IJASRM International Journal of Advanced Scientific Research and Management, Volume 3 Issue 6, June 2018
www.ijasrm.com
ISSN 2455-6378

A brief Analysis of the Patents associated with the Indian Electrical energy sector.

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Abstract

Patent documents are an ample source of technical and commercial knowledge and analysis of patent is considered as a useful tool for R&D management and techno economic analysis in different sectors across the globe. Patent statistics provide a fertile ground for analyzing the strength and weaknesses of individual actors in selected technology fields. This paper tried to analyze patents pertaining to Indian electrical energy sector.

Keywords *Patent, RTA, RPA, PS, RPP, Concentration index*

1. Introduction

Patent is a legal document, granted by the government, which allows an inventor the exclusive right to make, use and sell the invention for specific numbers of years. Patent are also available for significant improvement on previously invented items.

The goal of patent data analysis system is to identify the technology trends in particular field and detection of emerging technological trend among others. Patent documents provide ample source of technical and commercial knowledge. Patent analysis is considered as a useful vehicle for R&D management and techno economic analysis in different sectors.[1]

Patent represents an invention in technological field and increasing volume of patent information plays a key role in influencing managerial decision-making process.[2] Translating patent data into competitive intelligence allows the firm to gauge its current technological trends and to plan for potential competition from new technology[3].

The intent of this paper is to evaluate technique of patent analysis as a standalone intelligence method. The paper has been divided into two sections. Section one deals with different indicators of patent analysis and technology specialization, particularly in electrical energy studies. In section two the authors have also tried to explore the strength of any possible association between India's patent applications, published by resident and non-resident, with research and development expenditure % of GDP) and with the numbers of researchers who are involved in the R&D activities.[4] As patents data contain huge volumes of structured and unstructured data, it requires different tools that are intelligent enough to accomplish the analysis tasks. In this paper, the authors have used some common techno econometric tool for analysis.

2. Scope of study:

This study restricts the scope of patent analysis to (i) historical patent application and issuance trends, (Section I) (ii) how new patent innovation was related with R&D expenditure of a country (Section II)

3. Review of Literature

Objectives of patent analysis are to recognize the trends in technological development. Ekaterina Khramova etal (2013) [5] presented a systematic

[1]Byungun Yoon, Yongtae Park (2003) a text-mining-based patent network: Analytical tool for high-technology trend, Elsevier.

[2] Liu SH, Liao HL, Pi SM, Hu JW (2011),development of a patent retrieval and analysis platformea hybrid approach, Expert Syst Appl - 38(6):7864e8.

[3] https://sites.google.com/site/analyzingpatenttrends/Home/what-is-patent-analysis visited on 28/11/2016

[4]Regression analysis has been avoided as there exists a correlation (0.87) between R&D expenditure and No of R&D personnel who mean two independent variables are not mutually exclusive.

[5]Ekaterina Khramova (2013) , Dirk Meissner, Galina Sagieva (2013), statistical patent analysis indicator as means of determining country technology

overview of the most appropriate tools and methodologies that are available for determining the technological specialization of countries. Poh-Kam Wongetal (2005)[6] examined the changing pattern in technological specialization of the small, newly industrializing economies (NIEs) from East Asia as they move up the economic development ladder. Tassos Giannitsis etal(2009) [7] pointed out that technical change and innovation have been powerful engines for enhancing dynamic specialization advantages of firms and industries, constructing 'differences' vis-à-vis competitors and achieving cumulative growth and power. Assad Abbasetal etal (2014)[8] helped the researchers in finding the latest research efforts pertaining to the patent analysis in a unified form. OECD (2002) [9] , indicated set of quantitative indicators are necessary to the design and evaluation of science and technology (S&T) policy. It allows the comparison of the relative situations of countries, the assessment of their areas of strength and weakness, and the identification of domains where policy intervention is required. Julian Baumann etal (2016) [10] analyzed the link between R&D, innovation, and productivity in MSMEs with a special focus on micro firms in industrialized economies. Shiferaw Gurmuetal (2007) [11] analyzed that the contemporaneous relationship between patenting and R&D expenditures among developed continues be strong, accounting for over 60%of the total R&D elasticity.

