Institutions and Economies
Vol. 5, No. 3, October 2013, pp. 21-52

Export Innovation System: Changing Structure of India's Technology-Intensive Exports

Pranav N. Desai
Jawaharlal Nehru University
Email: dpranav@hotmail.com

Abstract: This paper attempts to analyse India's changing structure of technology-intensive exports using a systemic perspective. In doing so, it explores the increasing significance of linkages between National and International System of Innovation. Technology-intensive exports from the developing economies have witnessed rapid growth and an increase in their share compared with low-tech or medium tech exports in international trade in the last two decades. India is no exception to this and has demonstrated a sharp increase in the manufactured exports of technology-intensive products. The paper examines the changing structure of exports and its link with economic development and whether technological learning affects low, medium and high-tech differently. Findings reveal that export performance can be enhanced through improving technological capabilities. However, it is not only codified knowledge in R&D output such as publications, patents and designs that influence technological learning and innovation process. Interactive processes of international collaboration, inward and outward foreign direct investments also contribute significantly towards this process.

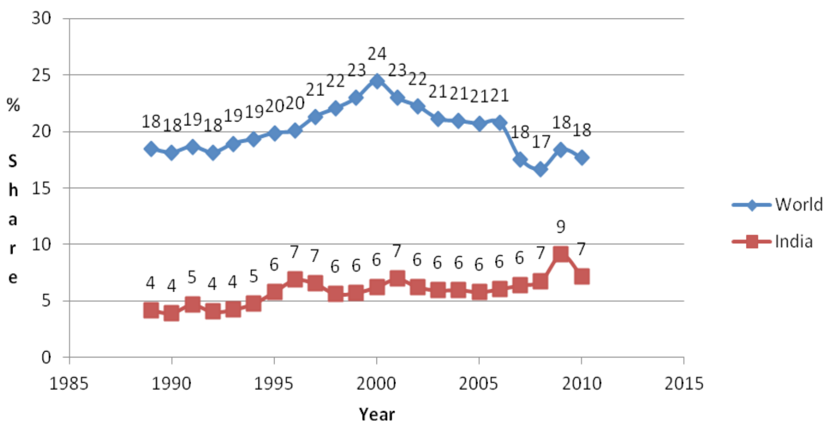
Keywords: Export Structure, FDI, Innovation process, International Innovation System, Learning, Technological intensity

JEL classifications: O32

1. Introduction

This paper examines India's changing structure of technology-intensive exports from a systemic perspective as well as the increasing significance of linkages between National System of Innovation (NIS) and International System of Innovation (ISI). Technology-intensive exports in the last two decades (1991-2010) have witnessed a rapid growth and an increase in their share compared with low-tech or medium tech exports in international trade. The growth and increasing share of technology-intensive exports are strikingly more evident in the developing countries than the developed countries (Lall, 1999). During the period 1985-1998, the developing countries outperformed the developed countries in the growth rate of technology-intensive exports, especially high-tech exports. The structural change in exports is quite striking suggesting the fact that technology-intensive products are drivers of export dynamism. India is no exception to this and has demonstrated a sharp increase in the technology-intensive products as the percentage of manufactured exports in recent years (Figure 1).

Figure 1: High-Tech as percentage of Manufactured Exports



Source: World Bank, 2011a

This paper argues that export performance can be enhanced through improving technological capabilities. Technological learning enhances technological capabilities. However, it is not only codified knowledge in R&D output such as publications, patents and designs that influence technological learning and innovation process. Interactive processes of international collaboration, inward and outward foreign direct investments (FDI), general socioeconomic environment also contribute significantly towards this process.

Furthermore, it is essential to note that this innovation process is mediated through dependencies emanating from the international science & technological (S&T) order and interdependencies generated by the globalisation process and emerging technologies. The paper has six sections. The first section is introduction to the paper while the second section analyses the evolution of different innovation system frameworks and its relevance to the present study. The third section discusses the relationship between technological-intensive activities and economic development and the role of interactive learning. Some important changes in export innovation system and technology–intensive structure of India's exports are analysed in the fourth section. The following section analyses the transformation of innovation processes in terms of the changing nature of inward & outward FDI and international S&T collaboration pattern. The final section is the concluding observations.

