Management of Intellectual Property and Technology Transfer by Public Funded Research Organizations in India: A Case of CSIR

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This study analyses the patents filed and technologies licensed by network of Indian laboratories under world’s one of the largest Public Funded Research Organization (PFRO) - Council of Scientific & Industrial Research (CSIR). A case study approach is followed based on secondary data collected from annual reports of CSIR laboratories, official websites, government data repositories and through Right to Information (RTI) applications filed (under RTI Act 2005, Government of India). The study analyzes various characteristics of patents filed and technologies licensed by CSIR laboratories and, using grounded theory approach, substantiated the analysis with existing literature to enhance robustness. It was attempted to establish relation between Extra Budgetory Resources generated, patents filed and technologies transferred by CSIR laboratories.

Keywords: Technology licensing, patenting, commercialization, public funded research, R&D, CSIR

There is a paradigm shift towards knowledge based economy in the 21st century that has become a major trend globally.1 With a limited R&D support and expertise, more firms are taking the external scientific knowledge support generated mainly by public funded research.2 As a result, knowledge generation through R&D has intensified and the ability to produce it is given a critical importance for any economy.3,4 In the recent past, growing number of studies have investigated and emphasized the importance of public funded scientific research and explored the impact of patenting for the future scientific research.

In this emerging scenario and competitive economy, Indian science continues to be seen as instrumental in its growth and development. India has long enjoyed a global reputation as preferred destination for IT and business process outsourcing. Now, the country is fast emerging as a major centre for cutting-edge research and development (R&D). Ambitious R&D projects are set up by companies in industries ranging from IT and telecommunications to pharmaceuticals and biotech with an eye on faster delivery of new generations of products to the global market. Publicly Funded Research Organizations (PFROs) play a vital role in developing national innovative capacity of Asian latecomer countries.5

Indian scientific research output has grown significantly since years along with the greater influence of India’s researchers in the sciences.1 An expression of stronger interest for proper follow-up of technologies generated from PFRO research,6 explains the need for improved knowledge regarding PFROs and therefore, the importance of this study. The present study is based on India’s largest PFRO with a chain of research laboratories covering a wide field of scientific research.

India has become one of the largest countries in terms of number of enterprises, universities and public research institutes. As per the Department of Scientific and Industrial Research (DSIR) Directory (2007), there are 559 research institutions and universities in India in which a great amount of R&D activity is taking place. A sector wise break-up into shares of R&D expenditure in India shows that the major portion of R&D expenditure is picked up by government. Private sector spending on R&D is sparse. Over the past few years, the interest of PFROs in the protection and commercialization of new technologies within India and abroad has increased considerably. As a result, there is a growing focus on the need for these organizations to serve a third-mission of contributing to local economic development and self sustenance. This change has spawned a focus on protection and diffusion of

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Moreover, these organizations depend, largely, on public funds. Reducing the dependency on these funds becomes necessary and acquiring private funds can help in reducing this dependency. Under these circumstances a study, focused on PFROs, which can decipher characteristics of patent filing and technologies transferred from these organizations of national interest will hold academic, research and policy related importance. One of the sections of this study gives a global patenting scenario of PFROs. A focus on Indian PFROs in a section of this study taking the case of CSIR to explain the phenomenon of patenting and technology transfers from Indian PFROs. The analysis is concluded in a brief summary of the article.

Patenting in PFROs: Global Scenario

Narin et al. (1997) showed that the majority of industrial patents are based on findings generated within public research labs and the 73 per cent of papers cited by US patents, owned by the private sector, are in fact public in nature, being authored at public institutions. Patents have become an important issue for public research organizations to the extent that there might be an incentive to shift the resources towards more applied research and to those areas where patents are easily obtained. The analysis of world patenting scenario in PFROs is taken first.

Since 1979, the number of international patent applications filed under the Patent Cooperation Treaty (PCT) by universities and PFROs has increased steadily by 5 per cent and 29 per cent respectively (Fig. 1), outpacing the overall rate of growth in PCT applications.

This growth has been driven largely by high-income economies, among which France, Germany, Japan, UK and US represent approximately 72 per cent of all university and PFRO PCT applications.

