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Globalisation, Innovation and Social Capital:

Changing Nature of Indo-French S&T Cooperation

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Abstract

The present paper is an attempt to explore whether the Globalisation process has enhanced the significance of social capital as an explanatory variable of innovation. The focus of present paper is on the international dimensions of innovation policies that are likely to influence not only international investment decisions and competitive strategy but also technological change and development process. An attempt is made to analyze the changing nature of Indo-French S&T cooperation in the wider context of the Globalisation of innovation process and whether any discontinuity is likely to be introduced in the collaboration pattern and international cooperation policy. India and France provide an interesting background for the study of the same as India and France are emerging as major global players.

Keywords: Globalisation, Innovation, Indo-French cooperation, FDI, R&D, Social Capital

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1. INTRODUCTION

The present paper is an attempt to explore whether the globalisation process has enhanced the significance of social capital as an explanatory variable of innovation. It tries to analyze the complex interrelationship between the contested concepts of globalisation, social capital and innovation. In addition to traditional variables such as technological and economic determinants, social capital is increasingly gaining theoretical acceptance in innovation literature. However, social capital is not a homogenous asset and many attempts to define and distinguish its structural forms are proving to be inadequate to explain its role. Some scholars (Landry et al, 2000) have broadly identified these indicators as business assets, cognitive assets, information network assets, research network assets and relational assets. Recently, a good number of new technology or research alliances worldwide were reported in six major sectors: information technology (IT), biotechnology, advanced materials, aerospace and defense, automotive, and non-biotechnology chemicals revealing greater interdependence in these sectors. Thus, the emerging technologies have also helped unfolding the globalisation process but it is interesting to analyze whether the globalisation process has enhanced the role of these five assets in radicalness of innovations. Moreover, extreme views prevail as far as the impact of this process is concerned. Innovation through international efforts conducted through different actors and channels is not a new but varied phenomenon. Recently, there has been an unprecedented increase in the number of agreements on international R&D collaboration world over. This phenomenon was confined to the triad countries (US, Europe, Japan) so far and Asian Tigers were added later. Hence, it is not surprising that the academic interest so far was confined only to this region rather than to the developing countries that are emerging destinations of R&D collaboration. However, these studies have focused mainly on corporate R&D (Carlsson, 2006) and due attention has not been paid to other types of collaborations like bilateral and multilateral collaboration. In a developing country like India with wide socioeconomic disparities, this process is expected to introduce new challenges and opportunities for innovations and policy making. Globalisation of R&D by foreign firms, as argued by some, is expected to divert resources from the main development needs and create high-tech islands and widen disparities. These perceptions imply further intensification of exploitation of financial, human and natural resources without any linkages with local industries or benefits to host countries. Contrarily, there are others who perceive this process as capacity enhancing with the changing nature of R&D and collaboration pattern. The transnational corporations are expected to add new innovation capacity bringing new technology, global knowledge network and the resultant diffusion of knowledge. Thus, a transition from international collaboration of R&D to globalisation of innovation is visualized. The third view point towards the contradictions that exist in the globalisation process itself and raises serious apprehensions about learning and competence building under globalisation. "In the present era of the globalizing learning economy (Lundvall et al, 2002) there are contradictions inherent in the economic process that threaten learning and competence building by undermining social capital". In the context of the extreme position often taken, it is being realized that there is a "missing set of negotiated rules and institutions enabling the economies involved in international production activities to capture and share the potential benefits associated to it" (Zanfei, 2005).

For a systematic comprehension of this concept, some scholars have categorized this process mainly into three stages. These stages are: International exploitation, global generation and global collaboration. “From a historical point of view, these categories emerged in three successive stages, even though the second and the third coupled rather than substituted the oldest one” (Archibugi and Iammarino, 1999). In recent years, the unfolding of globalisation has tended to change the routes, nature and magnitude of this process in significant ways. However, to analyze these changes, the complexities of the interrelationship between the three categories in its historical context require further exploration and so does the role of social capital during different stages as well. It is also essential to note here that this phenomenon is not only being shaped by the structure of the international S&T innovation system which is hierarchical in nature and tilted in favor of the countries where S&T resources are concentrated but it is also shaping the same. To provide a focus on contentious issues of globalisation of innovation process, an attempt has been made here to analyze the changing nature of Indo-French S&T cooperation. India and France provide an interesting background for the study of the same as India is emerging as one of the major global destination amongst developing countries for locating foreign R&D efforts and the transnational corporations (TNCs) of France are increasingly investing in R&D abroad. An effort is made here to analyze whether the ‘globalisation process’ is likely to change the collaboration pattern or introduce any discontinuity in the international cooperation policy.

The paper is structured around seven sections that explore the concept of social capital and the salient features of the international system of innovation to explain the process beyond NIS. The fourth section is an overview of changing structure of NIS in India’s and France. The fifth section has analyzed Indo-French S&T collaboration revealing the shifting focus of India’s international cooperation policy in the wake of globalisation process. This section is not restricted to R&D collaboration in the corporate sector but includes bilateral cooperation between different countries and inward and outward FDI that is expected to enhance technological learning. The sixth section focuses on French TNCs or recent phenomenon of FDI inflows in R&D, the sectors of investment and its impact is analyzed.

