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Evolution of Technical Competence in CSIR: A Case Study using Patents Data

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ABSTRACT

The paper examines the growth and evolution of technical competence in the Council of Scientific and Industrial Research (CSIR) during 1976-2004, as reflected in patents granted to CSIR scientists in India. The areas of technical competence were identified and studied using International Patent Classification (IPC) code assigned to each patent. In all 2841 patents were granted to CSIR scientists during 1976-2004, which were classified into 352 technical areas. Of 352 technical areas, 46 areas alone contributed 1994 patents. Among these technical areas, 9 areas (1324 patents) were classified as highly productive, 13 areas (372 patents) as medium productive, and 24 technical areas (298 patents) as low productive. The analysis also identified areas of emerging competence and future potential on the basis of evidence of patenting activity, particularly, during the most recent period of 2001-2004.

Keywords: Technical competence, international patent classification, science & technology, CSIR patents

1. INTRODUCTION

The Council of Scientific and Industrial Research (CSIR) is the leading publicly funded research organisation in the country. It undertakes research in diverse fields of science and technology like chemicals, drugs and pharmaceuticals, biotechnology, electronics, glass and ceramics, leather, mining, minerals and metals, oceanography, aerospace, and scientific instruments. The emphasis is on applied research and development, with the aim of contribution to the advancement of science, industry and fulfillment of the societal needs such as food, fuel, buildings, roads, etc. The scientists in CSIR are the repository of knowledge and expertise in several areas of technological competence nurtured over the years.

Recently, CSIR took conscious decision to implement several R&D programmes in network mode by establishing synergy within its vast multidisciplinary expertise, often niche areas and competencies available in the laboratories, which in turn has enhanced the need of understanding the significant technical competence of CSIR.

A few studies have looked into the concept of competencies in the organisational context, particularly, for firms and corporations[1-4]. In view of the changing economic and global contexts, a dynamic organisation like CSIR has to keep pace by continuously upgrading its competencies and addressing the challenges of new S&T developments, for example, aero-acoustics and aerospace materials, nano-biotechnology, cell and tissue engineering, fuel cells, polymer materials, nanomaterials, and nanocomposites. Selective support and building up of necessary facilities including the technical competence and human resource development are essential for this purpose. The competence of an organisation essentially enables understanding of relatively unique set of skills, which allow organisations to successfully compete in the current and future markets[5]. These competencies usually describe the general technical capabilities and skills that would be valuable for the development of a wide variety of products and output of an organisation.

The output of CSIR has grown considerably over the years, both in terms of patents and publications[6]. It has made significant contributions in the generation and protection of intellectual property and has achieved the status of a leading publicly funded R&D organisation in terms of patents obtained in India and abroad. It had filed 260 and 58 patent applications in India and abroad during 1995-96, which increased to 407 and 645, respectively, during 2005-06. The number of scientific publications by CSIR scientists in peer-reviewed journals also increased from 1576 (with an average impact factor 1.264) in 1996 to 3018 (with an average impact factor 2.01) in 2005 indicating qualitative shift in the competence of scientists. The external cash flow (earnings from commercialisation of results of research) in CSIR has also increased from Rs 245 crore in 2000-01 to Rs 341 crore in 2005-06. Although the output of CSIR increased, but the active number of scientists engaged in R&D work in CSIR decreased from 5,550 in 1995-96 to 4,635 during 2005-06. The competence and skills of R&D scientists and their continuous monitoring and strengthening is, thus, the key component to sustain an accelerated growth of output in CSIR. What are the key competencies of scientists in CSIR? In which technical areas of competence, R&D scientists indicate strong capabilities and strengths, both over short-term as well as long-term. A review of the evolution and identification of strong and weak areas of competences of CSIR is likely to benefit the re-orientation of current approach and strategy of preparing the eleventh five year plan (2007-12) in the emerging global and competitive context.

2. LITERATURE REVIEW

Several quantitative studies have been published using patent data as an indicator of innovation, technological change, R&D policy and management[7]. Studies have also examined the patents granted to CSIR scientists from several angles, such as trends in its growth and output, productivity patterns, pattern of collaboration among scientists, the nature of sources used (patent and non-patent literature) in citations, and commercialisation of R&D[8-14]. There is, however, no study to examine the international patent class in patent data as an indicator of technological competence. The present study analyses patents obtained by CSIR in India with a view to examine its areas of technological competence and productivity of these areas during 1976-2004.

