiple purposes. First, the R&D output of institutions can be evaluated; second the dynamics of industrial R&D activities can be understood. Third, the intensity of industry-science linkages and international cooperation in technology fields can be interpreted and measured; fourth, the specialisation profiles of institutions, regions, and countries can be constructed. Moreover, the technological specialisation at country level can be benchmarked and correlated to international patenting trends, and hence, technology trends. Thus, the analysis of national technological specialisation allows for many different paths of analysis:

- existing correlations between a country's technological specialisation and global trends;
- monitoring internationalization activities of country's innovators;
- understanding global and national technology trends; and
- strengthening of countries in the global technology sphere (markets).

Eventually the analysis of patent statistics allows for the investigation of patent office policies, which have an impact on the patenting ability and activity of residents and non-residents.

The paper is organized as follows: first, aims and objectives for technological specialization studies are summarized based on (assignee and inventor) patent data; second, databases as information sources are discussed; third, different approaches, including the role of national assignee and inventor studies, and the potentials and limitations of different aggregation levels, are presented. Eventually indexes used in technological specialization studies based on patent data are discussed.

Aims and objectives for technological specialization studies

Patent information is collected and stored in patent databases, which allow for the analysis and comparison of patenting behavior at the national, or firm, level. Country analysis here, and throughout, refers to the patenting activities of all national actors and institutions but not countries as individual actors. In any analysis special attention must be given to data comparability, especially when comparing data from the United States Patent and Trademark Office (USPTO) with other databases due to differences in legal definitions, and therefore differences in interpretation of the data. Patent databases offer many analysis possibilities, including assignee and inventor statistics, resident and country statistics, etc (Table 1).

Table 1. Analysis Possibilities of Patent Statistics

	potentials	limitations
Assignee (applicant) data study	• more significant data then in inventor data study	• at a national level, assignees are less visible in the patenting process than inventors • adequate data is available for developed countries only
Inventor data study	• more complete data • a greater number of patents allows for more accurate calculations and analysis	• applicants are more connected with their country of origin than inventors
Country data study	• technological specialisation analysis allows for the comprehensive study of advanced countries, or countries with a comparable (large) number of patents	• a small number of patents require analysts to use a wider variety of different indexes, as only one index can distort results.
Company data study	• provides a broader view of company technological activities • analysis of a company's current global position compared with other companies working in the same technological field	• data must be collected individually ("one by one"), or with special databases like Questel Orbit or Patstat
Analysed periods	• analysis of the dynamics mostly include 2-3 periods of 3-5 years (depends of the studies purpose)	• indexes for each year will show too much fluctuation
Residents / nonresidents patenting	• illustrate the domestic/national structure of patenting • nonresident patenting analysis allows areas with strong competition that are not of much interest for the country's applicants domestically to be identified	• statistics on the patenting activity of residents / nonresidents by field of technology is not available for most countries (WIPO data are mainly available for developed countries; for other countries, these data will need to be collected one by one)

In accordance with the methodology and practice of studies (based on patent data), statistics on a country's applicants allow for a more detailed and precise analysis of country's patenting than those based on inventor patent data. Data on the patenting activities of a country's assignees, and patent applications by a country's inventors, allow for global trends in patenting, and differences in patenting structures to be identified and analysed. When analysing the patenting activity of assignees at the national level, proper allowance must be given for the structure of assignees, e.g. the size of assignees, their origin and field of operations; this is especially true when using European Patent Office (EPO) databases. When conjecture and hypotheses are made about detected trends, it is necessary to take into account how the selection of the data under consideration correlates with companies in a single country as a whole, and differences in patent strategies between the sample (survey frame) and the dataset as a whole. Archibugi and Pianta (1992), and other scholars in most technological specialisation studies, analyse data on assignee patenting.

It is the primary path in a significant number of technological specialisation studies, as it presents the "clearest" analysis of technological activities across countries, of individual firms and patent applicants within countries, and of the ambitions and participation of firms and individuals in international (or internal) technology markets.