2. SOCIAL CAPITAL AND GLOBALISATION

There has been a renewed interest in the concept of social capital in the current literature of social sciences including innovation studies. Exploring the wider literature and definitions available (Hanifan, 1916; Jacobs, 1961; Bourdieu, 1985, 1992; Coleman, 1988; Schiff, 1992; Putnam, 1993; Fukuyama, 1995, 2000; Gargiulo & Benassi, 1999; Lin et al., 1981, Lin, 1999, Serageldin & Grootaert, 2000), different scholars have broadly identified six dimensions of social capital: networks, reciprocity, trust, the formal and informal institutional settings, the commons, and proactivity. However, these definitions have neglected an important dimension like power relations that precludes its integration with development theory that can provide policy implications. Some development theorists have argued that all economic exchanges are inherently embedded in social relations. An excess of these relation may result into costs and benefits and the costs could be in terms of losing autonomy by building closed boundaries. In order to explore these complementary concepts of embeddedness and autonomy, some scholars have argued for precise labels to embeddedness and autonomy as they manifest themselves at the micro and macro level (Woolcock, 1998). At the micro level, embeddedness (i.e., intra-community ties) is referred to as Integration, and autonomy (i.e., extra-community networks) as Linkage. Embeddedness (i.e., state-society relations) at the macro level is referred to as Synergy, while autonomy (i.e., institutional coherence, competence, and capacity) identified as Organizational Integrity. “Focusing on the conditions supporting an effective complementarity and cooperation between the state and civil society, and more generally the public and private sectors, helps forge a path for development theory between rigid socialist models, isolationist communitarian prescriptions, and simplistic "free market" doctrines. This path calls for a more sophisticated understanding of the role of state-society relations in development, arguing that a range of developmental outcomes is possible, depending on the prevailing combinations of the state's organizational capacity, and its engagement with and responsiveness to civil society" (Woolcock, 1998). It is important to note here that though this concept provides preciseness and dynamism to these concepts for investigating different dimensions of empirical situations, it falls short of recognizing the international dimensions. The international dimensions play an important role and especially in the context of globalisation of innovation. It is observed by many that globalisation affects social capital in multiple ways and societies may gain or lose from increased exposure to external forces and ideas. Some societies may lose traditional values, norms, and networks without making further progress. In other societies, new practices brought by globalisation may transform "dysfunctional" traditional groups into more productive ones.

3. SALIENT FEATURES OF INTERNATIONAL INNOVATION SYSTEM (ISI)

The National Innovation System (NIS) approach that rightly recognized the interactions between socioeconomic, political and institutional factors in the NIS within the national boundaries has not only visualized its crucial role in the developing countries but also the increasing significance of international cooperation in the catching up process (Freeman, 1995). However, this perspective has de-emphasized the relationship between NIS and ISI and therefore it may not provide a sharp focus for adequate understanding of the interactions between the international institutional factors, R&D collaboration, migration and return migration of knowledge workers and other linkages. There are some scholars (Fromhold-Eisebith, 2006) who perceive the effective linkages between the NIS, regional innovation system and ISI as beneficial for evolving balanced science, technology and innovation policies for the developing countries. It is argued that these linkages would provide meaningful insight without assigning any causal priority to any of these levels. It is observed that the technological gaps in a few instances are bridging and at the same time it is widening for many countries. Neo-classical economists for a long time did not perceive this technological gap between industrialized and developing countries as a major problem calling for political action.

These linkages at three level are not only important for countries like Singapore, Malaysia, Philippines, Indonesia, China where the share of TNCs in exports ranges from 50 to 70 percent or even the overwhelming portion of manufactured products is accounted for by the TNCs but also for other developing countries where international collaboration takes place in various forms. Moreover, International S&T collaboration hold significance for not only areas like Space, Ocean and atomic energy with international scope but it is observed that there is more international collaboration in agriculture and health that are more regional in character (Desai, 1997). With the increasing complexities of emerging technologies like information and communication technologies, biotechnologies and nanotechnologies and the multiplying convergence between them, a greater need is felt for S&T collaboration. Thus, globalisation has not only introduced fierce competition but there are instances where competitors are also forced to cooperate in these areas. In the recent past, many international institutional frameworks[1] have evolved that either regulate some interactions in the NIS or support national markets, facilitate technology transfer and capacity-building, and reduce financial barriers. In recent times, the structure of ISI that holds significance in this process is also changing as revealed by the following basic indicators. As far as world share of gross domestic expenditure on R&D (GERD) is concerned, North America still remains the dominant region with 37% share. Asia has now emerged as the second largest investor, with a share of 32%, overtaking Europe, which contributed 27% of world GERD in 2002 (El Tayeb, 2005). Asia also had the highest number of researchers in the world accounting for 37% compared to Europe (33%) and North America (25%). Similarly, the global share of North America in the patents issued by the USPTO and EPO remained at the top with 56% and 36% respectively. The share of Asian countries was higher (27%, 30%) as compared to that of Europe (19%, 29%). During the year 2006, the share of patents originating from the Asian countries in the patents issued to residents of foreign countries by the USPTO was also as high as 47%. However, a few Asian countries like Japan, China, Newly Industrialized Countries and India together contributed the overwhelming portion. Thus, the Asian regional S&T order still remains hierarchical as there is unequal distribution of S&T resources, intellectual property rights and the digital divide is threatening to widen. This also explains the divergence in their innovation system and its role in economic development. With the increasing trend of globalisation and Asia's integration with the global economy, there are signs of rapid intra-Asian economic integration. Along with the increased levels of FDI, there has been increasing FDI in R&D activities in the Asian region. Table 1 provides data on some of the

Table 1. FDI by Multinational Companies in Research and Development Projects (Asia, Developing, 2002-2007)

Sr. No.	**Country**	**R&D Projects**	**Percentage Share in Total FDI Projects**
1.	India	745	24
2.	China	485	8
3.	Taiwan	61	16
4.	South Korea	53	11
5.	Malaysia	47	7
6.	Thailand	26	4
7.	Philippines	14	5
8.	Vietnam	14	2
	Total	**1445**	
	(Asia, Developed, 2002-2007)		
1.	Singapore	104	13
2.	Japan	54	8
3.	Hong Kong	16	3
	Total	**174**	

Source: http://www.locomonitor.com

major Asian countries that received the FDI flows in R&D as the key business function. This is a new feature added, which is likely to hold greater influence on the National Innovation System (NIS) of the countries receiving greater share of the same. Table 2 also reveals that India has emerged as the top destination of R&D investment globally out of the major strategic investments received during the year 2005. It is also interesting to note that even as percentage of total FDI, the share of R&D during 2002-2007 was as high as 24 percent and during the year 2005, the share was 65 percent as shown in the global strategic FDI in R&D.