2. System Scales Linkages

A new perspective emerged in the 1980s, enriching scientific policy studies, with the seminal contribution of Freeman (1987), Lundvall (1985), Nelson (1993) and others who advanced the concept of the national system of innovation (Carlsson, 2006). This concept that recognises the interconnectedness between different actors, institutions and networks as well as an interactive process between economic, social and political factors started gaining greater credibility. Though this concept recognises the increasing significance of international dimensions (Freeman, 1995), it does not believe that national technological development is intertwined with the global system and rightly so given the historical circumstances involving the triad countries (USA, Europe and Japan). The idea that an innovation system is predominantly rooted within the national borders, and that the nation-specific institutions shape production, diffusion and use of knowledge began to be challenged by analogous concepts such as "technological system", "regional system" and "sectoral system" of innovation. Thus, the dynamics of technological development were perceived as set within spatial boundaries. This reflects the growing interest in the framework of innovation systems. Many scholars of different persuasions are expanding the horizon from the perspectives of economic geography, industrial economics and actor-network theory by proposing a concept of "international system of innovation" and by building linkages between regional, national and international innovation system for bridging system scales in innovation policy (Fromhold-Eisebith, 2007). However, this concept certainly is helpful in integrating systems at different scales for evolving a balanced innovation policy; it is devoid of "power" dimension and assumes that ISI operates in a vacuum. This paper finds that the hierarchical international S&T order generates multiplying effect in favour of countries and regions where S&T resources are concentrated and even shapes ISI (Desai, 1997). Moreover, this dependency results from this international S&T order and simultaneously, the unfolding of the globalisation process and the sheer nature of emerging technologies are increasingly generating interdependency between different actors and institutions. Hence, the following sections will explore whether innovation policies that attempt to strengthen the linkages between different scales will infuse technological dynamism and transform the NIS or obstruct its growth and whether these linkages at various system scales are all the more relevant for analysing the export innovation system.

3. Technology, Trade and Development

The relationship between technological-intensive[1] activities and economic development is well established in the literature of technological change. However, whether the export structure has a relationship with economic development, inclusive growth and efficiency equity remains unanswered by traditional trade theories or the canonical Heckscher-Ohlin theory of comparative advantage. These theories treat technological development as exogenous and export structure entirely flexible and equivalent in their welfare effects. The new trade theories recognise the role of technological change in trade and development. However, most of these new trade theories focus on issues relating to the developed countries and interpret the North-South trade in the context of innovator-imitator relationship. Hence, these theories fail to explain the changing South-North technology trade relationship (Wangwe, 1993).

A strong relationship is observed between the evolution of export diversification and its link with economic development. A study (Carrère *et al.*, 2007) using a large database of 159 countries over 17 years has unravelled a robust hump-shaped relationship between export diversification and the level of income. Diversification occurs mostly at the extensive margin for low- to middle-income countries, as new export items multiply and are marketed at increasingly large scales. The re-concentration of exports occurs at above a threshold of PPP$ 24,000 for a few products. Low-tech exports are common among low-income countries, and high-tech exports occur is concentred in high-income countries. This phenomenon has some exceptions in countries such as the Philippines, Singapore, Malaysia, Indonesia and China where the share of high-tech exports as a percentage of manufactured exports is equivalent or much higher than many of the high-income countries. Many scholars explain this in terms of production fragmentation and exports of "processed" and "assembled" high-tech. There are many studies (Srholec, 2006; Yuqing, 2010) that treat the greater share of high-tech exports among the developing countries as a statistical illusion. The analysis of intra-product imports suggests that the bulk of high-tech exports can actually be attributed to the effect of increasingly international fragmentation of production systems in electronics rather than gradation of domestic technological capability. Specialisation in exports of electronics appears in tandem with a high propensity for imported electronics products, particularly components. These kinds of exports require only a low-skill assembly of components. Hence, these studies suggest that increasing technological intensity in exports has led to a naïve assumption that high-tech exports reflect the technological intensity of the local business activity and, therefore, not much attention is given to the possibility that actual technological content may differ across countries. The actual technological content is reflected in the nature of R&D and, therefore, human resource as well. This argument is amply demonstrated in several empirical studies carried out recently in the IT (high-tech) and other sectors (medium-tech) for the Southeast Asian and other regions as well (Rasiah, 2010; Rasiah, 2011a; Rasiah, 2011b; Amsden and Tschang, 2003). A valuable methodological contribution made here is the categorisation of R&D activities into six levels on the basis of knowledge intensities from simple to mature R&D. This has revealed a correlation between knowledge intensities and skills and better export performance in countries such as Korea and Taiwan compared with Southeast Asian countries. In the case of India, despite impressive technological capabilities built over the years the country has maintained lower share of high-tech exports.