Data on inventor patents provide a better ‘‘picture’’ of the technological activities of developing countries than assignee patents. The advantage of studies based on inventor data is that a country's inventors are more visible in the patenting process than a country's assignees. Therefore, inventor data is more complete data. A large number of these type of patent data allow calculations to be made, and data to be more accurately analysed. However, the results drawn from inventor-based analysis are not as significant as the results and outcomes from an analysis of assignees data. This is because applicants – companies and individuals – are more interconnected with their country of origin than inventors (Debackere, K.; Luwel, M., Veugelers R., 1999). Analysis of technological specialisation provides a comprehensive source of information for the study of advanced countries, as well as countries with a comparable (large) number of patents. Small patent numbers require analysts to use a wider variety of indexes, because the use of only one index can distort results. For studies of individual companies, data must either be collected “one-by-one”, or by using a special database like Questel Orbit or Patstat. An analysis of technological specialisation at the firm level can illustrate the technological activities and current global position of individual companies in contrast with other companies working in the same technological field. Scholars study the relationship between technological specialisation and other indicators based on patent data with an eye to developing quality-adjusted measures of a firms’ technological structure (Chen Y.-S., 2011; Chen, Y.-S., Chang, K.-C., 2010).

For the study of the dynamics of patent development two to three periods of three to five years (chosen from the comparable steady state period until the last available period in the database) can be analysed. This provides reliable data, and at the same time allows for smoothing, and to a certain degree, the elimination of random fluctuations in patenting dynamics. The United States Patent Classification can be used in studies based on USPTO patent data only. In different reports USPTO internet resources consist of these data and also patent statistics by US patent classification (USPC) and International Patent Classification (IPC) 1-3 digit technical groups. Chen identified the most important technological areas according to the three-digit USPC classes (Chen Y.-S., 2011).

The IPC is used for all patent authorities analysis. Most aggregated data are based on 3-digit or 4-digit groups of IPC. Among them is an IPC-based classification, which has 32 groups ascending in order of appeararance from “A” to “H”. The IPC-based technology classification used at WIPO has 35 groups, and better reflects special technology areas (Schmoch, U. 2008). It is based on 3-digit and 4-digit IPC groups in sequence from “A” to “H”. It should be noted that in October 2012 the Cooperative Patent Classification (CPC) based on the classification of the EPO (ECLA), which fully integrates IPC, and the best elements of USPC was introduced. CPC is created as the first practical step towards the harmonization of different classifications. Common Hybrid Classification (CHC) will be next result of joint work of five offices / IP5 (EPO, USA, Japan, Korea and China), The creation of joint classification expand the capacity and effectiveness of comparative analysis of the technological advantages of countries. An analysis of the areas of technological specialisation allow for the level, and trends of patent activity of a country's applicants and inventors in specific technological areas to be measured. Some technology areas have traditionally been patented, and cited more than others. This is true for medicine. In this context it is important to view the substantial patenting activities of a country's assignees (or inventors) against the backdrop of global patenting trends in this field. Most effective patent analysis can be provided for the technological areas (industries) in which patents play an important role in protecting innovation outputs, such as the chemical industry and the pharmaceutical industry (Comanor, W.S.; Scherer, F.M. 1969; Bettis, R.A.; Hitt M.A., 1995).

An analysis of patenting activity by nonresidents allows for the identification of areas with strong competition that are not of much interest for the country's applicants domestically; these areas can be considered of a lower priority, as statistics on the patenting activity of residents / nonresidents by field of technology is not available for most part of countries (at WIPO this statistic is available for advanced economies only, and for other countries it must be collected one-by-one). The study of patenting activity of residents in/by the domestic patent authority reveals a country’s patenting structure. Compared with country’s domestic patenting

the patenting activity of a countries' residents in/by a foreign patent authority, and it highlight differences between trend in patenting and most significant patents structure.

Data sources for patent statistic analysis

The limitations and potentials of various databases, approaches, and indexes are discussed later in the text. The most comprehensive and frequently used patent databases are provided by the European Patent Office (EPO), the United States Patents and Trademarks Office (USPTO), the Organisation for Economic Co-operation and Development (OECD), the Japan Patent Office (JPO), the World Intellectual Property Organization (WIPO), Questel Orbit, and Eurostat, although data from domestic patent offices are often analysed for supplementary purposes too. However, the most complete patent data are contained in the EPO Patstat database. Some of the important issues which arise when selecting a database for analysis are addressed (Table 2).