It is in the preceding context that the relationship between the different stages of international collaboration and innovations requires to be analyzed.

Table 2. Strategic FDI in R&D by Destination Country (2005)

Destination Country	Research and Development Projects	Total Projects	Share of R&D Projects (%)
India	146	224	65
China	109	241	45
UK	32	122	26
USA	24	146	16
France	24	62	39
Russia	20	82	24
Singapore	20	50	40
Canada	18	67	27
Germany	17	38	45
Ireland	13	44	30
Poland	10	86	12
Hungary	7	48	15
Brazil	7	35	20
Czech Republic	6	47	13
Romania	5	46	11
Other Countries	130	742	18
Total	**588**	**2080**	28

Source: *Prime Locations: Strategic Investment Location 2005,* Issue 3-Qtr 4*, 2005*

As far as developing countries are concerned, the exploitation of nationally produced innovations from the developed countries was facilitated by several factors. Firstly, the priorities of the multilateral and the bilateral programmes overlapped, as agriculture remained the top priority for both the programmes. Moreover, the overwhelming part of the many of the multilateral organizations including United Nations Expanded Programme for Technical Assistance was allocated for surveys, education and organizational work in the pre-globalisation period. Hence, no direct economic benefit was expected from this rather this assistance prepared ground for the bilateral assistance or the developing countries were left with no choice but to depend on the TNC for the other productive sectors (Desai, 1997). The concept of social capital cannot explain this phenomenon as the developing countries were not the centres of innovative activities during this phase. This could best be explained in terms of historical reasons and the structure of ISI or power relations.

In the second category of global generation of technologies, the TNC activities have more or less remained confined to the developed countries. In the developing countries as some of the studies have indicated, the R&D conducted by the TNCs was also primarily of adaptive nature to suit local conditions and not particularly leading to any significant innovative activity. Many studies have analyzed these partnerships from various theoretical and empirical perspectives (Hagedoorn, 2002; Hagedoorn et al, 2000). Following are some of the findings of various studies conducted.

1. Starting from cost transaction theory, strategic management, and industrial organization theory, competitive forces, resource based view of the firm, etc. These theories have certainly explained certain features like the concentration of the research partnership in the developed world resulting from preferences for geographical proximity, cultural and linguistic affinities. Some studies have also highlighted the role of the historical and colonial roots (Rhode and Stein, 1999).
2. An analysis of patent (Guellec and van Pottelsberghe de la Potterie, 2001) as well as internationally co-authored papers (Glanzel et al, 1999) reveals that the size-effect of a country was one of the factors determining the level of international collaboration. This implies that the greater the size of the scientific community in a given country, the lesser is the need for international collaboration. Another insight from the study is that internationalization of a country's technological activities decreases with the increasing level of its GDP and with its R&D intensity. Moreover, the major aim of multinational firms when establishing research facilities abroad is to adapt their products to local conditions rather than to "tap" foreign technology. Moreover, the role of intellectual property rights in research partnership (Hertzfeld and Vonortas, 2006) is also assuming greater significance.
3. In the case of France where the share of co-authored papers in all papers published is more than 30 percent, the factors like geographical proximity, historical, colonial (Rhode and Stein, 1999), cultural and linguistic affinities (Zitt et al, 2000) are explained by the fact that France had Spain, Portugal and Italy as main partners. All the former colonies of France in Africa and the Maghreb show high probabilistic affinities to France, even though the absolute number of co-authorship is low.

Thus, these forms of social capital had limited autonomy in the second category of global generation of technology. Many of the foregoing features are changing or are likely to change rapidly with the accelerating globalisation. This is reflected in the fact that the share of foreign R&D sites has increased from 45 to 66 percent during the years 1975-2004 (Doz, et al, 2006). Recently in the last five years or so, there was a wider geographic dispersion and China and India are emerging as the major destination. It is also reported that by 2007, China and India will account for 31 percent of the global R&D staff. This will be a sudden jump from a figure of 19 percent in 2004. The major companies involved responded by stating that 41 percent of all new sites will be in China and India. The major reason for dispersion in India was not simply low cost skill base but also highly qualified human resource. Another interesting feature of the R&D partnership is the types of sectors in which these alliances are taking place and that most of them are in high-tech sectors. In 2000, 574 new technology or research alliances worldwide were reported in six major sectors: information technology (IT), biotechnology, advanced materials, aerospace and defense, automotive, and non-biotechnology chemicals (National Science Board, 2002). The vast majority involved companies from the United States, Japan, and countries of Western Europe. Thus, the emergence of new technologies is also influencing the unfolding of globalizing forces.