4. Objective of the study:

The study tried to

(i) Understand the technological progress of the Indian electrical energy sector by analyzing different patent based indicators

(ii)Evaluate how new patent innovation by different patent applications was related with R&D expenditure of the country.

5. Hypothesis:

India's technological achievement, in terms of patent applications, in electrical energy sector is noteworthy.

6. Methodology of the study:

There are many approaches and indicators to identify technology trends and detect emerging technology specialization. The paper mainly concentrated on different parametric indicators and techniques used for patent analysis.

Four domains namely, country specific; technology specific; sector specific and firm specific domains, have been used as patent analysis indicators[12].

Most commonly used indicators used to measure technology changes and specializations are: Revealed Technology Advantage (RTA)[13], Revealed Patent Advantage index (RPA) [14] , Patent Share (PS)[15], Relative Patent Position index (RPP)[16], C20 Concentration index [17] , Gini Concentration Index (GCI)[18]; RTA in its Most Important Technology field (RTAMIT) [19] and Patent Share in a Special Technology Area (PSSTA)[20].

7. Data Source:

specialization, National Research University higher school of economics (HSE),

[6]Poh-Kam Wong etal (2005), Annette Singh (2005) technological specialization and convergence of small countries: the case of the late industrializing Asian Nies, working paper of National University of Singapore, Entrepreneurship Centre

[7] Tassos Giannitsis etal(2009), Marianne Kager (2009), Technology and Specialization: Dilemmas, Options and Risks?, Expert group "Knowledge for Growth" ,European Commission,

[8]Assad Abbasetal (2014)[8], Limin Zhang, Samee U. Khan (2014), a literature review on the state-of-the-art in patent analysis, Elsevier

[9] OECD (2002), Special Issue on New Science and Technology Indicators (no-27)

[10]Julian Baumann, Alexander S. Kritikos (2016),the Link between R&D,Innovation and Productivity: Are Micro Firms Different?, IZA discussion paper No 9734

[11] ShiferawGurmu , Fidel Pérez-Sebastián (2007), Patents, R&D and lag effects: Evidence from flexible methods for count panel data on manufacturing Firms, International Conference on Panel Data, Texas A&M University, the Midwest Econometrics Group Meeting, and the Annual Conference of the Southern Economic Association

[12]Changyong Lee , Juram Kim , Ohjin Kwon , Han-Gyun Woo(2016), Stochastic technology life cycle analysis using multiple patent indicators, Elsevier

[13] The revealed technology advantage (RTA) index provides an indication of the relative specialization of a given country in selected technological domains and is based on patent applications filed under the Patent Cooperation Treaty

[14] RPA allows the level of a country's (or firm's) patenting activity in special technology areas to be measured.

[15] Main indicator used in national patent studies and foreign patenting analysis.

[16] It allows to measure country's leading degree in several particular technological fields.

[17] Best index for measuring specialization "concentration"

[18]Gini is sensitive to a large number of small groups

[19]Shows the relative strength of a technology field (strong or weak positions of the institution in the special technological field)

[20]Measures the concentration of resource investment in key technology fields within a patent portfolio

The OECD patent database[21]has been mainly used for this analysis. Beside that the different patent database which covers data on patent applications, like the European Patent Office (EPO), the US Patent and Trademark Office(USPTO)[22], patent applications filed under the Patent Cooperation Treaty (PCT)[23] that designate the EPO as well as triadic patent families, Worldwide Patent Statistical database (PATSTAT) have been used. For electrical energy studies only IPC[24] section H has been considered.