These studies have, nevertheless, examined only the East Asian region with a focus on information and communication technologies and with three basic assumptions: that the codified knowledge is the key R&D output; R&D is the most unfragmented part in international trade; and that no technological learning takes place through production and exports of high-tech products. Are these perceptions changing rapidly and does this argument hold true for other regions and other high-tech sectors? Do the developing countries continue to enhance their export performance through cheap labour and devaluation of their currencies? Does technological learning affect differently in different cases of low, medium and high-tech? These are some of the questions that will be answered in the following section.

4. Changing Export Innovation System

India has witnessed several phases of regulation and deregulation of the economy since independence which has led to changes in the export policies. These had altered the structure of export as well as geographic destinations. Till early 1990s, India largely pursued import substitution policies and hence was biased against exports. In the 1950s, India neglected exports while there were conscious attempts to promote exports in the 1960s. However, a narrow range of manufactured exports were subsidised, and an overwhelming portion of traditional exports were neglected. This prevented development of any new, dynamic and technology-intensive product exports. The following decade witnessed a remarkable growth in exports. However, this can be attributed to many factors such as devaluation and steady depreciation of Indian rupee, global inflation, and emergence of a new, importing actor. Some scholars have characterised this growth as deceptive and unsustainable (Nayyar, 1976). Though mild and hesitant doses of liberalisation were injected into the Indian economy in the 1980s, this provided opportunities for technology capacity building in high-tech sectors such as automobile, pharmaceuticals, (this was also due to the Indian Patent Act 1970 and subsequent exit of many Pharma MNCs), computer hardware and resource-based technologies like leather (export of raw skin and hides were prohibited). Indian exports also grew faster than world exports during this period. Indian exports continued to grow in the 1990s as exports were actively encouraged. During 1991-95, total merchandise exports grew at over 15 percent and manufactured exports at nearly 13 percent annually. This though was much lower compared with to the East Asian countries and China. Most of the growth occurred in the early 1990s as a result of the government's liberalisation policies. A serious macroeconomic crisis triggered the new policy whereby urgent attempts were made to liberalise trade policy, improve domestic competition and technology inflows and attract foreign investment, quantitative restrictions on imports were relaxed, and tariffs (particularly on industrial inputs and capital goods) lowered. Industrial policy controls were relaxed by easing domestic licensing procedures. Trade regime was liberalised with respect to capital goods. Import licensing was virtually abolished especially those related to machinery and equipment and manufactured, intermediate goods. There was also a significant cut in tariff rates, with the peak tariff rate reduced from 300 per cent to 150 percent and the peak duty on capital goods cut to 80 percent. Import-weighted custom duty rates fell from an average of 97 percent in 1990-91 to 29 percent in 1995-96. It is in spite of this positive response, a significant slowdown was observed in export growth after 1995.

This slowdown was not felt in India alone; there was a slowdown in exports of manufactured goods globally especially in the East Asian countries. The economic crisis in East Asia (1997-98) and the global financial crisis that started around 2008 affected Indian exports. The exports of manufactured goods globally started picking up in 2003, from the levels since 2000, right up to 2009. It is clear that the success or failure of national exports is partly influenced by the expanding or shrinking international markets. The East Asian miracle started in the 1970s (Korea, Singapore and Taiwan) and 1980s (Malaysia, Indonesia and Thailand) while the international economy was expanding.

Those who subscribe to the "East Asian Miracle" explain the phenomenon in terms of export-led growth as against import substitution or the neo-liberal as against *Dirigiste* nature of the state. But there are scholars who point towards state interventions that have led to rapid growth in countries such as Japan and Taiwan (Ernst *et al.,* 1998). These countries provided incentives in selective areas that would not have occurred in free trade environment and more investment in key industries as well. More examples could be cited in the key industries in Korea or even the rapid growth of software industry in India.

Thus, government policies were aimed at spreading risk and allocating resources differently which is anathema to the free market system. Here, the emphasis is given to greater exposure and opportunities to interactive technological learning rather than a linear technology capability building.

4.1 Changing Technology-Intensive Export Structure

From 2008-10, India's exports of high-tech manufactured goods witnessed a fresh upswing. The share of high-tech product exports hovered around five percent between 1990s and recently jumped to nine percent of the total manufactured goods exports (World Bank, 2011a). Though these signs of change are crucial, India will have to cover a lot of ground to reach the world average of 21 percent. Between 2002-03 and 2007-08, the proportion of low-tech goods export declined from 66 percent to 56 percent. But the share of medium and high-tech products rose to 30 percent from 22 percent and 7 percent to 14 percent respectively according to Indian estimate (Table 1). This reveals a significant structural change in the Indian manufactured goods exports. Corresponding shares in patenting also demonstrate the patenting strategy as well as technological capability developed by the firms in India. The patents filed under the PCT reveal that the high-tech patents enjoyed the maximum share of 56 percent followed by medium-tech with 31 percent and low-tech only 13 percent.