Moreover, the FDI continues to surpass other private capital flows to developing countries as well as the flows of official development assistance (ODA). In 2004, it accounted for more than half of all resource flows to developing countries and was considerably larger than ODA (UNCTAD, 2005). However, FDI is concentrated in a handful of developing countries, while ODA remains the most important source of finance for most of the least developed countries (LDCs). The European TNCs had high levels of R&D

internationalization (41 percent on average) with India ranking as the 6th preferred R&D location.

The high rates of growth of FDI were common to both developed and developing countries although the developed countries still account for over 70 per cent of the world's FDI. Some developing countries received more FDI compared to others. In this regard, the case of China is highlighted which now accounts for around 20 per cent of the inward stock of FDI to developing countries. Out of total outward stock of FDI in 1995, the developed countries accounted for an overwhelming portion of around 92 per cent and the developing countries only for 8 per cent of the same. Moreover, TNCs are now setting up R&D facilities outside developed countries and increasingly in some developing, South-East Asian and CIS countries. The R&D effort of TNCs is targeting global markets and is integrated into the core innovation efforts of TNCs.

In the preceding context, the changing structure of NIS of India and France is discussed that is likely to have a bearing on international collaboration policy.

4. CHANGING STRUCTURE OF NATIONAL INNOVATION SYSTEMS

4.1. India

The innovation system in any country consists of Institutions (laws, regulations, rules, habits, etc.), the political process, the public research infrastructure (universities, research institutes, support from public sources, etc.), financial institutions, skills (labour force), etc. that affect how it generates, disseminates, acquires and applies knowledge. “To explore the technological dynamism of innovation, its various phases, and how this influences and is influenced by the wider social. Institutional, and economic frameworks has been the main focus of this type of analysis.” (Fagerberg et al, 2005). Tapping global knowledge is another powerful way to facilitate technological change through channels such as FDI, technology transfer, trade, and technology licensing.

In recent times, despite glaring socioeconomic disparities, India has witnessed rapid socioeconomic and technological development. This is reflected in some of the key indicators like higher GDP growth rate that has touched around 9 percent in 2006. In terms of purchasing power parity (PPP), India’s GDP is already the fourth largest in the world after the USA, China and Japan. There has been a significant increase in the adult literacy rate and decrease in population living below poverty levels. India like many other developing countries does not have an explicit innovation policy to strengthen the innovation system as a whole though India was the first country in the world that passed Scientific Policy Resolution in 1958. As far as R&D is concerned, an overwhelming portion of 76 percent performed by the central and state governments including the public sector industrial sector. The private sector spent 20 percent and 4 percent was spent by the higher education sector. Thus, the university system had a moderate role in the innovation system with limited interactions. This situation is in contrast with the developed countries where a large proportion of R&D is performed by the private enterprise and the universities have strong linkages with the corporate world. Though the proportion of the private sector in the overall national R&D expenditure is relatively small, out of the total industrial R&D of 27 percent (1998-99), the private sector invested 81 percent and the rest was accounted for by the public sector. If one considers industrial sector as a whole comprising both public and private sector, the share of industrial sector in the total national R&D expenditure decreased from 27 in 1998-99 to 25 percent in 2002-03. The decrease in the share of R&D expenditure of industrial sector in the total R&D expenditure is mainly due to the decrease in the share of public sector R&D expenditure. The share of private sector has remained constant during the period 1998-99 to 2002-03. During 1998-99, Biotechnology and Drugs and Pharmaceuticals groups that constituted 13.8 percent of total industrial sector R&D units accounted for 35.6 percent R&D investment.

Table 3. A Comparison of Innovation Performance

Variable	India		France	
	actual	normalized	actual	normalized
Annual GDP Growth (%), avg 2001-2005	7.0	8.5	1.5	1.0
GDP per Capita (in/nal current $ PPP), 2005	3452.5	3.0	30385.7	8.7
Human Development Index, 2004	0.6	2.5	0.9	8.8
Poverty Index, 2004	31.3	3.3	11.4	6.9
Life Expectancy at Birth, 2005	63.5	2.4	80.2	9.3
Adult Literacy Rate (% age 15 and above), 2004	61.0	1.3	100.0	8.5
Gross Tertiary Enrollment Rate, 2005	11.8	2.9	56.0	7.7
Brain Drain (1-7*), 2006	3.7	6.1	3.9	6.6
Intellectual Property Protection (1-7), 2006	4.5	7.0	5.9	9.0
FDI Outflows as % of GDP, 2000-05	0.2	5.2	5.8	9.0
FDI Inflows as % of GDP, 2000-05	0.9	1.2	3.0	4.5
Royalty and License Fees Payments (US$ mil.), 2005	420.8	7.1	3229.5	9.1
Royalty and License Fees Receipts (US$ mil.), 2005	25.2	6.2	5924.4	9.6
Science and Engineering Enrolment Ratio (%), 2005	25.0	43.0	n/a	n/a
Researchers in R&D, 2004	117528.0	9.1	192790.0	9.4
Total Expenditure for R&D as % of GDP, 2004	0.9	6.3	2.2	8.6
University-Company Research Collaboration (1-7), 2006	3.6	6.8	3.8	7.5
Technical Journal Articles, 2003	12774.0	9.0	31971.0	9.6
Technical Journal Articles / Mil. People, 2003	12.0	4.3	531.1	8.7
Availability of Venture Capital (1-7), 2006	4.6	8.3	4.2	7.7
Patents Granted by USPTO, avg 2001-05	316.4	8.4	3959.0	9.5
Patents Granted by USPTO / Mil. People, avg 2001-05	0.3	5.1	66.1	8.6
High-Tech Exports as % of Manuf. Exports, 2005	4.9	4.3	20.0	8.1
Private Sector Spending on R&D (1-7), 2006	4.2	7.9	4.7	8.6
Firm-Level Technology Absorption (1-7), 2006	5.8	8.7	5.2	6.7
Value Chain Presence (1-7), 2006	5.1	8.0	6.1	9.3
Computers per 1,000 People, 2005	15.5	2.1	575.0	8.9
Internet Users per 1,000 People, 2005	54.8	3.2	429.6	7.8
ICT Expenditure as % of GDP, 2005	5.8	4.3	6.3	5.5

Source: World Bank, "Knowledge Assessment Methodology," http://www.worldbank.org./kam

*This is based on the statistical score on a 1-7 scale of a large sample group.