8. Result and Discussions:

8.1 Analysis of section 1

This section shows growth rate of Indian patent documents under different IPC classes and of that IPC class which particularly relates to electrical energy sector. The paper evaluate countries technological advantages and specialization over different years using different parameters like Revealed technology advantage (RTA), revealed patent advantage (RPA) and concentration ratio. This Paper also evaluates relationship between total residential and non-residential patent applications with countries' R&D expenditure and researchers who are associated in R&D sector.

- **Comparison among growth rate of India's patent document under different IPC class along with electrical energy:**

Table 1 shows Indian total patent value and growth rate among different IPC classes from 2000 to 2013. High growth rate of India's total patents goes up to year 2002 then falls. There is lot of fluctuations in the rising growth rate of patent of India from year 2005 to 2013 except year 2012 where growth rate is negative.

From table2 we evaluates total Indian patent under IPC H[25], growth rate of IPC H, total no of IPC H in the world and % of patent under IPC H with respect to world from year 2000 to 2013. Growth rate of IPC class H are positive among different year except 2003, 2008, 2012 and 2013. Percentage of patent with respect to world under IPC H is slowly increasing among different years from 2000 to 2013.

Table 3 shows the percentage of total patents of India with respect to total patents of world among different IPC classes in different years namely 2000, 2005, 2010 and 2013.It indicates that the growth rate of total patents of India under IPC H with respect to total patents of the world was increasing during 2000 and 2005, 2010 and 2013 among all different IPC classes,

- ***Evaluation of RTA and RPA of Indian electrical energy:***

The most common indicator of technological specialization is revealed technology advantage (RTA). 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. The index is equal to zero when the country holds no patent in a given sector; is equal to 1 when the country's share in the sector equals its share in all fields (no specialization); and above 1 when a positive specialization is observed. Revealed Technology Advantage (RTA) can be defined in equation 1

Equation of (1)

$$RTA_{ij} = \frac{POij / \sum_i POij}{\sum_j POij / \sum_{ji} \sum POij}$$

where RTAij is the Revealed Technological Advantage index in area of technology ifor country j; Poij is the number of patents of national applicants in patent office; $\sum_j POij$ is the total number of patents from all j countries in technological area iin a patent office; $\sum_i$ PO ij is the number of patents of applicants from country j in all technological areas in a patent office and $\sum_{ji} POij$ is the total number of patents from all j countries in all technological areas in a patent office.

From RTA value in IPC class H it's clear that value is positive and slowly improving but less than one in last five year from 2009 to 2013 (from table 4) of the study period.. From these values it's clear that India have no technological advantage in electrical energy sector as the RTA values in IPC class H were less than one.

Revealed Patent Advantage (RPA) Index, which is a slight modification of RTA and configured in equation 2.

Equation of (2)

$$RPAij = (RTAij^2-1) / (RTAij^2+1))$$

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 it has been attempted to avoid such uneven distribution

[21]http://www.oecd.org/sti/inno/oecdpatentdatabases.htm visited on 15/11/2016, OECD patent indicators are counted according to priority date, which closest to date of inventions. Time lags also consider between priority date and availability of patent information.

[22]https://www.uspto.gov/ visited on 16/11/2016

[23] www.ipophil.gov.ph/services/patents/patent-cooperation-treaty-pct visited on 16/11/2016

[24]http://www.wipo.int/pct/en/treaty/about.htm visited on 15/11/2016

[25]http://www.cooperativepatentclassification.org/cpc/scheme/H/scheme-H.pdf visited on 01/12/2016

of values of the relatively neutral position between these two options, by normalized RTA, hence creating RPA.

India's Revealed Patent Advantage (RPA) from year 2000 to 2013 was less than zero for the IPC classes H (from table 5). From this it can be inferred that India had no patent advantage, in electrical energy sector, during that period of the study.