WIPO data for the period 1980-2010 shows that patenting by universities and PFROs is highly concentrated and confined to the science-driven biomedical and pharmaceutical sectors. Universities and PFROs in US filed 52,303 and 12,698 international applications, respectively. PFROs in France filed the second largest number of international applications with 9,068, followed by Japan with 6,850. Among middle-income countries, Chinese universities topped the list with 2,348 international applications followed by Brazil, India and South Africa. China and India together account for 78 per cent of all international applications filed by PFROs from middle-income economies during this period.

Post product patent regime, India has also shown surge in patent filing trend. The total number of applications for patents has increased significantly over the years. The number of applications from persons in India as well as abroad followed an increasing trend. In the year 2005-06, the highest annual increase of 25 per cent was observed in the number of patents filed by residents in India. The years 2004-05 and 2005-06 had the highest annual increase of 47 per cent and 44 per cent, respectively, in the number of patents filed by foreigners. In the year 2005, India allowed product
PFROs in India have also started showing interest in patenting, which is perceived to be more effective than other legal IP mechanisms. Over the years, several PFROs (CSIR, DRDO, ICAR and ISRO) have emerged as major patent applicants in India. This stimulated interest of PFROs in patent filing along with technology transfer renders the importance of this case study which is a step forward in understanding the patent filing behavior and technology transfer in PFROs of emerging economies. The scarce focus of literature on the subject, particularly on PFROs in emerging economies, explains the need for this study.

Data and Methodology

The sample focus of this study is public funded autonomous institutes and laboratories (PFROs) in India. The interpretative case study approach was used that allows both quantitative and qualitative analysis of the data. The study is based on data collected from CSIR and its laboratories. Secondary data constituted the patent data collected from Office of the Controller General of Patents, Designs, Trade Marks and GI (CGPDTG), United States Patent and Trade Mark Office (USPTO) and World Intellectual Property Rights Organization (WIPO) databases. In addition, Thomson Reuters Database and Google Search were carried for patents that could not be traced from database of CGPDTG. Data was also collected from annual reports of CSIR and its associated laboratories, their official websites, questions addressed by Science & Technology Ministers, Government of India, in Indian Parliament, Right to Information (RTI) applications filed (under RTI Act 2005, Government of India). 432 CSIR technology licenses that were signed during the period 2002-03 to 2010-11 were analyzed. All 37 CSIR laboratories were found to be active in patent filing during this period and therefore, formed a part of this study.

Managing Intellectual Property and Technology Transfer: A Case of CSIR

CSIR, with a network of laboratories spread across the country, is a premier PFRO in India. The attempt was to showcase the patent and technology transfer practices and trends followed by India’s largest and one of the most successful PFROs in order to facilitate a better understanding of the IPR and technology transfer dynamics of PFROs in India.

CSIR’s Surge and Management of IP

CSIR is the premier PFRO in India covering a wide field of scientific research. With its 37 research laboratories, 4 units and 39 extension centers, CSIR aims to pursue a cutting edge science and advanced research. Table 1 gives the clusters of CSIR laboratories based on their field of research.

In this section, the overall patent filing trend of CSIR and technologies licensed by its laboratories was explored. A sector wise distribution of patents filed and technologies licensed are analyzed and an attempt is made to find a correlation between patents filed and technologies licensed.

CSIR has a strong IPR policy which emphasizes the need to stimulate advanced innovation through its intellectual capital. CSIR’s energy scholarship, reflected in Energy-Index (E =C^2/P, where P is papers of five previous years and C is the citations received in the target year) shows CSIR ahead of other PFROs in India (CSIR, 2012). CSIR shows a strong scientific excellence over the years which is reflected in its scientific publications in SCI journals, scientific human resource and intellectual property generated.