Normalized on a scale of 0 to 10 against all countries in the comparison group.

India's innovative performance improved from 3.65 to 3.93 during the period 1995-2007. A small but positive change of +0.28 was observed despite the fact that India's R&D expenditure during 1990-2007 has hovered around only 0.8 percent of its GDP. Table 3 reveals some of the basic indicators of development as well as the index of innovation performance. India receives very little in worldwide royalty and license fee. As far as scientific and technical articles in mainstream journals (per million people), the contributions are very low compared with those of developed countries. FDI, although increasing, is also rather low by global standards. The majority of the R&D-related inward FDI in India materialized only after the economy had been liberalized. This FDI, however small, has been creating a new competitive advantage for the country, especially in the IT domain and in industries, such as automotive. Availability of venture capital is also rather limited in India, but some signs of vibrancy are evident, and a notable venture capital investment market is emerging. In addition, India's share of global patenting is small; therefore, despite having a strong R&D infrastructure, India is weak on turning its research into profitable applications. But, an increasing trend is discernible in the number of patents granted to companies by the Indian Patent Office, indicating greater awareness of the importance of knowledge and the India has done a remarkable job of diffusing knowledge and technology, especially in agriculture. As a result of the "green revolution," India has transformed itself from a net importer to a net exporter of food grains. India's "white revolution" in the production of milk has helped it to achieve the twin goals of raising incomes of rural poor families and raising the nutrition status of the population. It also has vast and diversified publicly funded R&D institutions, as well as world class institutions of higher learning, all of which provide critical human capital. It is endowed with a critical mass of scientists, engineers, and technicians in R&D and is home to dynamic hubs of innovation, such as Bangalore, Chennai, Delhi, Hyderabad, Mumbai & Pune. There has been significant structural change in S&T human resource in the recent period. In the year 2001 at tertiary level, enrolment in science and engineering was 79 and 21 percent respectively. This has changed to 71 and 29 percent by 2004. From innovation point of view, the increase in engineering branches is considered to be a positive development. India's labour force is concentrated in the informal sector as the formal sector is relatively small.

Among Indian patents, the drugs and electronics industries have shown a sharp increase in patenting in recent years. In addition, several Indian firms have registered their inventions with the United States Patent and Trademark Office (USPTO). Thus, the total number of patents filed with USPTO has witnessed significant increase. The average number of patents filed annually during the period 1986-95 was just around 20 and during 1997-2006 this number has increased to around 248. This shows that the focus of research is shifting to patentable inventions and awareness for patenting internationally has heightened. The recent amendments to the Indian Patent Act adopted in a move toward adhering to the intellectual property norms under Trade-Related Aspects of Intellectual Property Rights (TRIPS) has possibly encouraged greater interactions with the international players.

4.2. France

Compared to India, the French innovation system reveal a far better performance based on several indicators (see table 3) except that India scores higher on availability of venture capital and the level of researchers in R&D is almost similar. However, it should be noted that the annual GDP growth for India during this period is much higher than that of France. India and France, both the countries, have started slowly adapting to globalisation and began liberalizing their economies at almost same time during 1980s. In the wake of liberalization, France has emerged as the second biggest investor of FDI in the world (UNCTAD, 2006). Out of the largest TNCs in the world, over 80 percent come from only five developed countries. The French TNCs are fifth largest with 35 firms and spend 5 percent of the global TNC R&D expenditure (UNCTAD, 2005). Subsequently, certain discernible changes in the

French innovation system have emerged. These changes have influenced a major shift in the framework of overall international cooperation policy as well.

The French innovation system that was so far characterized by the centralizing Colbertist[1] state is transforming into a more decentralized system (Mustar and Larédo, 2002). New actors have emerged as reflected in the Europeanization, decentralization and Privatization Act (1993) that have further added to this process. Later, in the 1990s, the state intervention in research did no longer remain a dominant mode. Especially in the Large Civil Programmes, with the exception of space, the state intervention got diluted. A perceptible decrease in public R&D expenditure on defense was witnessed due to Europeanisation of firms and markets. A strong hybridization of the CNRS and the universities and a convergence between mission-oriented research institutes and "academic" research and the privatization of almost all public companies had also started by that time.

The preceding changes were also followed by some of the structural changes in investment decisions and policy thrusts. A separate organizational structure, Ministry for International Cooperation and Francophony for dealing with the international cooperation with the former colonies was wound up or merged with Ministry of foreign Affairs. At the same time, the cooperation policy has been expanded to cover many regions in Asia and Latin America. Some of the countries like Brazil, China and India have been included as priority regions. As many as in 49 countries, France has established a permanent structure for the promotion of Advance research instead of short-term mechanism like cooperation agreements or MOUs. The permanent structure for international cooperation is expected to insulate S&T cooperation from any periodic ups and downs in the diplomatic relations between two countries. In India, since 1989, the Indo-French Centre for the Promotion of Advanced Research (IFCPAR) has been in existence. This has promoted research in diverse areas with changing priorities from material science to health and life sciences.