- **Measurement of technology specialization in Indian electrical energy**:

Varieties of specialization indices have been developed to capture the specialization of a country on a particular technology field. Most common technology indicator is Concentration Ratio, which measures the weight of the n more important sectors. Here n can take the value of relevant figure for a specific technology variable e.g. R&D, patents. The Concentration Ratio ((C (xj)) $=\sum_{k=1}^{x}((P k (j)/\sum_{i=1}^{n}(Pij))$, k goes to 1 to x and i goes to 1 to n. where X is the number of the largest IPC being take into account, pij 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. Lot of fluctuations in Concentration Index of India observed under IPCH over the years 2000 to 2013 (Table 6), which indicates lack of specialization in this field of technology.

For avoiding fluctuation in patent index value due to negligible variation in patent numbers author used Patent Share (PS) index for a valid and correct identification of trends in patents. PS is calculated by dividing the number of patent in a given technology field by the total number of patents in a country. PS index value of India is observed under IPC class H from year 2000 to 2013 (Ref table 7). From the figures it can be inferred that India had no patent attractive patent share in electrical energy sector, during that period of the study.

For evaluation of patent specialization and quality author used an index, Relative Patent Position Index (RPP). Countries Relative patent position (RPP) in its most important technological field i.e. electrical energy means the patent counts of 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. RPP index value of India is observed under IPC class A, C (As India has highest numbers of Patents) and H from year 2000 to 2013 (Ref table 8). From the figures it can be inferred that India had no patent specialization advantage, in electrical energy sector, during that period of the study.

8.2 Analysis of section 2

Investment in R&D encourages innovation, which in turn, enhance economic growth of a country. Several scholars have applied different patent databases for analyzing, evaluating, and recommending different planning activities related to technology management, including the efficiency of investment in R&D sector. One of the relevant studies, on both OECD and non-OECD countries, Hulya Ulku (2004)[26], showed positive relationship between R&D expenditure and stock of innovation. Prodan, Igor (2005)[27] has shown that research and development expenditure on obtaining patents was essential for the economic development, driven by new technology, ideas, and innovation. Economic wheel accelerates a high degree of innovation across all sectors. Patented products will be more independent on the market and more aggressive against competition among different companies. There is enough research work which showed a positive relationship between effect of new innovation and R&D expenditure (% of GDP).[28]

Objective of this analysis is to assess whether there is a significant relationship between total residential and non-residential applications for patent with (i) R&D expenditure as % of GDP and (ii) total researcher who are associated in R&D sector of India.

- **Relationship among innovation of new patent (both by resident and nonresident) with R&D expenditure and numbers of researchers of India:**

The study considers (Ref table 9) total numbers of patent applications by both resident and non-residents, % of resident and non-resident patent applications w.r.t total patent applications during 1996 to 2011.

The figs in the table 9 reveal that percentages of non-residential patent applications are much higher than residential application.

Table 10 contains data on Indian research and development expenditure (%of GDP) and researchers involved in R&D sector (per million people of India) during 1996 to 2011. Data indicates that India's R&D expenditure as percentage of GDP was very

[26] HulyaUlku(2004), R&D, Innovation, and Economic Growth: An Empirical Analysis, IMF Working Paper WP/04/185

[27] Prodan, Igor (2005), Influence of research and development expenditure on number of patent application: selected case studies in OECD countries and central Europe, 1981-2001, Applied Econometrics and International Development, AEID.Vol. 5-4 (2005)

[28] Changtao Wang (2013), the Long-run Effect of Innovation on Economic Growth, https://www.murdoch.edu.au/.../The-long-run-effect-of-innovation-on-economic-gro...

low (less than 1%) and the numbers of researchers (per million) have not increased during the fifteen years (1996-2011) of this study.

Table 11 reveals:

High correlation (0.87) persists between total patent applications (both resident & nonresident) and R&D expenditure.

Moderate correlation (0.66) persists between total patent applications (both resident & nonresident) and researcher associated with R&D,

Moderate correlation (0.58) persists between total patent applications of resident and researcher associated with R&D sector.