Table 2. Data Source Limitations, Potentials, and Applications (According to the technological specialisation study)

Institution	Potentials	Limitations
OECD	• data from different patent authorities (EPO, USPTO, triadic patent families) are available • patent data are weighted by size of country participants • 4-digit IPC	• statistical tables with only general aggregation are available • Patent authority's (for example, USPTO) data counts are less than in the authority's (USPTO) database
EPO	• allows for the most comprehensible analysis (in terms of patent value)	• individual queries are needed for the each type of data
Patstat (provided by EPO)	• includes all the information about patents; suitable for technology area studies • allows multiparameter analysis including technology area studies based on data at different aggregation levels and measurement of different patent activity indicators;	• data requires cleaning, and making queries in order to retrieve data requires special software (and programming language proficiency)
USPTO	• especially well suited for US technology market studies and analysis	• first-to-file system requires close attention to differences when comparing data from USPTO and other patent authorities; • individual queries are needed for every piece of data
JPO	• allows for analysis of Japanese domestic patenting	• only very general, aggregated statistical tables are available • appropriate for the general analysis of Japan only
Domestic Patent Offices	• suitable for domestic patent market studies; can be used for contrasting domestic patenting trends with foreign patenting trends	• one can expect some difficulty in accessing information of some patent authorities (especially in less developed

Institution	Potentials	Limitations
		countries)
WIPO	• complete data on country's patenting in the world • easy data extraction • statistics on patent publications by field of technology is available by leading countries	• only very general, aggregated statistical tables (with residents/ nonresidents patent counts by countries) are available;
Questel Orbit	• includes a significant amount of information on patents • suitable for all kinds of patent data studies; • includes a large variety of information about patents	• for different databases (from national and international patent offices), various fields (e.g. applicants country of origin) are not available; individual queries are needed for the each type of data
Eurostat	• data for high-tech patent groups	• except for high-tech patent groups, only very general, aggregated statistical tables are available

OECD provides patent databases that allow for easy data extraction, and make available EPO, USPTO, and triadic patent families patent data. EPO, and USPTO data are also available at European and American patent authorities, but they are not the same as OECD data. In contrast to European and American patent authorities, the OECD patent databases are cleaned (for example, the share of every country's assignee/inventor for every patent/ patent application is calculated). It is an important advantage of this database.

It should be noted that *EPO* patent data allows for the most significant and comprehensive analysis (in terms of patent value), especially when analysing European patenting activity. Analysis conducted by van Zeebroeck, van Pottelsberghe de la Potterie, and Han (2006) shows that most appropriate data for measuring technological specialisation are patents filed at the EPO (and also Triadic Patent Families could therefore provide a neutral data source). EPO database consists of patent applications filed to, and granted by EPO. Analysis of patent applications provides data with the shortest time lag (for analysis of the latest available patenting activities), and they overweight the number of granted patents. With the shorter time lag the patent data analysis becomes more robust in terms of detecting and monitoring technology trends over time. Therefore, patent applications are suitable for the study of developing countries, which typically have a small number of patents. Data are available by either key technology area, or by 1-4 digit technology groups (in accordance with IPC). The 1-4 digit technology groups is the most commonly used aggregation level because it is quite detailed and sufficient for comparison with other (product) classifications.

For other purposes, such as the study of achievements on the American technology market, the USPTO database becomes the most logical and suitable source of data. For example, Chen and Chang (Chen, Y.-S., 2011; Chen, Y.-S., Chang, K.-C., 2010) in their study of the American pharmaceutical industry use USPTO data, Albuquerque (2000) in his study of patenting activity in Brazil, also uses USPTO data when analysing the foreign goals of Brazilian

patentees; when analyzing the domestic patenting structure, he uses the domestic Brazilian patent database. The USPTO database contains data on patent applications and patents granted by USPTO, but data on patents granted by the USPTO is most often used in studies and analysis because USPTO does not follow the "first to file and first to invent" system yet, which makes some of its data incompatible with data from other patent authorities. The "first-to-file" system is used in all countries except the United States, so during the comparison of the data from USPTO[4] and other patent authorities, these differences should be taken into account.

The methodology of data analysis by the EPO, USPTO, and other non-domestic patent authorities is based on the notion that analysis of a country's foreign patenting is the most appropriate tool for the study of the technological potential of country's assignees (in comparison with data on a country's inventors). It is pertinent to suppose that foreign patents reflect the most internationally competitive technologies of a country, and that foreign patents, are suitable for international comparison (Soete, L.G.; Wyatt, S. M.E., 1983). So, data collected from foreign patent offices better reflect a country's most competitive patents (or patent applications).