The ORSTOM a public scientific research institute that dealt only with the former colonies was renamed IRD (Institut de Recherche pour le development). This was also followed by some policy changes. This has sites in 25 countries. The share of IRD budget for the Asian and Latin American region, though smaller compared to the former colonies, has increased in the recent past.

5. INDO-FRENCH COOPERATION

Indo-French cooperation in S&T really began only in the late seventies[2]. The first effort was made in the area of petroleum. This was also the time while India had most of the international agreements in the agricultural sector. Agricultural research in India always had the most highly endowed organizations. As a result, it is being argued that it is the developed country partner that benefits most from the cooperation activity taking advantage of human and financial resources invested in that area (Desai, 1997). As against this, the Indo-French cooperation began with industrial research and that was most needed at that time for India. India and France since 1978 had entered into cooperation agreements not only in the area of agriculture, atomic energy (In India, these two sectors were highly endowed in terms of financial & human resources) but also in diverse areas like space, telecommunication, solar energy, oceanography, environmental sciences, medical sciences/biotechnology, etc. (see table 4).

As far as the objectives of international cooperation in S&T are concerned for any country, the international cooperation is supposed to be driven by different objectives like scientific objectives, socio-economic objectives and diplomatic & political objectives. However, usually it is found that a fine balance between different objectives is difficult to achieve. In many countries, the diplomatic objectives have overbearing influence or socio-economic and scientific objectives are subordinated to political, diplomatic objectives. In the case of USA it is observed that the security concerns or political objectives have at times sidetracked S&T objectives. As against this, France or any other European country had integration of Europe as a major objective. As far as recent policy framework of France is concerned, it is the Ministry of foreign affairs that lays down the geographic priorities in terms of changing strategic interests. Here, though the scientific institutions have opportunity to articulate their scientific interests, the geographic and strategic interests of a country determine the funding. Hence, this could be a complex situation requiring further research to assess its impact on the S&T system of the cooperating countries.

Table 4. Indo-French Agreements in Science and Technology

Area of Cooperation		(Year of Agreement)
1.	**Agriculture**	
	Agricultural Science	(1978)
2.	**Atomic Energy**	(----)
3.	**Technology of Energy**	
	Solar Energy	(1978)
4.	**Space**	(1977)
5.	**Telecommunication**	(1978)
6.	**Oceanography**	(1978)
7.	**Environmental Sciences**	(1978)
8.	**Medical Sciences**	
	DNA Gene Mapping of Hemoglobinopathies	(1986)

---- = Data not available

Source: The information is based on actual agreement, Foreign Affairs records of the corresponding years and the annual reports of the DAE, DST, ICAR and Department of Space.

5.1. Permanent Organizational Mechanism

Though India and France entered into cooperation in various areas in the seventies, a significant step was taken by establishing the IFCPAR in the year 1987. A need was felt by both the countries to create a permanent organizational mechanism after growing interest in S&T cooperation. The IFCPAR was a unique experiment in S&T cooperation with equal sharing of rights and responsibilities. An important feature is that the budget is shared equally by both the governments and besides this all the S&T and administrative decisions are taken jointly by the two sides. The main objective of the Centre is to promote collaborative research between Indian and French scientists through joint research projects in thrust areas identified periodically. The overall management is structured around the Governing Body, Scientific Council and the Director.

5.2. Areas of cooperation

The Scientific Council, from time to time, identifies thrust areas for being supported by the centre. The following list of thrust areas reveal diversity as well as the significance of applied research.

Pure and Applied Mathematics; Computer and Information Science; Life and Health Sciences, Pure and Applied Physics, Material Science, Pure and applied Chemistry, Instrumentation, Environmental Sciences, Geophysics and Astrophysics

Out of the total expenditure, the expenditure on research project constitutes around 80 per cent and the rest is accounted for by the activities such as seminars, publications, travel and administrative expenditure. In the last decade, between 1994-95 and 2004-05 the annual expenditure for research projects has increased by 47 per cent in rupee terms from Rs. 79.07 million to 116.37 million (Euro 2.67 million).

The following analysis includes the projects that are completed or approved and being conducted during 1993-2006. It is clear from table 5 that the approved budgets of both sides are almost same as far percentage share of each sector in their total allocation is concerned.

Table 5. Area-Wise Expenditure* and Share of the Indo-French Research Projects
(1993-2006)

Area of Cooperation	**Approved**		**Equipment**	
	Indian side:	**French side:**	**Indian side:**	**French side:**
Life & Health Sciences	**89382739**	**2778663**	**28755909**	**146038**
%	29	27	32	5
Material Sciences	**60948493**	**2241771**	**17907231**	**290246**
%	20	22	29	13
Pure and Applied chemistry	**50801131**	**2337120**	**17422031**	**209304**
%	17	23	19	22
Pure and Applied Physics	**45321986**	**1261565**	**11370171**	**140548**
%	15	12	25	38
Environmental Sciences	**12875856**	**320999**	**4474063**	0
%	4	3	35	0
Earth and Planetary Sciences	**8401880**	**434076**	**3281548**	**121768**
%	3	4	39	28
Pure and Applied Mathematics	**8448200**	**282478**	**3854685**	**41618**
%	3	3	46	15
Computers	**7386600**	**122111**	**2244561**	**3328**
%	2	1	30	3
Others	**19719360**	**413740**	**2288004**	**0**
%	7	4	12	0
Total	**303286245**	**10192523**	**91598203**	**952851**
	100	100	30	4

* The expenditures are shown in their respective currency. The French Francs are converted into Euros at 1 EUR = 6.56 FRF

Source: IFCPAR, *1999-2006. Annual Reports,* Indo- French Centre for the Promotion of Advanced Research, New Delhi.