4.2 Role of Foreign Collaboration

Another interesting feature of manufactured exports is the role played by foreign collaboration (Table 2). Looking at the total amount of exports, the companies without foreign collaboration fared better with much higher export earnings and hence it appears that foreign collaboration does not play a significant role in export performance. Nevertheless, if the breakdown between high, medium and low-tech is analysed, companies with foreign collaboration see significant proportion of as much as 54 percent in high-tech followed by medium-tech with 26 percent (it has increased over the previous year) and only 20 percent in low-tech (this figure decreased compared with the previous year). Companies without foreign collaboration contribute significantly in terms of export earning, an overwhelming 94 percent comes from low-tech exports (this was an increase over the previous year) and the medium and high-tech contribute only 5 percent and 1 percent respectively (these decreased over the previous year). Thus, foreign collaboration in the high-tech sector has become significant.

Table 1: Technology-Intensive Exports as Percentage of Total Manufactured Exports from India (2002-03 to 2007-2008)

Sector	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	%age change in 2007--08 over 2006-07	% share in industry patent filed under PCT 2003-05
Low Technology	1318.58	1440.10	1637.49	1965.14	2436.93	2576.79	5.74	13
	(66.34)	(63.82)	(61.43)	(59.82)	(57.9)	(56.4)		
Medium Technology	434.74	566.17	746.48	943.69	1,198.75	1,357.17	13.21	31
	(21.87)	(25.09)	(28)	(28.73)	(28.48)	(29.71)		
High Technology	133.34	160.84	227.38	300.01	573.08	634.56	10.73	56
	(6.71)	(7.13)	(8.53)	(9.13)	(13.62)	(13.89)		
Total Manufactured Exports	1987.60	2256.39	2665.52	3285.07	4208.76	4568.52	8.55	

Source: Department of Scientific and Industrial Research (DSIR) and Indian Institute of Foreign Trade (IIFT) (2010). European Patent Office (2008) *Compendium of Patent Statistics: 2008* (OECD, Paris).

Table 2: A Comparison of Exports of Companies/Organisations with and without Foreign Collaboration

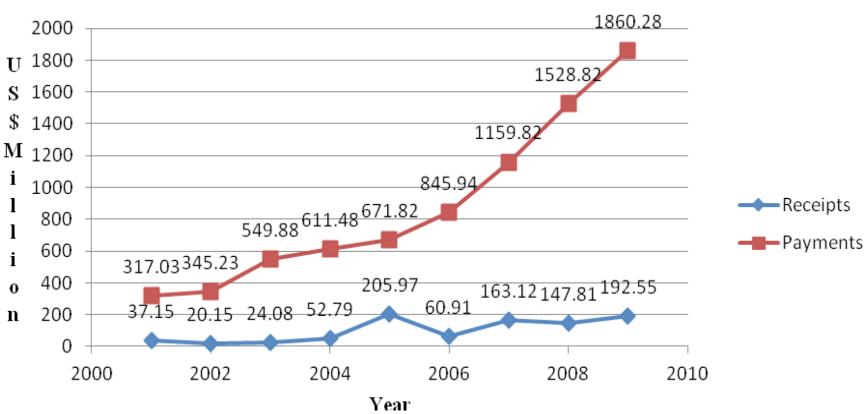
	No. of Companies		2006-07		2007-08		% change in 2007-08 over 2006-07	
Level of Technology	With Foreign Collaboration	Without Foreign Collaboration	With Foreign Collaboration	Without Foreign Collaboration	With Foreign Collaboration	Without Foreign Collaboration	With Foreign Collaboration	Without Foreign Collaboration
Low Technology	28	48	15893.83	76705.58	16116.62	97210.15	1.4	26.73
(%)			23.01	92.93	19.58	94.06		
Medium Technology	93	102	17529.09	4751.44	21838.65	4905.42	24.59	3.24
(%)			25.37	5.76	26.53	4.75		
High Technology	59	37	35664.23	1084.89	44371.5	1235.65	24.41	13.89
(%)			51.62	1.31	53.9	1.2		
Total	180	187	69087.15	82541.91	82326.77	103351.22	19.16	25.21

Source: Department of Scientific and Industrial Research (DSIR) and Indian Institute of Foreign Trade (IIFT) (2010). p.54.