CSIR is majorly dependent on government allocated budgetary support but it is also able to generate extra budgetary resources. CSIR constitutes around 3-4 per cent of India’s scientific manpower and according to Ministry of S&T, Government of India, the contribution of CSIR to the scientific output of India is 11 per cent.
With a strong patent portfolio in its armory, CSIR is actively pursuing management of its intellectual property and contributing to the intellectual property of the nation. CSIR has 2278 patents in force in India and 3046 patents in force abroad, as on January 2011. The percentage utilization of patents, which is roughly 8.67 per cent, is much above the world average of 3-5 percent. Fig. 3 shows the patent filing trends of CSIR. CSIR has consistently emerged among major patent filing applicants in India and amongst the top entities from emerging nations in terms of PCT filing. Interestingly, CSIR appears to show no consistent trend of increase or decrease in patent filing. CSIR’s eleventh five year plan report considers US granted patents as one of the indices in measuring the technological achievements of the countries. However, it is observed that US patents granted to CSIR over the years has slumped and came down from 133 patents in 2003 to only 53 in 2009. The present study, therefore, is an attempt to study the patent filing behavior and technology transfer at India’s premier PFRO and traces a relationship between its patent filing and technology licensing. The impact of patent filing activity and licensing on generating extra budgetary funds by CSIR Laboratories is also examined.

CSIR patent filing trend for Indian and foreign patents, as shown in Fig. 3, sees major fall in the year 2006-07, which also sees a fall for foreign patents in the year 2009-10 after increase in 2008-09. CSIR experts claim selective patenting, seeking only those patents which would have potentially commercial value or preemptive nature, as the reason for decrease in the patent filing trend. This decreased trend is more for foreign patents, possibly, because of expensive
nature of foreign patenting. CSIR’s expenditure on securing foreign patents during 2002-03 to 2011-12 was Rs. 724.6 million as compared to Rs. 17.8 million on securing patents in India. The initial high patent filing trend by CSIR, according to CSIR experts, was to foster a culture of patenting in CSIR by motivating the researchers to file more patents. However, the present study didn’t observe any consistent trend of increase or decrease in patent filing in CSIR. This may rather be the result of varying patent filing motives among the researchers that may differ among researchers in PFROs. PFRO researchers learn to patent through experience in patenting. This along with variable patent filing motives which may be influenced by various demographic and relational factors may result in fluctuating patent filing trends in PFROs. Various studies have reported the impact of various factors like experience, age and sector of scientists to impact their patenting behavior.

Patent Filing Behavior and Technology Transfer

Some experts favor encouraging universities and PFROs to patent inventions considering that to enable them to “reveal their inventions”, encourage follow-on innovation and helps create a market for such inventions. Patents are increasingly being used as a technology currency in the markets driven by innovation and technology. Licensing of patents to generate revenues as an important motive for filing patents has been recognized by several studies in the literature. Licensing can be a much more profitable option for organizations like PFROs that lack the necessary resources and capacity to manufacture and market the products generated from their inventions.

Comparing the patent filing trends among the individual laboratories of CSIR in the spectrum of research areas, as shown in Fig. 4, non-uniform pattern of patent filing behavior was again observed. The observation again points at the discrete patent filing motives of researchers in PFROs that may vary according to different factors resulting in non-uniform pattern of patent filing in these organizations.

In this case study, 432 CSIR technology transfer licenses are analyzed from the period 2002-03 to 2010-11. Table 1 gives the distribution of technology transfers, through licensing, from various CSIR laboratories. CSIR laboratories are broadly divided into four sectors based on their field of research. Research suggests technology transfer activity to vary among spectrum of technologies e.g. Arora & Fosfuri (2000) observed licensing to be more prevalent in industries like biotech and chemicals which they found relatively more active in patenting. From the present study, it is observed that technology transfer activities vary among the spectrum of research areas in CSIR. With 198 successful technology licenses, chemical sciences area showed maximum activity during the period of observation, followed by biological sciences with 164 technology licenses. Engineering sciences, with 41 technology licenses, was relatively much less active in technology transfer compared to above two sectors. Physical science, with
23 technology licenses, was found least active in technology transfer. Patent filing activity during this period was also observed to vary with similar trend across the spectrum of these research areas. Past research has also reported patent filing activity to vary among spectrum of technologies in various organizations.9

Comparing the patent filing activity of CSIR laboratories from 2003-04 to 2010-11 (Table 2), it is observed that the overall patent filing activity in the spectrum of research areas correspond to the overall technology licensing activity in these sectors. Significant statistical correlation (0.699, P <0.001) was found between patents filed and technologies licensed by CSIR laboratories during the period under consideration. Chemical sciences with maximum patent filing activity (2275 patent applications filed) among CSIR laboratories, licensed maximum technologies in CSIR (198 technology licenses). This is followed by biological science sector with 2006 patent applications filed and 164 technology licenses. Engineering sciences sector with 485 patent applications filed, succeeds in 41 technology licenses, while as physical sciences sector with least patent activity among CSIR laboratories (388 patent applications filed) has only 23 technology licenses.