However, there are major differences in their allocation towards purchase of equipment. As far as Indian side is concerned, there is a heavy emphasis on the purchase of equipment except only in one area. The Indian side has spent several times over on equipment as the share of their total approved budgets. This is a commonly observed feature in most of the S&T projects where international cooperation takes place between a developing country and a partner from the developed countries or even in multilateral programmes (Desai, 1997). The obvious reasons are that most of the developing countries including India do not have a highly developed scientific instrumentation industry. Hence, they require imports of such equipment from the developed economies (at times at the cost of duplication of equipment). In the case of Indo-French cooperation, there was no such restriction laid down for importing equipment from France or any specific country. However, the argument that the salary load would be higher on the side of the developed country partner cannot compensate the situation as the amount for the equipment is spent on the developed country economies. The component of capacity building like advance training is observed to have direct benefits to the developing countries. To certain extent, this was taken care of by utilizing more of human resource from India by imposing condition that most of the post-doc positions on the projects filled by the Indian scientist. This condition has seemed to have benefited both the sides.

A bibliographic analysis done of the publications resulting from 85 Projects out of 166 projects supported by IFCPAR revealed a mixed picture. The average impact factor 1.71 was considered too low by the Audit Committee (Curien and Ramanna, 2000) and stated that only 60 percent of the publications received citation.

The organizational breakup of both the sides reveals that the projects are distributed fairly in organizational as well as geographic terms. The universities or deemed universities like IITs and IISc have constituted about 31, Council of Scientific and Industrial Research 22, medical and biomedical 4 percent and other autonomous research institutes under state or central government 33 percent. Similarly, for France 44 percent is accounted for by universities and Centre Nationale de la Reecherche Scientfique (CNRS) Laboratories and 8 percent by the Grandes Ecoles and another 8 percent by Institut Pasteur and Institut Nationale de la Santé et de la Recherche Médicale (INSERM) and 22 percent by others.

5.3. Conversion into Industrial Research Project

There has been traditional reluctance to collaborate between industry and scientific institutions and secondly the sharing of patent benefits has also contributed to this reluctance. It is because of these reasons that it has taken so long evolve some mechanism to exploit the results commercially from occasionally resulting industrially relevant research. IFCPAR had no mechanism to support such an activity for the extra work required such as validation. A mechanism of Bridge projects was created with a limited budget only recently in the year 2001 and especially bearing in mind the interests of small and medium enterprises of both the countries. As expected, some delay was caused in implementing certain projects in sorting out intellectual property rights (IPR) issues. At times some industrial units claim 'prior knowledge' in certain areas or some scientific organizations like CNRS have strict IPR guidelines that require to be negotiated. Now, a more flexible set of guidelines are prepared that governs the operationalization of joint projects. Though a limited number of projects have been completed so far and only three patents are filed, it was a major departure from cooperation policy that was confined only to scientific research. This kind of cooperation is likely to entail direct economic benefit to both the countries.

5.4. French TNC in India

In the pre-liberalization period during 1951-91, there were 772 collaborations between India and France and the figure was only 643 in the post-liberalization period during 1992-2000. Though, the figure indicates much higher pace, it has not exceeded the pre-liberalization figure like in the case of many other countries like USA, Canada, Netherlands and Denmark (Kumar, 2003). The pattern[3] of this collaboration is similar to the general pattern of foreign collaboration in India where the proportion of financial collaborations has increased over the technical collaborations during the post-liberalization period contrary to the earlier period (see table 6). The total value of these collaborations has also increased and France accounted for 3 percent of the total value of 112 collaborations that India has from different countries. This phenomenon indicates that the purpose for which the Indian firms are entering into foreign collaborations are diverse rather than the sole purpose of building industrial base or technological capability. This is also reflected from the fact that the export-import ratio has also become unfavourable and declined from 78 to 68 percent. During this period, India has not witnessed any improvement in global competitiveness or technological capability if export is treated as a proxy to technological capability.

Table 6. Approved French Foreign Investment in India (1991-2002)

Year	**Number of Collaborations**			**Foreign Investment**
	Technical	**Financial**	**Total**	(Rupees in millions)
1991	28	12	40	193.34
1992	39	20	59	271.09
1993	28	19	47	1290.90
1994	26	34	60	897.32
1995	36	32	68	4203.62
1996	29	61	90	16720.52
1997	25	52	77	7134.13
1998	29	43	72	5135.57
1999	19	69	88	14486.18
2000	23	60	83	2020.73
2001	9	51	60	6798.09
2002	6	28	34	5852.93
Total	**297**	**481**	**778**	**65004.42**
Source: Indian Investment Centre, Government of India				

Another feature that requires to be noted here is that the priorities of the bilateral S&T cooperation and the dominant areas of the FDI are quite dissimilar during the post-liberalisation period. The bilateral cooperation has focused more on the Life science and material sciences (49 percent) and the FDI has been attracted more by the chemical industries (58 percent). The process of globalisation in the recent period during 2000-06 has added new and unexpected dimension and this is the offshoring of R&D services. Because of the very nature of R&D services which is least fragmentable and requires sophisticated skills, this activity was confined to the developed countries. This situation has vastly changed due to increasing competition, complexities involved in the emerging technologies and demographic changes have forced the companies to look for avenues outside the developed world. In India, The major FDI investments in the R&D of 100 major companies were found be concentrated in high-tech areas such as Computer & IT R&D software, Engineering Design (auto, consumer durable, aerospace), Chemical Design (design of molecules, chemical structure), Agriculture and Biotech (seeds, food, enzymes). Most of the companies have filed patents in US numbering at least 415 (Academy of Business Studies, 2006).