It should be noted that the most valuable patent applications are often filed in more than one country. These are usually patents filed using the Patent Cooperation Treaty (PCT) procedure and triadic patent families. Therefore, a study of PCT filings (PCT international applications are available at WIPO) allows for a more accurate analysis. The most significant ones are included in filtered subsets of patent families for which there is evidence of patenting activity in all triadic blocs (WIPO, Glossary on Industrial Property Statistics). Especially *triadic patent families*, are part of a filtered subset of patent families for which there are published applications or grants registered simultaneously by leading patent authorities, such as the EPO, JPO, and USPTO (the Trilateral Co-operation *statistical reports*; Dernis, H. and Khan, M 2004) collected by OECD (Institut de la statistique du Quebec; OECD *work on patent statistics*). Therefore, such technology specialisation studies can be based on triadic patent families' data, or patent filings that share common priorities consolidated into a single patent family. Van Zeebroeck et al. (2006) also notice that triadic patent families provide the most neutral data source. But there are too few of these patent families, and therefore triadic patent family data should be used only in countries with a substantial number of patents.

The JPO is another important patent agency. However, the JPO reports only very general, aggregated statistical tables for countries other than Japan. Therefore, data corresponding with national patent authorities should also be collected. The most detailed statistical tables in the JPO database are provided for Japan patent applications. Thus, JPO is best suited for studies of the Japanese domestic technology development. Domestic patents show country specific

[4] United States will switch to a first-to-file system on March 16, 2013 (after the enactment of the America Invents Act [4])

peculiarities. Domestic patent office databases are suitable for studies of domestic patent markets, and are very important for contrasting domestic and foreign patenting activity (Archibugi, Pianta 1992). Almost every country has its own patent law and a patent office; of which most provide information via dedicated internet resource. The main issue with this type of patent data is that one can expect some difficulties in accessing information from some domestic patent authorities (especially in less developed countries).

Questel Orbit includes significant information about patents, making Questel Orbit suitable for all kinds of patent data studies. Therefore, one may use Questel Orbit to conduct technology specialisation analysis. One drawback is that a special query must be made for each piece of Questel Orbit data. These data may be collected with the use of queries for every IPC group, or can be based on keywords. Queries based on keywords require special methodology, and so searches based on IPC groups are preferable. The main issue with this, however, is that for different databases (national and international) different fields (for example, an applicant's country of origin) are not available.

Eurostat makes very general, aggregated statistical tables available to everyone. However, the most interesting data are statistics on patenting in high-tech areas, and special groups, which are not contained in these tables.

Patstat provided by EPO is the most suited database for technology area studies because it includes a full set of information about patents (in fact, one could say it includes all possible information). However, it requires special preparatory work and data cleaning. Also, one must possess proficiency in special software programming languages in order retrieve data. After data cleaning and other preparatory work, Patstat allows for multiparameter analysis of the patenting process to be conducted, including technology areas study based on data at different aggregation levels, measuring of the different patent activity indicators.

There are many studies confirming the quite obvious assumption that it is primarily companies focused on foreign market or international (global) partnerships that have an interest in patent filing. In this case, the most relevant patents are filed to foreign patent authorities, typically EPO, and USPTO. Therefore, the best strategy for significant results of technology specialisation studies, especially in developing countries, is to complement an analysis of domestic patenting with an analysis of foreign patenting as well.

Technology Specialisation Indicators

A broad range of indicators have been developed and are used for measuring technology specialisation, as well as the concentration and quality of patents. The most commonly used indicators to measure technological change and specialisation are:

- Revealed Technological Advantage Index (RTA);
- Revealed Patent Advantage Index (RPA);
- Patent Share (PS);
- Relative Patent Position Index (RPP);
- C20 Concentration Index;
- Gini Concentration Index;
- RTA in its most important technological field (RTAMIT);
- Patent Share in a special technology area (PSMIT).

Determination of a country's technological development stage is usually done using indicators such as PS, and RTA among others whereas technological specialisation of a country's (resident) inventors and technological specialization of a country's (resident) assignees give an impression of the countries inventor's and assignees structural dimension. RTA allows the level of a country's (or firm's) patenting activity in special technology areas to be measured. This is useful when making world comparisons of patenting activity in a specific technology area. Each patent indicator has different potentials and limitations, as shown in Table 3.

The technological specialisation of a country's (resident) assignees is measured during an analysis of the patent database that contains patent applications filed by country's assignees while technological specialisation of a country's (resident) inventors is measured by the analysis of patent databases containing patent applications wherein a country's inventors were registered. Indicators based on patent applications data (patents filed) reflect more recent trends than indicators based on patents issued (granted) data.