However, the distribution of laboratories in these different areas is not uniform. Analyzing the average number of patents filed (P/L) and technologies licensed (T/L) per laboratory among different research areas, it is observed that chemical sciences (P/L = 252.77 and T/L = 22) again performing well above the average CSIR P/L (139.29) and T/L (11.51). However, engineering sciences and physical sciences both were observed to have lower P/L (44.09 and 77.6 respectively) and T/L (3.72 and 4.6) in comparison to average CSIR P/L and T/L.

### Technology Licensing: Lineaments

In this section, the list of CSIR technologies was studied that were licenced over a period of time, to find some common characteristics or trends in technology transfers from PFROs. The use of grounded theory approach was tried to relate these characteristics and trends with the established research in the literature.

The impact of geographical distance on technology transfers has been widely discussed in the literature. Majority of the research findings reveal that small distances facilitate face-to-face interactions (both planned and serendipitous) and, therefore, foster knowledge and technology transfer.29 Shorter geographical distances may bring organizations together, favor interaction with a high level of information richness and facilitate the exchange of knowledge between these players.30 While some researchers consider this to be true for exchange of tacit knowledge, some even argue this to be true for the exchange and use of codified knowledge, because its interpretation still requires tacit knowledge and, thus, spatial closeness.31

Empirical studies showed that knowledge externalities are geographically bounded, since collaborations between close organizations show better innovative performance than those between distant ones.32,33 Geography may favor the creation of economical and institutional linkages between these players, and the development of common institutional practices, that are important to generate innovative activities and knowledge spillovers.34,35

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<td>485</td>
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Audretsch & Feldman (1996)\textsuperscript{36} studied impact of geographical distance between universities and firms and found that knowledge flow from public science to firms declines with geographical distance. Arundel & Geuna (2004),\textsuperscript{37} analyzing the European largest R&D-performing firms, found that the acquisition and absorption of public science is strongly affected by geographical proximity to public research organizations.

Sung and Gibson (2005)\textsuperscript{38} have outlined four key factors to accelerate knowledge and technology transfer: communication, distance, equivocality, and motivation. Fabrizio (2006)\textsuperscript{39} used a sample of biotechnology and pharmaceutical firms to examine the relationship between the numbers of citations to universities in a firm’s patents. Using a measure of the minimum distance to a university to the focal firm, Fabrizio\textsuperscript{39} found that the greater distance from a research university to the focal firm, the lower will be that firm’s rate of exploitation of public science.

Abramovsky et al. (2007)\textsuperscript{40} showed a positive relationship between the location of private R&D labs and university research departments in Great Britain. Ponds et al. (2007)\textsuperscript{41} found similar results for research collaborations in the Netherlands. Petruzzelli (2011)\textsuperscript{42} extended the current research framework investigating the role that specific technological and relational attributes play on the relevance of university-industry collaborations. The study focused on the effects exerted by three relevant factors, namely technological relatedness, prior collaboration ties, and geographical distance, on university–industry joint innovation value. The results suggest that prior ties and geographical distance between universities and firms are both positively related to the achievement of higher innovative outcomes.

Research explains diffusion of knowledge and technology transfer to be dependent on several other factors. Kumar et al. (2007)\textsuperscript{43} highlighted the importance of understanding the selecting technology components and technology transfer mode, negotiating effective process and developing capability in successful technology transfer process. According to Kremic (2003),\textsuperscript{44} the context, or environment, and the motives of the particular organizational level both reflect the method of technology transfer employed. Motives are not necessarily homogenous across organization levels. Therefore, the successful implementation of technology transfer depends upon creating an environment that will capitalize on the motives that exist at each level, and taking an approach that reflects those motives.