3. OBJECTIVES

The main objectives of the study are: (i) to identify strong and week areas of technical competence of CSIR scientists during 1976-2004; and (ii) to identify technical areas of future competence and potential to CSIR scientists. It aims to provide relevant insights for policy-making by indicating most productive, medium productive and low productive areas of competence.

4. DATA AND METHODOLOGY

The data on Indian patents granted to CSIR scientists during 1976-2004 was taken from the two databases: (i) Database on Indian Patents during 1976-2000, (INPAT, (CD-ROM Version) developed by National

Institute of Science Communication and Information Resources (NISCAIR)[15], New Delhi and (ii) Database on CSIR Patents in India during 2001-04 (available online) developed by CSIR Unit for Research and Development of Information Products (URDP)[16], Pune.

International Patent Classification (IPC) is a comprehensive subject classification system applied to all patents by the patent-issuing authorities and is denoted by a set of symbols[17]. A complete IPC symbol comprises section, class, sub-class and main group or sub-group. Each patent indicates the international patent class to which the invention belongs. The technical subjects of inventions dealt within patent documents indicate either the intrinsic nature or function of a thing or the way a thing is used or applied. The thing may mean any technical matter, e.g., process, product or apparatus. The technical areas are defined at the level of a class or a sub-class in the International Patent Classification in a patent.

These classifications were analysed to indicate the areas of competence of CSIR. The areas were ranked on the basis of the total number of patents obtained during 1976-2004, which enabled identification of productivity according to technical areas in CSIR. Further, the areas of sustained competence were defined as the areas in which there was a continuity of patenting activity during all the six block-periods of 1976-80, 1981-85, 1986-90, 1991-95, 1996-2000 and 2001-04. The areas of emerging future potential were also indicated on the basis of analysis of patenting activity during recent block periods 1996-2000 or 2001-04.

5. ANALYSIS OF DATA

5.1 Growth in CSIR Patenting

R&D scientists in CSIR obtained 2841 patents in India during the period 1976-2004, with an average of 98 patents per year (Tables 1 and 2). The annual output in CSIR patents showed a lot of fluctuations over the years, which may be associated with frequent re-orientation of R&D policies and shifting priorities in research. The number of patents granted to CSIR scientists increased significantly during 2001-04, almost one and a half times that of 1996-2000. The growth in patenting is significant during post-WTO period (1996-2004), wherein the annual average reached 158.4 patents per year from 68.95 patents per year in pre-WTO period (1976-95). The result is in consistence with the pattern of patenting by Indian organisations, which showed that the annual average of patents in USPTO rose from just 3.4 patents per annum in the pre-WTO phase to 34.2 patents in the post-WTO phase[12].

Table 1. Patents granted to CSIR scientists during 1976-2004

Year	No. of patents	Year	No. of patents	Year	No. of patents
1976	97	1986	63	1996	95
1977	144	1987	121	1997	190
1978	130	1988	63	1998	95
1979	48	1989	49	1999	123
1980	41	1990	77	2000	60
1981	36	1991	63	2001	215
1982	56	1992	35	2002	72
1983	36	1993	30	2003	255
1984	103	1994	58	2004	321
1985	49	1995	116	**Total**	**2841**

Table 2. Growth in CSIR patents in different blocks during 1976-2004

Block period	Number of patents	Block period	Number of patents
1976-80	460	1996-2000	563
1981-85	280	2001-2004	863
1986-90	373	Total	2841
1991-95	302	Annual average	98

5.2. Major Technical Areas of Competence

The patents granted to CSIR scientists (2841) during 1976-2004 are assigned to 352 technical areas. Of these, 46 technical areas contributed 1994 patents, accounting for 70 per cent of the total patents of CSIR. These areas are classified as highly productive (contributing 50 or more patents), medium productive (contributing 20 to 50 patents), and low productive (contributing 10 to 20 patents). In addition, there were several areas with less than 10 patents in which patenting continued for two or more block-periods since 1976-80. Detailed analysis of these areas has not been made, as the patenting activity in most of these areas was not significant.