Table 3. Patent Indicators: Potentials and Limitations

Indicator	Potentials	Limitations
RTA/Revealed Technological Advantage Index	• allows for the measurement of the level of country (or firm) patenting activity in particular technology fields • allows for international comparison	• analysis only possible for countries with a large number of patents (primarily developed countries) • analysing a small number of patents in a country leads to a distorted picture of country's advantages – such analysis must be complemented by other indicators • only possible for foreign patenting studies
PS/Patent Share	• main indicator used in national patent studies and foreign patenting analysis	• does not reflect strategic intend of patent holders
RPP /Relative Patent Position Index	• allows to measure country's leading degree in several particular technological fields	• relative position only, does not give quantitative information about differences between countries
C20 Concentration Iindex	• best index for measuring specialisation "concentration" • analyses 20 largest groups;	• concentration ratios within the 20 largest classes requires having *more* than 20 classes in a classification when being used
Gini Concentration Index	• Gini is sensitive to a large number of small groups	• should be used in the case of data with a large number of small groups
RTAMIT/Revealed Technological Advantage in a country's most important technological field	• shows the relative strength of a technology field (strong or weak positions of the institution in the special technological field) • emphasize patenting in country's most important and valuable technological field	• difficulties in most important technological field identification in the case of country analysis
PSMIT/Patent Share in a country's most important technological field	• can be used for domestic patenting studies • measures the concentration of resource investment in key technology fields within a patent portfolio	• does not consider global trends

The most commonly used indicator of technological specialisation is RTA. It was first developed by Balassa (Balassa B., 1961, 1965), and later adopted by different scholars to measure the technological advantages of various countries and firms in certain technology areas.

Usually RTA is defined as the ratio of the share of national applicants' patents in any patent office, in the total number of patents in the office of a specific technology field (group) to a share of the country in general number of patents in this patent office. Depending on the purpose of analysis for such calculations are used one of international patent databases (OECD, 1994).

$$RTA_{ij} = \frac{Po_{ij} / \sum_{j} Po_{ij}}{\sum_{i} Po_{ij} / \sum_{ij} Po_{ij}}, \quad (1)$$

where RTA_{ij} is the Revealed Technological Advantage Index in area of technology *i* for country j; *Poij* is the number of patents of national applicants in patent office; $\sum_{j} Po_{ij}$ *is the total* number of patents from all *j* countries in technological area *i* in a patent office; $\sum_{i} Po_{ij}$ is the number of patents of applicants from country *j* in all *i* technological areas in a patent office and $\sum_{ij} Po_{ij}$ *is the total* number of patents from all *j* countries in all *i* technological areas in a patent office.

RTA reflects the relative advantage of a country in a specific technology field in reference to world patenting trends

$$RTA_{ij} = \frac{(Pd_{ij} + Pf_{ij}) / \sum_{j} P_{ij}}{\sum_{i} (Pd_{ij} + Pf_{ij}) / \sum_{ij} P_{ij}}, \quad (2)$$

where *Pij* is the number of patents with participation of holders from country *j* in area of technology *i*: *Pd ij* and *Pf ij* are the number of domestic and foreign patents granted to applicants of the country *j* in the technological area *i*; $\sum_{j} P_{ij}$ is the world-wide number of patents granted to applicants of all *j* countries in the technological area *i*; $\sum_{i} (Pd_{ij} + Pf_{ij})$ is the sum of the domestic and foreign patents granted to applicants of the country *j* for all *i* technological area and $\sum_{ij} P_{ij}$ *is the* world-wide number of patents granted to applicants of all *j* countries in all *i* technological areas.

It should be noted that index can be calculated differently, as the share of technology area in the country's patents relative to the share of technology area in total patents (OECD, 2008), so, for example, the formula 1 can be transformed

$$RTA_{ij} = \frac{Po_{ij} / \sum_{i} Po_{ij}}{\sum_{j} Po_{ij} / \sum_{ij} Po_{ij}}, \quad (3)$$

But at the same in both cases (formulas 1 and 3) the value of the index they will constitute different indicators reflecting diverse phenomena. In the first case - the proportion of countries in the global flow of patents in specific technology area and in general (i.e. revealed technological advantage), in the second case - the share of a specific technology area in the country's total number of patents and the share of the total number of patents in a specific technology area in global patent flow (i.e. technological structure of the patent flows – the country's and global).