D’Este & Iammarino (2010),\textsuperscript{45} conducting an extensive analysis of collaborative research grants awarded by the UK Engineering and Physical Sciences Research Council over the period 1999–2003, confirmed the importance of geographical proximity for University-Industry (U-I) collaborations. Specifically, the authors demonstrated that geographical proximity exerts a positive impact on the occurrence of U–I partnerships, especially referring to engineering-related disciplines. However, the positive influence of spatial closeness tends to become less significant when dealing with high quality academic organizations, which are able to attract also distant business partners. Friedman & Silberman (2003)\textsuperscript{47} studied technology transfer in universities and found location of the university in a region with a concentration of high technology firms as an important determinant of technology transfer.

Analysis of 432 CSIR technology licenses for the proximity of actors and the location of licensees was done and the conclusions were summarized with the understanding of research literature. The analysis of CSIR technology licenses revealed 31.48 per cent (136) technology license cases where licensee firm/organization is located in the same geographical area where laboratory is located. In case of 68.52 per cent (296) technology licences, licensor and licensees are located at different geographical locations. Although a significant number of technology licensees are located in close proximity to the licensor research laboratories, more number of technologies are licensed to firms that are not located in close proximity to the licensing laboratories. CSIR laboratories have been able to attract firms located far from CSIR loci. Moreover, nine technology licenses among the list were found to be issued to companies outside India.

From the analysis of literature, proximity between the technology players is found to have an important role in technology transfers even though it recognizes that high quality academic organizations are also able to attract distant business partners. Focus on local firms may, therefore, boast technology transfers from these PFROs. The study, therefore, suggests devising policies with focus on more interactions with local industries.

In order to, further, understand and evaluate the importance of location and proximity factor in
technology transfer in public funded research, the analysis of these technology licencees was done for their location in India. It was observed that CSIR technologies were, majorly, licensed to the firms located in metropolitan or big cities in India. Table 3 shows the list of cities where majority of licencees are located. Mumbai, with 51 technology licenses, locates majority of CSIR licencees followed by National Capital Region (NCR), Chennai, Hyderabad and Kolkata.

Mansfield and Lee (1991), using survey results, demonstrated that firms prefer to work with local university researchers within a hundred miles of the firm’s R&D laboratory. Siegel et al. (2003), further, revealed that research productivity of firms in science parks, located near a university, is higher than that of a matched sample of firms outside science parks, suggesting real benefits from close physical proximity to universities. PFROs like CSIR, with a network of laboratories, can, therefore, explore the possibility of engaging firms and laboratories in metropolitan cities in order to boost technology transfer. Moreover, laboratories in metropolitan cities may act as nodal centers for other laboratories to promote interactions and transfer of technologies with industries. Setting up of science parks should be promoted.

Innovation speed, defined as the elapsed time between an initial discovery and its commercialization, has been well addressed by literature on innovation. By accelerating the pace of successful innovation, organizations are able to fully leverage research-related assets, amortize the costs of research projects across more successful introductions of new products, and thus maximize profit. Since PFROs lack the necessary resources and capacity to manufacture and market the products generated from their inventions, the time elapsed between patent filing and technology licensing in PFROs becomes more important in their case. Research shows that this speed is positively related to licensing royalties and the number of PFRO-based new ventures. Moreover, researchers tend to file for provisional patent applications in order to get priority. The ability to patent quickly and comprehensively can shield a discovery from the rent destroying effects of imitation and work-around solutions. This makes quick filing of patents and subsequent urge for licensing an important task for PFROs and management of its intellectual property to yield maximum returns. In order to understand this phenomenon, the average time taken by CSIR to license its technologies from filing patent applications for its innovations was examined. From this study, it is observed that on an average 3.95 years is taken by a PFRO to license a technology from the year of filing a patent application. However, the list contains discrete cluster of technologies licensed by CSIR to the industry. There are 74 cases where technology is licensed within 2 years of filing a patent application. 42 technology licenses are signed the same year as filing the patent application and surprisingly, in 28 cases of technology licensing, patent application is filed after signing the agreement for patent license. This shows that patents, although considered essential for protection of technologies in India and preferred by licencees, may still not, necessarily, be required for transfer of technologies. Based on these findings, we argue that time being a valuable resource, PFROs like CSIR should take advantage of time and combine it with other capabilities to confer leverage. “Patenting to transfer delays” should be abbreviated.