Low (0.39) correlation persists between R&D expenditure and researcher involved in R&D sector.

Table1: Total Indian patent IPC class A-H and patent growth rate of India during 2000-13 in all technology domains

Year	Total Patent IPC class A-H	Growth Rate of total patent
2000	267.8	---
2001	420	56.83
2002	729.9	73.79
2003	951.9	30.42
2004	932.9	-2.00
2005	1091.1	16.96
2006	1184.5	8.56
2007	1313.5	10.89
2008	1358	3.39
2009	1537.2	13.20
2010	1877.8	22.16
2011	1994	6.19
2012	1967.6	-1.32
2013	1969.9	0.12

Source: stats.oecd.org

Table2: Total Indian patent of IPC H, growth rate of Indian IPC H, total no of IPC H in world, % of patent under IPC H w.r.t world from 2000-13

Year	IPCH	Growth rate of IPCH	Total no of IPCH in world	% of patent under IPCH w.r.t world
2000	21.6	-----	19 562.8	0.1104
2001	31	43.52	20 219.9	0.1533
2002	43	38.71	20 011.1	0.2149
2003	46.8	8.84	22 252.5	0.2103
2004	69.3	48.08	25 722.1	0.2694
2005	93.1	34.34	29 790.9	0.3125
2006	134.4	44.36	32 756.0	0.4103
2007	154	14.58	35 147.5	0.4382
2008	164	6.49	33 633.6	0.4876
2009	178.7	8.96	37 061.1	0.4822
2010	260.1	45.55	40 828.9	0.6371
2011	289.5	11.3	46 612.8	0.6211
2012	292.2	0.93	47 474.8	0.6155
2013	296.9	1.61	47 181.1	0.6293

Source: stats.oecd.org

Table3: % of total patent of India in 2000, 2005, 2010 and 2013 with respect to total patent of world under different IPC classes

IPC class	% of IPC class Indian patent w.r.t total world patent in 2000	% of IPC class Indian patent w.r.t total world patent in 2005	% of IPC class Indian patent w.r.t total world patent in 2010	% of IPC class Indian patent w.r.t total world patent in 2013
Class A	36.56	29.73	27.93	21.68
Class B	5.12	4.95	8.42	8.02
Class C	34.43	38.04	27.49	23.72
Class D	1.34	1.49	0.93	0.83
Class E	0.00	0.39	1.19	2.60
Class F	1.83	3.18	3.98	6.06
Class G	12.66	13.67	16.15	22.01
Class H	8.07	8.53	13.85	13.66

Source: stats.oecd.org, author calculation

Table4: RTA of India in last 5 years under IPC class H

Year	RTA-IPC Section H
2009	0.4912
2010	0.5841
2011	0.5866
2012	0.6128
2013	0.6454

Source: stats.oecd.org, author calculation

Table 5: RPA of India in last 5 years under IPC class H

Year	RPA-IPC Section H
2009	-0.611243333
2010	-0.49123214
2011	-0.487985012
2012	-0.453991521
2013	-0.411889789

Source: stats.oecd.org, author calculation

Table6: Concentration index under IPC class H of India from 2000 to 2013

Year	IPCH	Concentration index of IPCH
2000	21.6	0.2175926
2001	31	0.3774194
2002	43	0.3255814
2003	46.8	0.3739316
2004	69.3	0.2568543
2005	93.1	0.3523093
2006	134.4	0.3154762
2007	154	0.2909091
2008	164	0.2384146
2009	178.7	0.2501399
2010	260.1	0.2033833
2011	289.5	0.2687392
2012	292.2	0.2587269
2013	296.9	0.2883126