In countries with a small number of the patents in the index, value and group ranks will fluctuate. A small number of patents implies that the index will be unstable (or less stable) hence it is extremely sensitive when responding to data changes (increase, fall, etc.). Therefore, RTA should be used along with supplementary indexes when studying the patenting activity in developing countries. RTA –should be complemented, in some cases, by other patent indicators which reflect other aspects of patent activity. There are additional indicators that are often used by authors for wider and more general studies.

Grupp (Grupp H., 1990) introduced the Revealed Patent Advantage (RPA) Index, which is a modification of RTA and configured as following:

$$RPA_{ij} = (RTA_{ij}^{2}-1) / (RTA_{ij}^{2}+1) \qquad (4)$$

Since RTA can vary between 0 and 1 in the absence of specialization in area of technology, and from 1 to infinity in the presence of competitive advantage in it was attempted to avoid such uneven distribution of values of the relatively neutral position between these two options, by normalized RTA hence creating RPA. So the resulting index characterizes the symmetric distribution of identifying technological advantages.

Also scholars combine technology specialisation indicators with balance of payments. Meliciani (Meliciani, V., 2002) explores the effect of technological specialisation on national innovation performance. Meliciani found that average GDP growth rates are higher (above average) in countries that specialise in high-tech fields (the reason for this being that specialization in high-tech is related to their international competitiveness). Patent data are used by scholars in comprehensive studies of country technology specialisation (and diversification) and correlation with the strongest technological performance. Cantwell and Vertova show how technology specialisation within countries has changed over time (Cantwell J.; Vertova, G. 2004; Vertova G., 2001). In all of these studies the main indicator of technology specialisation is RTA.

If a country has a small number of patents, acute fluctuations of the index value caused by comparatively small/negligible variations in patent numbers are likely to occur. Therefore it is important to consider other indicators for a valid and correct identification of trends. Patent share (PS) is among these indicators. PS is calculated by dividing the number of patent in a given

technology field by the total number of patents in a country (or owned by the company). Another "patent share" indicator is the share of domestic patent applications for a specific technology area compared to the number of global patent applications in this same technology area. Van Zeebroeck et. al (2006) show that the most stable measures of technology specialisation can be obtained with the Gini, or C20, concentration index. A wide range of technology specialisation indicators was developed for studies which conduct firm level analysis. In spite of Chen's papers, which focused on the firm level, it should be noted that some indicators (including C20 and Gini concentration indexes) are appropriate for country level analysis.

C20 Concentration Index is calculated as following:

$$C(X)_j = \frac{\sum_{k=1}^{X} p_{k(j)}}{\sum_{i=1}^{n} p_{ij}} \qquad (5)$$

where X is the number of the largest IPC being take into account, p_{ij} is the number of patents (or applications) of country j in technology class i, with i=1,…,n, where n is the total number of classes, and $p(k)j$ is the k^{th} largest number of patents per technological class. For technology specialisation studies which attempt to analyse specialisation as a concentration, other indexes can be used.

Gini Concentration Index is calculated as following:

$$G_j = 1 - \sum_{i=0}^{n-1}\left(F_{i+1,j} - F_{i,j}\right) \times \left(\Phi_{i+1,j} + \Phi_{i,j}\right) \qquad (6)$$

where F_{ij} is the cumulative population share,

$$\Phi_i = \frac{1}{n\mu}\sum_{k=1}^{i} p_{kj} \qquad (7)$$

the cumulative patent share of class i, φ_{ij} being the number of patents (or applications) of country j in the technological class i with i=1,…,n, where n is the total number of classes. The C20 Index is a measure of technology concentration which allows researchers to calculate a share of the 20 largest technology groups neglecting the distribution of these 20 groups and other ones. Authors using the word "specialisation" generally mean "concentration", rather than "advantage".

Relative Patent Position Index (RPP) is an indicator of patent specialisation and patent quality. Relative patent position (RPP) of a given country in its most important technological field means the patent counts owned by the country in its technological field where it has more patents than in others divided by the patent counts of the leader in the technological field (Ernst, H. 1998; Ernst, H. 1999). Ernst used RPP to measure their leading degrees in several particular technological fields: mechanical engineering, the chemical industry and others (Ernst, H. 1998), later he also analyzed RPP as Relative Technology Share indicator (Ernst H. et al 2004).