4.3 Technology Trade

One of the indicators that reflect the growth of technology-intensive exports as well as technological capability is the receipts and payments of royalty and licence fee in technology trade. Though India made impressive gains in the last decade (Figure 2), the ratio of royalty and payment became more unfavourable. The receipts of royalty and fee were only US$37 million in 2001 and increased to US$192 million in 2009. The payment also increased from US$317 million to US$1,860 million. In terms of absolute amount, these figures are relatively moderate compared to that of the USA. In 2009 the receipts notched US$89,791 million and the payment US$25,230 million registering a favourable ratio of 3.6 (Figure. 3). Compared with China, India had a better ratio of royalty and payment. This reflects the fact that China depended more on foreign technology than endogenous manufacturing technology compared with India. Furthermore, the Indian scenario proves that governmental policy interventions are necessary for strengthening indigenous manufacturing technological capability.

Figure 2: India's Receipts and Payments of Royalty and Licence fee

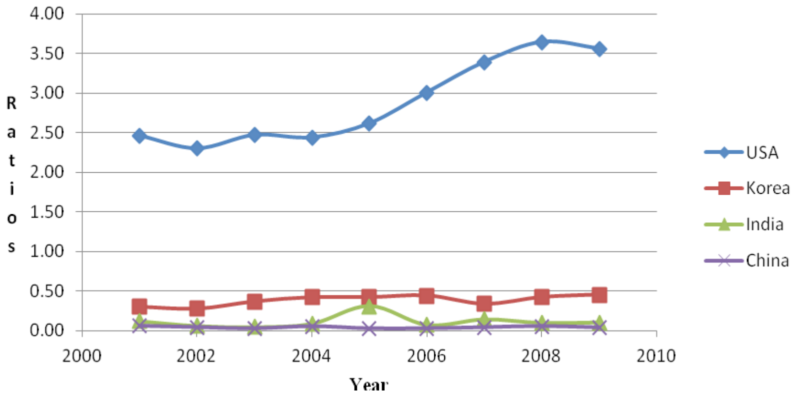


Source: World Bank, 2011a

4.4 High-Tech Services

India has made rapid strides in high-tech services especially in Information Technology (IT) and IT-enabled services. The high-tech services are not reflected in the manufactured export data but merchandise export data. About 70 percent of India's merchandise exports are manufactured goods. The data

Figure 3: Receipts/Payment Ratios of Royalty & License Fee



Source: World Bank, 2011a

for the period 2002-03 to 2007-08 reveal that manufacturing sectors such as engineering goods, electronic goods, chemicals & allied products, gems & jewellery, textiles & textile products and petroleum products dominate exports. Even in the overall merchandise export, the structural change is quite evident. The share of resource-based goods, and low-tech products has declined considerably, and the share of high-tech has increased from 5 percent to 10 percent during this period. India's software exports increased significantly from US$6,200 million in 2001-02 to US$23,200 in 2006-07. An annual average growth rate of 37 percent was registered between 1996-97 and 2006-07. A new addition to high-tech service is the R&D service export that might be smaller in proportion but a significant contribution from an innovation perspective.

During the past decade (2001-2010), India has maintained an average annual GDP growth rate of more than 7 percent despite the global economic crisis. India's literacy rate was 74 percent in 2011. India's innovative performance has also improved calculated on the basis of 28 variables listed by the World Bank over the last decade (World Bank, 2011b). The overall innovative performance has improved from 3.70 to 4.15 during the period 1995-2009. A small but positive change of +0.45 was observed despite the fact that India's R&D expenditure during 1990-2009 has hovered around only 0.8 percent of its GDP. In the backdrop of improving innovation performance, there are many signs of transformation of innovation processes reflected in inward and outward FDI investment patterns and international S&T collaborative patterns and interactions.

5. Transformation of Innovation Processes

As far as the innovation process is concerned, some scholars have observed that the neo-classical model has entirely disregarded the fact that most economically useful kinds of knowledge have a tacit dimension and that such knowledge can only be obtained in a process of social interaction (Lundvall and Borrás, 1997). Moreover, the processes that influence knowledge production and distribution have undergone transformation world over in the recent period. Some of the factors contributing to this phenomenon are globalising forces including changing nature of emerging technologies, heightened significance of national and international S&T collaboration and changing nature of international innovation system. An interesting feature of the R&D collaboration is that most of these collaborations take place 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 defence, automotive, and non-biotechnology chemicals (National Science Board, 2002). Thus, the emergence of new technologies is also influencing globalisation. It is essential to note here that the NIS does not operate in a vacuum but in a definite ISI context. The ISI covers international institutions,[2] agreements and actors but also the structure of international S&T order. Moreover, international S&T order is hierarchical in nature and tilted in favour of actors endowed where S&T resources are concentrated. The ISI is shaping the NIS, and it is also being shaped by the dominant actors and dynamic NIS (Desai, 2009).