Source: stats.oecd.org, author calculation

Table 7: Calculation of Patent Share (PS) under IPC class H

Year	IPCH	Total Patent IPC class A-H	Patent Share
2000	21.6	267.8	8.07
2001	31	420	7.38
2002	43	729.9	5.89
2003	46.8	951.9	4.92
2004	69.3	932.9	7.43
2005	93.1	1091.1	8.53
2006	134.4	1184.5	11.35
2007	154	1313.5	11.72
2008	164	1358	12.08
2009	178.7	1537.2	11.63
2010	260.1	1877.8	13.85
2011	289.5	1994	14.52
2012	292.2	1967.6	14.85
2013	296.9	1969.9	15.07

Source: stats.oecd.org, author calculation

Table 8: Calculation of Relative Patent Position Index (RPP) under IPC class A, C and H

Year	IPC Class A*	IPC class C*	IPC Class H
2009	0.01494	0.02017	0.00482
2010	0.01766	0.02229	0.00637
2011	0.01477	0.02058	0.00621
2012	0.01488	0.02300	0.00612
2013	0.01458	0.02075	0.00616

*indicates India has highest number of patents in that IPC class
Source: stats.oecd.org, author calculation

Table 9: Total Patent applications both resident and non residents, % of Resident patent application w.r.t total applications and % of nonresident patent application w.r.t total applications during 1996 to 2011

Year	Patent Application(Resident only)	% of Resident patent application w.r.t total applications	Patent Application(Non-Resident only)	% of nonresident patent application w.r.t total applications
1996	1661	19.40	6901	80.60
1997	1926	18.97	8229	81.03
1998	2247	25.09	6707	74.91
1999	2206	45.71	2620	54.29
2000	2206	25.84	6332	74.16
2001	2379	22.46	8213	77.54
2002	2693	23.49	8772	76.51
2003	3425	27.15	9188	72.85
2004	4014	22.98	13452	77.02
2005	4721	19.36	19661	80.64
2006	5686	19.66	23242	80.34
2007	6296	17.88	28922	82.12
2008	6425	17.45	30387	82.55
2009	7262	21.18	27025	78.82
2010	8853	22.26	30909	77.74
2011	8841	20.91	33450	79.09

Source: stats.oecd.org, author calculation

Table 10: Indian research and development expenditure (percentage of GDP) and Researchers in R&D (per million people of India) during 1996 to 2011

Year	India(Research and development expenditure (% of GDP))	Researchers in R&D (per million people)
1996	0.6280	152.4839
1997	0.6748	139.2354
1998	0.6917	115.6313
1999	0.7117	117.2467
2000	0.7440	110.0504
2001	0.7232	155.7851
2002	0.7132	137.2546
2003	0.7069	138.6541
2004	0.7438	142.3685
2005	0.8104	135.2997
2006	0.7972	164.2354
2007	0.7908	187.3654
2008	0.8411	151.3654
2009	0.8188	147.5876
2010	0.7972	156.6380
2011	0.8222	158.6574

Source: stats.oecd.org, author calculation

Table 11: Correlation between Patent applications vs R&D expenditure, researcher in R&D during 1996-2011of India

Particular	Correlation value	Level of significance
Correlation b/w Patent application(both resident &nonresident) vs R&D expenditure	0.870136924	.0022
Correlation b/w Patent applications(both resident &nonresident) vs researcher in R&D (per million people)	0.666326485	.0041
Correlation b/w R&D expenditure vs researcher in R&D(per million people)	0.39218733	.0012
Correlation b/w Patent applications of resident vs researcher in R&D	0.583068654	.0121

Source: stats.oecd.org, author calculation

9. Conclusion:

In this paper, we used different patent indicators for the India's technological specialization in energy sector and evaluate current position across the globe. From the analysis of Indian patent data on energy sector, we try to find out the following research findings: i) patent application field in India reflects trends in technology development in energy sector are not encouraging. ii) Though average level of technology based on patent has increased in Indian energy sector over the years, spending particularly

on research and development has to be increase in coming years for implementing new technologies particularly in energy sector that leads to overall growth of that sector as well as country's economy.

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