Revealed Technological Advantage in an institution's or country's most important technological field (RTAMIT) is calculated as following:

$$RTA_{MIT} = \frac{P_{kg}/\sum_i P_{ig}}{\sum_j P_{kj}/\sum_i\sum_j P_{ij}} \qquad (8)$$

where P_{kg} is the patent count of domestic company g, in its most important technology field k; $\sum_i P_{ig}$ is the patent count of local company g in all technology fields; $\sum_j P_{kj}$ is the patent count of all companies in the most important technological field k; and $\sum_i \sum_j P_{ij}$ is the patent count of all companies in all technological fields (Chen, Y.-S., Chang, K.-C., 2010).

The indicator Patent Share in an institution's or country's most important technological field (PSMIT) is calculated as the number of patents in its most important technological field divided by the total number of patents owned by the company or country. This indicator complements RTAMIT especially in cases where there is only a small number of patents (such as in developing countries).

Patent indicators have been developed and used from the second half of twentieth century till nowadays; from Balassa's indicator to more specialized formulas by Grupp and Chen. However all these indicators have some limitations, e.g. they don't fully consider all characteristics of patents, especially the intrinsic patent value, quality-adjusted measures of inventive output, productivity of R&D and others which can be studied using rich set of control variables including patent citation statistics, patent claims parameters, patent litigation or reissuance, the type of patent assignee and technology and others. Therefore there is still a need for improvement and further development to reflect these characteristics better.

Conclusions

Patent statistics provide a fertile ground for analyzing the strength and weaknesses of individual actors in selected technology fields. Although patent data are typically ex post data, which do not necessarily reflect state of the art of technologies, patents have a 20 year lifespan, the competitive position of individual actors can still be determined for a given time. However, the general limitations of patent statistics analysis lie in the unknown strategic behavior of patent holders and applicants; the reasons that entities, especially large ones, seek legal protection are often unknown (for example, is it for application protection, assuring competitive position in a technology field by keeping alternative solutions out, or some other reason?) . One way of determining the strategic intend of patent applicants is by analysing the number, and formulation of claims in the patent document. However, to ensure statistical soundness, and significance, only the number of claims can be used as an indicative indicator, as the precise formulation of claims does not give a reliable indication of the strategic intend due to the lack of standard/accepted methodology, especially for semantic analysis. Moreover, the number of claims filed also determines the cost of a patent for filing and maintaining. Hence, the cost-benefit considerations of patent applicants, and holders, influence the strategic intent for a patent document. Also, the place where a patent holder resides, and the place where an invention originated, is not necessarily the same. It has become almost common practice in large, multinational firms to run service companies that are registered at different locations, which function as patent holders for the parent company. The reasons for this are manifold, including liability issues, tax regulation, among others. However any analysis of patent statistics databases must consider the potential mismatch between the IP right holder, which might be a registered company in some exotic place, and the place where the invention originated, which is typically listed as the inventors' name and address.

Despite these problems and uncertainties, the above mentioned indicators are still appropriate for the country's technological specialisation analysis because they provide easy and verified tool for this kind of study. Indicators derived from patent statistics provide an indication of the current position of individual actors in the global competition for innovation. The aggregation of national patent holders in turn allows for the compilation of indicators which mirror the attractiveness of a country as the host or home base of these actors. Moreover such indicators also allow for the exploration of the relationship between different technology fields, industry-science linkages, and cooperation behavior between different actors, either from different sectors, or different locations, regions and countries.

References

Albuquerque, E. (2000) Domestic patents and developing countries: arguments for their study and data from Brazil 1980–1995, Research Policy, 29, pp. 1047–1060

America Invents Act: Effective Dates, USPTO, Release date: October 5, 2011

Archibugi, D., Pianta, M (1992) 'The technological specialisation of advanced countries'. A report to the EEC on International science and technology activities / Kluwer Academic Publishers. Dortrecht/ Boston / London, p. 112

Archibugi, D.; Pianta, M. (1992), Specialisation and size of technological activities in industrial countries: The analysis of patent data, Elsevier Science Publishers B.V

Balassa, B (1961) The theory of economic integration, Irwin, Homewood, Illinois

Balassa, B. (1965) Trade liberalisation and 'Revealed' comparative advantage, The Manchester School, v.33, no.2, pp. 99-123

Bettis, R.A., Hitt, M.A. (1995) The new competitive landscape, Strategic Management Journal, 16 Volume 16, Issue S1 (Special Summer Issue), pp. 7–19

Cantwell, J., Vertova, G. (2004) National technological specialisation and the highest technological opportunities historically

Chen, Y.-S. (2011) Using patent analysis to explore corporate growth, Scientometrics, v.88, no.2, pp. 433-448