5.1 Globalisation and Innovation process

This section analyses whether the "globalisation process" is likely to change the collaborative pattern in innovation process. The impact of these changes on India's innovation capabilities is analysed after having identified these new changes, the role of new actors and learning process. It is in the preceding context that the relationship between the different stages[3] (Archibugi and Iammarino, 1999) of international collaboration and innovations is discussed. However, as globalisation of innovation does not seem to be adequate as analytical categories, the processes of the innovation system require for it to be analysed in its historical context. In the developing countries, the exploitation of nationally produced innovations was facilitated by several factors. Firstly, the priorities of the multilateral and the bilateral programmes overlapped as agriculture remained the top priority for both programmes. Moreover, many of the multilateral organisations including United Nations Expanded Programme for Technical Assistance focused on surveys, education and organisational work in the pre-globalisation period. Hence, no direct economic benefits accrued from this; rather, this assistance prepared the ground for the bilateral assistance or the developing countries were left with no choice but to depend on the transnational corporations (TNCs) for the other productive sectors (Desai, 1997).

In the second category of global generation of technologies, the TNC activities have more or less remained confined to the developed countries. In some of the developing countries, studies have indicated that the R&D conducted by the TNCs was also primarily adaptive in nature to suit local conditions and not necessarily leading to any significant innovative activity. Many of the foregoing features are changing or are likely to change rapidly with accelerating globalisation. Recently, in the last decade, India and China have emerged as major destinations. This phenomenon is taking place between the countries with stark differences in their political, socioeconomic, cultural and innovation systems. India not only had low-cost skills base advantage but also highly qualified human resources. Another interesting feature of the R&D partnership is the types of sectors in which these collaborations are taking place, and that most of them are in high-tech sectors. The vast majority involved companies from the United States, Japan, and Western Europe. The US companies remained top investors. India has emerged as the major destination with R&D in the ICT sector as the major focus of investment (Desai, 2012).

The FDI continues to surpass other private capital flows as well as the flows of official development assistance (ODA), to developing countries. In 2004, the FDI accounted for more than half of all resource flows to developing countries and were considerably larger than ODA (United Nations, 2005). However, FDI is concentrated in a handful of developing countries while ODA remains the most significant source of finance for most of the least developed countries (LDCs). After 2005, even in the LDCs the significance of FDI inflows compared with ODA has increased. During 1990–2008, FDI flows to almost all LDCs have increased (United Nations, 2010).

In 1995, the developed countries accounted for 92 percent of FDI and the developing countries only 8 percent. More importantly, for the first time, TNCs are setting up R&D facilities outside developed countries that go beyond adaptation for local markets; increasingly, in some developing and South-East European and CIS countries, TNCs' R&D is targeting global markets and is integrated into the core innovation efforts of TNCs. In the changing environment and qualitative technological change, it is pertinent to discuss India's international cooperation policy.

Learning and knowledge accumulation through inward (IFDI) and outward FDI (OFDI) is a feature de-emphasised by the NIS approach. In the changed economic environment, many scholars have analysed the role of this process with fresh empirical insight. Many studies have focused on a positive relationship between export-orientation and R&D intensity, but it is difficult to deny the role of the outward FDI and licensing activity in learning and positive influence on R&D intensity. Moreover, as some studies suggest (Montobbio and Rampa, 2005), export performance is also affected by the growth of technical capabilities, foreign direct investments, productivity, and the initial level of technical skills; in medium tech, by the growth rates of FDIs.

India has progressively liberalised the policy governing outward FDI and with recent amendment, Indian enterprises are now permitted to invest abroad up to 100 per cent of their net worth on an automatic basis. This has resulted in a sharp rise in outward investments since 1991 and is marked by a shift (Kumar, 2006) in geographical and sectoral focus. Before the liberalised period, more than 50 percent of the total FDI was concentrated in the Asian developing countries. Now, the share of the same has been reduced to about 30 percent. The share of the developed countries has risen to about 60 percent. Similarly, India's outward FDI was concentrated in manufacturing sector accounting for over 65 percent. After 1991, nearly 60 percent of of OFDI have gone to services and other major sectors such as drugs and pharmaceuticals, IT, communication, software, media, broadcasting and publishing. These geographical and sectoral shifts illustrate greater technological competence through learning and not only as a result of liberalisation. After 2000, the IFDI and OFDI have grown rapidly. And, recently, India came close to becoming a net OFD investor. This is an enigmatic situation for a low-income country like India. Moreover, most of the investment is taking place in the developed countries and the knowledge-intensive industries (Sauvant and Pradhan, 2010). Many scholars have explained this in terms of the market and resource-seeking behaviour, but the dominance of pharmaceutical and IT industry including the OFDI in R&D reveal that factors like technology and R&D are becoming more attractive for Indian firms.