As far as the French R&D investment in India is concerned, the following situation prevailed.

6. FRENCH R&D INVESTMENT IN INDIA

It is observed by a study (Academy of Business Studies, 2006) that India is emerging as a global R&D hub. India has moved from BPO (Back Office Processing Operations) to KPO (Knowledge Processing Operations). R&D investment worth of 1.13 billion has flowed into India during the five-year period 1998-2003. The US has the biggest footprint followed by Germany and France is also emerging as an important partner. The reasons cited for this are not only the availability of cheap labour but also the availability of quality of human resource. At least 415 patents are already filed in US. The Majority (56 percent) prefers to work alone in India with 100 percent equity. The investment in R&D was also accompanied by the capacity building activity such as contract research, collaborative research with Indian Universities/Firms, supporting own manufacturing unit in India and training programmes for R&D employees (Agarwal and Sarkar, 2006). Not only that spillover effects are expected from the R&D services but the export of R&D services is also increasing. For instance, the share of FDI based R&D services in export of IT services amounted to 2.3 billion or 18 percent of the total software export during 2003-04.

Table 7 reveals the FDI investment in R&D by the French companies in India. There are five major companies that have invested worth US $ 21.3 million and have planned investment of US $ 225.3 million. These companies have also generated considerable employment in R&D sector. Out of these, three companies have taken contract from other global companies, two have shifted in-house R&D to an offshore low cost location (In-house outsourcing) and only one carries out exports of R&D or technology. The areas of R&D activities of these companies range from agro-chemicals, IT hardware to mineral exploration engineering.

Table 7. FDI in R&D of the French Companies and Related Activities

(Rs. in million)

Name of Company	Year of Establishment	Planned Investment	Area of R&D	R&D Investment	R&D Workers	Manufacturing Domestic+ R&D Exports	In house out sourcing	Contract Research
ST Micro Electronics	1995	9000.0	VLSL Design	900.0	800		✓	
Hoechst schering	2003	116.9	Unani plus insecticide Herbicide Rice	20.0	20	✓	✓	✓
Rhone Poulenc	1999	70.0	Agro-Chemicals	14.2	140			✓
Horizontal Drilling	2000	40.0	Engineering Construction	4.0	10			✓
Pernod Nicard	2001	700.0	Fruit Juices & Wine Spirits	NA	NA			
Total		**9926.9**		**938.2**	**970**			

Source: Academy of Business Studies (2006), *FDI in the R&D Sector: Study for the Pattern in 1998-2003*, Technology Information, forecasting, and Assessment Council (TIFACS), New Delhi.

6. CONCLUDING OBSERVATIONS

The process of globalisation has promoted greater complexities into the national innovation system and international cooperation. An element of fierce competition, nature of emerging technologies associated with greater risk and uncertainty, shortage of highly skilled S&T human resource and bio-resources are overshadowing other determinants like transaction cost and weakening of some forms of social capital like geographic proximity and cultural affinities. The changing structure if ISI is also influencing the power relation in the S&T collaboration pattern. It seems that strengthening of the NIS and building up high-tech sector infrastructure will further the process rather than developing capacity to regulate it. In the first two categories of exploitation and generation of technology, the process was partly facilitated by the nature of bilateral or multilateral cooperation. During these phases, the R&D component of TNCs tended to remain unfragmented or restricted to its adaptive nature and geographic spread. In particular, the globalisation process has influenced the collaboration pattern by encouraging relatively wider geographical spread and the alliances in high-tech sectors have accelerated this process. In this context, the following observations are made regarding the changing nature of Indo-French S&T cooperation.

1. In order to adapt to globalisation, the French innovation system has undergone transformation that has also led to changes in international cooperation mechanism.
2. There has been a constant increase in the volume of bilateral or government-to-government cooperation shared equally by both the countries. This was accompanied by gradual changes in the priorities in areas of cooperation introducing a divergence between the FDI and bilateral areas of cooperation. Moreover, a convergence has been recorded in terms of the type of cooperation described as follows.
3. The bilateral cooperation activities have been extended to basic as well as applied research, patenting and its industrial application. A widened interactions activity has been observed involving diverse types of research organizations including the university system. Though relatively restricted, a similar pattern of wider interactions also observed in the research collaborations of the French TNCs in India with an added dimension of offshoring of R&D services,
4. Several French companies have started investing in R&D or R&D collaboration in India with increasing volumes. This is also accompanied by the capacity building activity and exports of R&D services.
5. Some significant knowledge spillovers are expected from this activity and the new form of social capital is expected to facilitate exchange of tacit knowledge that is encouraging autonomy and synergy. To take advantage of these benefits, a developing country like India will have to gear S&T policies towards facilitating such knowledge flows.

NOTES

1. An interventionist model which places emphasis on the dominant weight of large civil and defense programmes, on the division between the universities and the CNRS, on the congenital separation between research and firms, on the monopolization of public support by certain large industrial groups.

2. This was due to the fact that the former colonial powers like France and UK had a tacit understanding of not involving themselves into the affairs of each other's colonies. The first formal agreement of cooperation between India and France was signed as early as in 1966. This was not an agreement signed exclusively in the area of S&T but this was covered under the agreement of Cultural, Scientific and Technical cooperation.

3. Out of the total FDI inflows from different countries, France ranked 7th between the years 1991-2005. The Chemical industries dominated with 58 percent and Food processing and Telecom 7 percent each and the metallurgical and electrical industrial investment 10 percent and the rest 18 percent.

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