Chen, Y.-S.; Chang, K.-C. (2010), The relationship between a firm's patent quality and its market value —The case of US pharmaceutical industry, Technological Forecasting and Social Change, v.77, no.1, pp. 20–33

Comanor, W. S.; Scherer, F. M. (1969), Patents statistics as a measure of technical change, Journal of Political Economy, v.77, no.3, pp. 392–398

OECD (2008) Compendium of Patent Statistics (2008), OECD

Debackere, K.; Luwel, M.; Veugelers, R. (1999) Can technology lead to a competitive advantage? A case study of Flanders using European patent data, Scientometrics, v.44no.3)

Dernis, H.; Khan, M. (2004), "Triadic Patent Families Methodology", OECD Science, Technology and Industry Working Papers, No. 2004/02, OECD Publishing

Ernst, H. (1998) Patent portfolios for strategic R&D planning, Journal of Engineering and Technology Management, 15, 4, pp. 279–308

Ernst, H. (1999) Evaluation of dynamic technological developments by means of patent data, in: Brockhoff, K.; Chakrabarti, A.K.; Hauschildt, J. (Editors) (1999) The Dynamics of Innovation: Strategic and Managerial Implications, Springer Corporation, Berlin

Ernst, H.; Fabry B.; Soll J. H. (2004) Enhancing Market-oriented R&D Planning by Integrated Market and Patent Portfolios, Journal of Business Chemistry, vol. 1, no. 1

Griliches, Z. (1990) Patent statistics as economic indicators: a survey, Journal of Economic Literature, v. 28. pp. 1661-1707.

Grupp, H. (1990) On the supplementary functions of science and technology indicators. Scientometrics, Vol. 19. No 5-6, 447-472.

Institut de la statistique Quebec 2012, Sources and Definitions: Triadic Patents Families, retrieved 14 September 2012, http://www.stat.gouv.qc.ca/savoir/sources_def/triadiques/index_an.htm

Meliciani V. (2002) The impact of technological specialisation on national performance in a balance-of-payments-constrained growth model, Structural Change and Economic Dynamics, v.13, no.1, pp. 101–118

Miyagiwa K. (2009) First- to-invent versus first-to-file. Invention and international patent law harmonization. Emory Economics

OECD 2012, OECD Patent Database, retrieved 14 September 2012, http://stats.oecd.org/index.aspx

OECD (1994) Using Patent Data as Science and Technology Indicators (Patent Manual), OECD, Paris, 1994

OECD 2012, OECD work on patent statistics, http://www.oecd.org/document/10/0,3343,en_2649_34451_1901066_1_1_1_1,00.html accessed September 2012

Pate1, P.; Pavitt, K. (1987) Is W. Europe losing the technological race. Research Policy, 16 , pp. 59-85

Pate1, P.; Pavitt, K. (1991) Large Firms in the Production of the World's Technology: An Important Case of "Non-Globalisation, Journal of International Business Studies, vol. 22, no. 1 (1st Qtr., 1991), pp. 1-21

Schmoch, U. (2008) Concept of a technology classification for country comparisons. Final report to the World Intellectual Property Organisation (WIPO), Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany

Soete, L.G.; Wyatt, Sally M.E. (1983) The use of foreign patenting as an internationally comparable science and technology output indicator. Scientometrics, vol. 5, no. 1, pp. 31-54

The Triaterial cooperation 2012, the Trilateral Co-operation statistical reports, retrieved 14 September 2012,http://www.trilateral.net/statistics.html

van Zeebroeck, N.; van Pottelsberghe de la Potterie, B.; Han, W. (2006). Issues in measuring the degree of technological specialisation with patent data. Scientometrics, Vol. 66, No. 3, 481–492

Vertova, G. (2001) National technological specialisation and the highest technological opportunities historically, Technovation, v. 21, no.9, pp. 605–612

WIPO 2012, Glossary on Industrial Property Statistics, retrieved 14 September 2012, http://www.wipo.int/ipstats/en/statistics/glossary.html)

Zoltan J.; Acs, D.; Audretsch, B. (1989) Patents as a measure of innovative activity, Kyklos, vol.42. fasc. 2., pp. 171-180

Dirk Meissner
Russia, Moscow, Myasnitskaya str. 20, 101000
National Research University – Higher School of Economics (HSE)
Deputy Head
International Laboratory for Science and Technology Studies
E-mail: dmeissner@hse.ru

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