India's inward FDI flow pattern in the regulated economic regime had revealed a higher level of technical cooperation. This pattern reversed after the mid-nineties with a higher proportion of financial over technical collaboration. During the post-liberalisation period, the export-import ratio became unfavourable and declined from 78 percent to 68 percent indicating no improvement in global competitiveness if the export is treated as a proxy to technological capability. The sectoral distribution pattern (Ministry of Commerce and Industry, 2007) has also undergone change, and the service sector has received greater investment than the pre-liberalisation period. In the latter period, the FDI pattern revealed a higher level of technical cooperation and this pattern reversed after the mid-nineties with higher level of financial over technical collaboration.

In the second stage of global generation of technologies, the transnational corporations' (TNC) R&D activities have more or less remained confined to the developed countries. In the developing countries, as some studies have indicated, the R&D conducted by the TNCs was primarily of the adaptive nature to suit local conditions and not particularly leading to any significant innovative activity. The Southeast Asian countries emerged as significant investors, due to institutional changes during the 1990s, both in India and other Asian countries. However, the proportion of the technical collaboration reduced from 39 (1991-95) percent to 26 percent (1995-2000). Some of the developing countries such as Korea, China, Malaysia and Thailand had a significant level of technical collaboration.

5.2 FDI Inflows in R&D

R&D so far was the least fragmented activity of the TNCs. This was not restricted to theoretical understanding in innovation studies that assumed technological complexity a constraint to the internationalisation of innovation. Technology usually involves tacit knowledge that requires physical proximity for its meaningful transmission. Many scholars (Patel and Pavitt, 1991) have attempted to substantiate these theories in an empirical light by using patent data and have demonstrated that innovative activities of the world's largest TNCs were among the least internationalised of their functions. They argued that firms tended to concentrate innovation in their home countries in order to facilitate the exchange of complex knowledge. In recent times, this situation has been changing worldwide as a greater dispersion of TNCs' R&D has become evident. This is a result of not only increasing liberalisation in various developing countries and changing nature of technology but also because of shortage of highly skilled S&T human resources. Many studies and surveys conducted on the subject have revealed this fact. One of the examples is the chip design that has witnessed a rapid expansion in leading Asian electronics exporting countries, a process that creates high value in the IT industry requiring complex knowledge. Similarly, the TNCs engaged in biopharmaceutical or agro-biotechnology innovations, in the developed countries, require bio-resources of the developing countries, conducting R&D and local trials in the host countries. This was a result of increasing realisation on the part of the TNCs that not only the proximity of markets and cheaper R&D costs that are relevant for innovations but the rich biodiversity, genetic diversity and leveraging knowledge in the host countries, as well. India has not remained untouched by this phenomenon, and a discernible change has been observed in India during the 1998-2007. The offshoring of R&D services has added a new dimension. During the five-year period between 1998-2003, a considerable FDI inflow in R&D worth of US$1.13 billion had been approved and a much higher level planned. These companies have filed at least 415 patents from India in the US. Nearly half the FDI companies have relocated their in-house R&D in the home country to an offshore location in India. Though TNCs from US, Germany, UK and France figure prominently, a number of firms from China, Republic of Korea, and Taiwan have also noticeable R&D activities in India (Academy of Business Studies, 2006).

More than 50 percent of the companies that have invested in R&D sector in India are from the US and account for about 72 percent of the total FDI. These companies have also filed a significant number of patents in US. Korea has emerged as one of the principal investor second only to USA. The Korean companies that have invested in R&D have established themselves in IT and automobile production network. Similarly, Chinese firms in telecoms & IT and Taiwanese in agro-biotechnology. Some of these companies have domestic partner from developed countries. The Korean company Hyundai partners DaimlerChrysler, and Tyco Electronics partners Siemens as collaborators in India. Thus, these efforts are also creating a global R&D network. These companies, in addition to supporting their own manufacturing, activities were also found to be engaged in exports including R&D exports benefiting the host economy. However, compared with other TNCs from the developed countries, these Asian TNCs have limited capacity building programmes. These are training programmes for R&D employee, contract research, collaborative research with universities/firms and supporting their own manufacturing activity (Agarwal and Sarkar, 2006). None of these companies has so far entered into any research contract with any local research organisation. They have not felt the need for any training programme for the R&D employees or any collaboration with any universities. These requirements vary among sectors. In Agriculture, Automobile and Chemical sectors, firms in India have not found any need to engage in contract research with Indian clients. Training programmes were more common in the Chemical sector than IT or Automobile sector, and the need for training is also gradually reducing in the IT sector. In the ICT sector, interviews conducted by the author revealed that some of the Asian companies had problems in recruiting or retaining middle-level technical personnel. This problem is due to high mobility of the sector. Secondly, the management style of these companies does not provide adequate autonomy in decision-making compared with western companies.