5.2.1 Highly Productive Technical Areas

Under the high productivity category, there are nine technical areas, which have contributed 1324 patents (47 per cent of the total). Table 3 lists highly productive technical areas of CSIR along with the number of patents contributed during 1976-04. These technical areas except C12N and B01J are also called the areas of sustained competence in CSIR, as patenting activity in these areas continued during all the six five-year block-periods (Table 4). The patenting in area of C12N (microorganisms or enzymes) increased slowly since 1986-90 and peaked in 2001-04 indicating growing competence. In the areas of acyclic or carbocyclic compounds (C07C) and the pharmaceutical preparations (A61K), there was a spurt in patenting during 2001-2004. In contrast, there was no significant growth in patenting in three areas, viz., C22B, B01J, and C01B during 1976 to 2004. The patenting activity in high productive areas generally increased significantly in the post-WTO period (1996-04).

Table 3. Highly productive technical areas in CSIR during 1976-2004

IPC code	Technical areas	No. of patents granted	Priority ranking
C07C	Chemistry? Acyclic or carbocyclic compounds	423	1
A61K	Medical or veterinary sciences–Pharmaceutical preparations	292	2
C07D	Chemistry? Hetrocyclic compounds	232	3
C01B	Chemistry? Non-metallic elements; compounds thereof	72	4
B01J	Chemical or physical processes, e.g., catalysis, colloid chemistry	71	5
C04B	Building materials; Ceramics; Refractories	70	6
C22B	Metallurgy? Production or refining of metals or pre-treatment of raw materials	63	7
C08F	Organic macromolecular compounds involving carbon-to-carbon unsaturated bonds	51	8
C12N	Microorganisms or enzymes; Compositions thereof	50	8
Total		1324	

Table 4. Highly productive and sustained areas of technical competence

IPC Code	76-80	81-85	86-90	91-95	96-2000	2001-04	1976-04
C07C	70	46	59	40	81	127	423
A61K	4	6	11	22	57	192	292
C07D	19	17	51	27	61	57	232
C01B	16	6	12	10	15	13	72
B01J	12	-	10	15	17	17	71
C04B	7	2	5	12	18	26	70
C22B	13	8	15	11	10	6	63
C08F	1	1	8	5	8	28	51
C12N	-	-	1	4	13	32	50
Total	142	86	172	146	280	498	1324

5.2.2 Medium Productive Technical Areas

Under the medium productivity category (Table 5), there are 13 technical areas, which have contributed 372 patents (13 per cent of the total). Among these technical areas foods, foodstuffs or non-alcoholic beverages (A23L) indicated sudden spurt in patenting during 2001-04, which may be the result of the impact of the changes in the Indian patents act on the sector of food and foodstuffs.

Some of these medium productive technical areas also showed sustained competence. These include measuring and testing: analysing materials by determining their chemical or physical properties (G01N); non-mechanical removal of metallic material from surfaces; inhibiting corrosion of metallic material; multi-step processes for surface treatment of metallic material (C23F); surface treatment of metallic material by diffusion into the surface by chemical conversion or substitution; coating by vacuum evaporation sputtering, ion implantation or by chemical vapour deposition in general (C23C); and producing (pressing, extraction), refining or preserving fats, fatty substances (e.g. lanolin), and fatty oils or waxes including extraction from waste materials, essential oils or perfumes (C11B).

5.2.3 Low Productive Technical Areas

Under the low productivity category, there are 24 areas, which have contributed 298 patents (11 per cent of the total). *Appendix I* lists the low productive technical areas of CSIR. E02D was the only technical area of sustained competence of CSIR under this category.

5.3 Least Priority Technical Areas

The technical areas of least priority were defined as those in which patenting took place only up to 1995. These included 32 technical areas with 158 patents wherein no patents were taken beyond 1995 and included C23B, B01K, C22D, G01B, C09D, D06M, F24J, A01B, B41N, E21B, F23D, and G01L18; and 120 technical areas (34 per cent of the total) with a total of 172 patents (6 per cent of the total), wherein there was no continuity in patenting beyond one block-period and only one or two patents were taken. It implied that the research activity in these areas was either dropped or not pursued or lead to any patent in subsequent periods.