Efforts are being made to put in place an organizational framework for protecting innovations generated by public research in India. Proposed legislation called ‘The protection and utilization of Publicly Funded Intellectual Property Bill 2008’ designed on the lines of U.S. Bayh-Dole Act of 1980 and tabled in the Indian Parliament is one such concerted effort in this direction. However, the Bayh-Dole Act of 1980 allows universities to patent and exclusively license federally funded inventions making the Act controversial and subject of policy review. Research critics contend that exclusive licenses are not needed for technology transfers from public research. However, some argue that exclusive license may be needed when inventions require further development before use. Jensen & Thursby (2001) in their survey of public research technology managers, found that most public research-generated technologies are licensed at a very early stage, require significant additional investment from their licensees, and enter the market place years after the initial license. Without an exclusive license, firms are
unlikely to be interested in investing in these inventions for their further development. Some experts argue that through exclusive licensing, patents can decelerate the diffusion of these inventions originating from PFROs and can stifle innovation and technology transfer by limiting the diversity of research and by negatively impacting other informal channels for knowledge exchange.

Being a PFRO, CSIR discourages exclusive licensing of its technologies. In the analysis of CSIR technologies, several multiple license agreements were found where same technology is transferred to more than one firm. A total of 362 technologies are found that are used to sign 432 technology licenses by CSIR. However this means a total of only 70 licenses are issued as multiple licenses. Patent applications are filed for all the technologies but only 212 technologies have granted patents. Rest of the technologies have either patent pending or not granted. 48 patents, filed and granted outside India are found to be licensed. These technologies are mostly licensed to large firms which are either multinational companies or export products to the nations where patent is filed. It is observed that only 32 patented technologies with patents filed abroad are being licensed to such firms. Technologies licensed to large firms appeared to be more exclusive than any other such technologies licensed to multiple firms.

In 2006, CSIR entered into an exclusive worldwide licensing agreement with Nostrum Pharma Inc., (Nostrum Pharma), for the hybrid SK molecule and the production process. The technology was exclusively and globally licensed to Nostrum Pharma for US $5 million, plus additional royalties to be determined later. Since Nostrum Pharma is the worldwide licensee of this technology, it also had the right to be the first worldwide licensee for any improvements. As IMTECH, a CSIR laboratory, developed improvements to the technology in 2009, an exclusive license for the patent was given to Nostrum Pharma for these improvements for approximately US $150 million, which includes upfront compensation, milestone payments, expected royalties subject to successful completion of clinical trials at various phases, fees to obtain regulatory approvals before the product goes to the market, and accrual of royalties on commercialization. Nostrum Pharma is responsible for all costs related to further R&D, toxicological studies, clinical trials and further IP protection.

However, as evident from the analysis of CSIR technologies in the study, multiple licenses are issued to small firms. This needs further analysis of these technologies to support Colyvas et al. (2002)\textsuperscript{56} argument of exclusive licensing being issued for technologies in embryonic stage. Many PFROs globally, signing exclusive license agreements, create effective research exemptions by reserving the use of inventions for themselves and for academic and not for profit research.\textsuperscript{58} Broad adoption of such exclusive licensing agreements can address the problems associated with exclusive licensing by PFROs. This issue could be readily addressed through incorporation of such provisions in the proposed Act.

**Value Generation through Intellectual Property**

Fig. 5 shows the yearly trend for extra budgetary resources (EBR) generated by CSIR. CSIR laboratories have been able to generate extra budgetary resources from different sources apart from their alloted government budget. The graph shows a regular increasing trend over the years.

Fig. 6 depicts the extra budgetary resources generated by different CSIR laboratories during the
period 2002-03 to 2011-12. The data is obtained from annual reports of CSIR and its laboratories. The data shows that NAL is able to generate maximum funds (Rs. 50.1492 billion) during this period while as CIMAP generates the least amount of funds (Rs. 3.4421 billion). CIMFR (Rs. 34.8753 billion), IICT (Rs. 28.4269 billion), NEERI (Rs. 27.9277 billion) and NCL (Rs. 23.5373 billion) are among the CSIR laboratories that generate maximum funds through extra budgetary resources.

Table 4—Comparison of patents filed, technologies licensed and EBR generated by different CSIR labs from 2002-03 to 2011-12.

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(*1 INR = 0.015US$ approx.)