The patenting activity in 54 such areas (67 patents) was not pursued beyond a five-year period of 1976-80 in 30 technical areas (32 patents) beyond 1981-85, in 22 technical areas (22 patents) beyond 1986-90, and in 14 technical areas (14 patents) beyond 1991-95. These areas did not reflect areas of technological strengths of scientists in CSIR. Some of such areas included producing decorative effects (processes for applying liquids or other fluent materials to surfaces (B44C), destructive distillation of carbonaceous materials for production of gas, coke, tar, or similar materials (C10B), preserving paintings; surface treatment to obtain special artistic surface

Table 5. Medium productive technical areas in CSIR during 1976-2004

IPC Code	Technical Areas	No. of patents granted	Priority ranking
A23L	Foods, foodstuffs, or non-alcoholic beverages	49	1
C01G	Compounds containing metals not covered by other classes	38	3
A01N	Preservation of bodies of humans, animals or plants; biocides, pest repellants, or herbicides	36	4
C23B	Coating metallic material; coating material with metallic material	35	5
G01N	Measuring and testing: analysing materials by determining their chemical or physical properties	32	6
C23F	Non-mechanical removal of metallic material from surfaces; Inhibiting corrosion of metallic material; Inhibiting incrustation in general; Multi-step processes for surface treatment of metallic material	28	7
B01D	Separation (separating solids from solids by wet methods	24	8
C11B	Producing (pressing, extraction), refining or preserving fats, fatty substances (e.g. lanolin), fatty oils or waxes, including extraction from waste materials, essential oils or perfumes	24	8
C09B	Organic dyes or closely-related compounds for producing dyes	23	9
H01M	Electricity, electro-chemical processes or apparatus	22	10
C08G	Organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon	21	11
C07G	Organic chemistry: compounds of unknown constitution	20	12
C23C	Surface treatment of metallic material by diffusion into the surface, by chemical conversion or substitution; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general	20	12
	Total	372	

effects or finishes (B44D), handling thin or filamentary material, e.g., sheets, webs, cables (B65H), capacitors, rectifiers, detectors, switching devices, light-sensitive or temperature-sensitive devices of the electrolytic type (H01G). The analysis points out that the CSIR system has kept its vibrancy in patenting by dropping R&D in certain areas and not pursuing patenting in a sustained or significant manner in these areas.

5.4 Emerging Areas of Technical Competence and Future Potential

The emerging areas of competence were defined as those in which patents were obtained for the first time during a block-period as well as during the recent block period 1996-2000 or 2001-04. In pre-WTO period, there were 13 such areas (with 74 patents) during 1986-1990, viz., A23C, A61F, B22D, C02F, C07J, H02P, F02B, F23C, A47J, A62C, B05D, B25B, and C12P, and 10 areas (with 22 patents) in 1991-1995, viz. A01C, A01J, A23D, C05B, C25F, E01C, F03G, F16C, F26B, and H02J18. During post-WTO period, i.e., 1996-2000, there were 10 such areas (with 45 patents), viz., C25B, C07K, A21C, C07H, C03B, B29C, A01H, A23J, A23N, and E21F18. The number of patents in each of these technical areas are not significant implying that the competence in these areas needs to be nurtured, if the areas are considered of future potential.

Further, there were certain areas in which a significant growth was obtained in patenting during 2001-2004 over and above the level in 1976-1980. These emerging areas were defined as the areas of future potential. In highly productive technical areas, all but the areas of C01B and C22B were such areas. Similarly, in areas with medium productivity, the areas of A23L, C08F, C01G, and A01N, reflected the areas of emerging competence and future potential.

There were 32 new technical areas (37 patents) during 1996-2000, and 21 new technical areas (27 patents) during 2001-04 in which patenting activity took place for the first time, wherein mostly single patent was taken during respective period. These areas may or may not be pursued in the future. New areas in 2001-04 included the areas of A01F, A01G, A22C, A23K, A23N, A41G, A43C, A62D, AG1K, B05C, B27N, B64C, B43K, B60R, H04K, C22F, F16D, F27, F28F, C03G, and C02F18. Some of these areas are: manufacture by dry processes of articles, with or without organic binding agents, made from particles or fibres consisting of wood or like organic material (B27N), details of heat-exchange or heat-transfer apparatus, of general application (F28F), and magnets; inductances; transformers; selection of materials for their magnetic properties (H01F).