Comparing the extra budgetary resources (EBR) generated by CSIR laboratories with the patents filed and technologies licensed from these laboratories during the period 2001-03 to 2011-12, the study did not observe any uniform direct relation between EBRs generated and patents filed or technologies licensed. Annual EBRs generated by these laboratories showed, mostly, a uniform growth. There is no significant correlation (p > 0.1) observed between EBRs and patents filed or technologies licensed. NAL, with maximum EBRs generated, filed only 38 patents and licensed 4 technologies during the period in consideration while as CIMAP, with least EBRs generated among CSIR laboratories, filed 164 patents and licensed 29 technologies.

Apart from IP licensing, CSIR laboratories are also active in joint ventures, sponsored research, contractual research, product or process co-development, consultancy and provision of technical services etc. which help them in generating EBRs. Moreover, some licensing agreements lead to large royalties while others fetch less amounts. NCL-GE Alliance in 1993 leading to a strong R&D collaboration of 9 years resulted in a cash flow to NCL from GE of around US $8.5 million over the period 1994-1995 to 2003-2004. GE also supported R&D at NCL and the collaboration also resulted in several patents assigned to GE and NCL.

Table 4 presents the comparison of patents filed, technologies licensed and EBR generated by different CSIR labs from 2002-03 to 2011-12. Laboratories like IICT and NCL appears among the top patent filing laboratories and also among the top EBR generating laboratories. CFTRI, CLRI and CIMAP are also among the top patent filing laboratories of CSIR and also lead in technology licensing among CSIR laboratories.

Apart from IP licensing, CSIR laboratories are also active in joint ventures, sponsored research, contractual research, product or process co-development, consultancy and provision of technical services etc. which help them in generating EBRs.
and marketing, there is a significant difference between EBRs generated by NAL and other CSIR laboratories.

Many other CSIR laboratories are following similar initiatives. Entrepreneur Development Centre Ltd. (EDC), a non-profit company incorporated in Oct 2006 by NCL under the trading name of Venture Centre, aims to help NCL not only with commercializing its research but also to provide incubator facilities to start-ups. Lack of professional management and entrepreneurs in leading the earlier initiatives is cited as the reason for CSIR’s inability to exploit the full potential in technology transfer by one of the former CSIR Director Generals. In order to overcome this disadvantage, CSIR started CSIR Tech Pvt. Ltd., an IP holding company incorporated as a new entity in April 2009 by CSIR, with the aim of yielding spin-offs. CSIR Tech Model includes a mission focused on product development through an independent private entity using expertise from experienced entrepreneurs, product development specialists and project managers to assist the conversion of technology to product. It also aims at a capital structure to incentivize entrepreneurs, management teams, employees and potential investors.

**Conclusion**

There has been a global paradigm shift towards knowledge-based economy where public funded research is finding an important role in complementing and supplementing firms who seek external knowledge support for their own R&D. Indian scientific research output has grown significantly over the years. The present study substantiates the established literature on public funded research through a case study approach on India’s premier PFRO with a network of laboratories spread across the country. Patent filing behavior and technology transfer is analyzed over a period of time. Patent filing behavior is analyzed by comparing the patent filing trends among spectrum of technologies across different CSIR laboratories. Non-uniform pattern of patent filing among these laboratories over the years pointed at discrete patent filing behavior of individual inventors in PFROs reported by literature. Since patenting is an expensive process, patent filing based on strategic motives other than protection and licensing need to be controlled in these organizations.

The study, further, analyzed technology transfer in CSIR through technologies licensed over the period of time. Using grounded theory approach various characteristics of these technology licenses were analyzed to substantiate the existing literature on innovations. The impact of location and proximity of technology licensee on technology transfer in PFROs is studied using the case of CSIR. The present study also studied the case of ‘exclusive licensing’ and ‘patent to license delays’ in public research and their policy implications.

Value generation through intellectual property in public research is widely discussed in literature. CSIR laboratories have been successful in generating extra budgetary resources apart from their allocated government budget. The present study attempted to establish relation between these EBRs and patents filed and technologies transferred by CSIR laboratories over the years.

A basic framework for further studies has been offered where research can validate the results with empirical data from universities and other PFROs in India. This may be extended to PFROs in emerging nations with a future research in this direction.

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