6. CONCLUSIONS

R&D scientists in CSIR obtained 2841 patents in India during 1976-2004, an average of 98 patents per year. The growth of patenting in CSIR accelerated since 1995, the year of signing of the Agreement on Trade related aspects of Intellectual Property Rights under WTO. It increased significantly during 2001-04, almost one-and-a-half times that of in 1996-2000.

The patenting activity in CSIR is distributed over 352 technical areas. Of these, only 46 areas (nearly 13 per cent of the total) produced 1994 patents (70 per cent of the total). The nine highly productive areas produced 1324 patents (47 per cent of the total). There was a spurt in patenting in the areas of acyclic or carbocyclic compounds and the pharmaceutical preparations during 2001-04. The patenting in the area of microorganisms or enzymes increased slowly and peaked in 2001-04 indicating a growing competence. The 13 medium productive areas produced 372 patents (13 per cent of the total). The area foods, foodstuffs, or non-alcoholic beverages indicated sudden spurt in patenting during 2001-2004, which may be the result of the impact of the changes in the Indian Patents Act in the sector of food and foodstuffs. Twenty-four low productive areas produced 298 patents (11 per cent of the total) during the period 2001. The technical areas of least priority were defined as those in which patenting took place only up to 1995. There were 32 technical areas of least priority with 158 patents. The emerging areas of competence were defined as those in which patents were obtained for the first time during a block-period as well as during the recent block period 1996-2000 or 2001-04. In pre-WTO period, there were 13 such areas (with 74 patents) during 1986-90 and 10 areas (with 22 patents) in 1991-95. During post-WTO period, i.e., 1996-2000, there were 10 such areas (with 45 patents), viz., C25B, C07K, A21C, C07H, C03B, B29C, A01H, A23J, A23N, and E21F.

There were certain areas in which significant growth was achieved in patenting during 2001-04 over and above the level in 1976-80. These emerging areas were defined as the areas of future potential. In highly productive technical areas, all but the areas of C01B and C22B were such areas. Similarly, in areas with medium productivity, the areas of A23L, C08F, C01G, and A01N, reflected the areas of emerging competence and future potential.

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Appendix I

Low Productive Technical Areas of CSIR during 1976-2004

IPC code	Technical areas	No. of patents	Priority ranking
C22C	Alloys	19	1
C21C	Processing of pig-iron, e.g. refining, manufacture of wrought-iron or steel	16	2
C14C	Chemical treatment of hides, skins or leather, e.g. tanning, impregnating, finishing; apparatus there for compositions for tanning	16	2
C25D	Processes for the electrolytic or electrophoretic production of coatings; electroforming	15	3
E02D	Hydraulic engineering, foundations or underwater structures	15	3
C10M	Lubricating compositions	15	3
C01F	Compounds of the metals beryllium, magnesium, aluminum, calcium, strontium, barium, radium, thorium, or of the rare-earth metals	14	4
E21D	Shafts; tunnels; galleries; large underground chambers	14	4
C02F	Treatment of water, waste water, sewage, or sludge	14	4
C09D	Coating compositions, e.g., paints, varnishes, lacquers; filling pastes; chemical paint or ink removers; inks	13	5
C09K	Materials for miscellaneous applications, not provided for elsewhere	12	6
C07B	General methods of organic chemistry; apparatus there for	12	6
C10L	Fuels not otherwise provided for	12	6
B01K	Physical or chemical processes or apparatus in general	11	7
C22D	Metallurgy; ferrous or non-ferrous alloys or metals	10	8
C12P	Fermentation or enzyme-using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a ceramic mixture	10	8
C09C	Treatment of inorganic materials, other than fibrous fillers, to enhance their pigmenting or filling properties	10	8
C07K	Peptides	10	8
B23K	Soldering or unsoldering; welding; cladding or plating by soldering or welding; cutting by applying heat locally, e.g. flame cutting; working by laser beam	10	8
H01L	Semiconductor devices; electric solid state devices not otherwise provided for	10	8
C10B	Destructive distillation of carbonaceous materials for production of gas, coke, tar, or similar materials	10	8
C01D	Compounds of alkali metals, i.e. lithium, sodium, potassium, rubidium, cesium, or francium	10	8
C07F	Acyclic, carbo-cyclic, or heterocyclic compounds containing elements other than carbon, hydrogen, halogen, oxygen, nitrogen, sulfur, selenium, or tellurium	10	8
C21B	Manufacture of iron or steel	10	8
Total		298	