Data on R&D inflows from 2007-2011 reflect a slowdown in the investment activity possibly due to global economic crisis. Between January 2003 and April 2011, global FDI markets recorded a total of 2,171 investment projects from 1,030 companies and the leading sector was Pharmaceuticals, which accounted for 18 percent of projects (Table 3). This period also indicated a negative annual average growth rate of -1.7 percent. It is despite this that China and India, remained the top two destination markets in the world for inward investment. Out of the total investment projects, these two countries have attracted 13 percent and 11 percent respectively. Moreover, both the countries recorded a negative average annual growth rate of 5 percent despite implementing Trade Related Aspects of Intellectual Property Rights (TRIPS) compatible Intellectual Property Rights (IPR) laws. The top three source markets for outward investment were United States, Germany and Japan, providing 46 percent, 9 percent and 7 percent of investment projects respectively. India and South Korea also figured as one of the top ten investors with 2 percent of the total outward investment projects each.

India attracted 289 inward FDI investment projects in R&D during the same period (Table 4). The USA emerged as the leading investor followed by Germany and UK. This also helped generate employment for 73,530 persons (Table 5). Software and IT services sector attracted the highest number of projects followed by the pharmaceutical sector (Table 6). Most of the inward investment has flowed into high-tech R&D projects. Similarly, India's outward FDI in R&D Pharmaceuticals emerged as the leading sector followed by Software and IT services sector; the total outward FDI investment also suggest that mainly it is high-tech sectors that attract R&D investment (Table 7). The geographic distribution of this outward investment indicate that the Indian companies have not only invested in the developing countries such as Malaysia, China, Kenya, Lebanon, Bahrain and Saudi Arabia but in the USA and UK as well that have emerged as leading destination countries (Table 8).

5.3 Indian Diaspora

Globalisation today is not only being shaped by the flow of capital, technology and services but the human-embodied technology or S&T human resources as well. In this context, the diaspora plays a significant role through transnational networks. In the recent period, the Indian diaspora played a significant role in the transformation of Indian innovation process. According to an estimate, the Indians are the second largest diaspora in the world. There are over 27 million Indians spread across 189 countries. The overseas Indians are today recognised as the "Knowledge Diaspora".

A recent study by the World Bank on the Remittance Market in India has pointed out that remittance inflows into India are some 4 percent of GDP and have surpassed both foreign aid flows and foreign direct investment. According to the Reserve Bank of India (RBI) remittances to India reached US$46.4 billion for fiscal year (FY) 2008/09 up from US$2.1 billion in FY 1990/91 (Singh, 2012). Their role, however, cannot simply be evaluated in terms of increasing remittances. "The largest and fastest-growing group of foreign born S&E talent in the region is from India" (Saxenian, 2011). Indians now make up 28 percent of the Silicon Valley's S&T talent. The emergence of information and communications technology has facilitated communications at a faster speed and lower cost. This has accelerated learning of new sources

Table 3: Global R&D FDI Inflows by Destination (January 2003-April 2011)

Destination Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total	Average Annual Growth
China	54	71	72	63	25	24	22	25	2	358	-5.50%
India	35	54	57	56	24	20	23	15	6	290	-5.10%
United States	27	14	18	19	32	46	40	37	9	242	11.10%
UK	9	11	18	23	15	21	18	15	6	136	12.60%
Singapore	7	16	10	18	15	15	14	10	3	108	17.00%
France	6	5	24	19	9	11	7	5		86	n/a
Spain	10	11	6	15	7	11	7	4		71	n/a
Ireland	8	11	7	11	9	8	11	6		71	n/a
Canada	10	9	10	5	5	8	6	3		56	n/a
Germany	8	4	6	10	5	7	10	2	1	53	2.80%
* Other Countries	82	107	102	134	59	71	73	60	12	700	0.90%
Overall Total	256	313	330	373	205	242	231	182	39	2,171	-1.70%

Source: FDI Intelligence, 2011

Table 4: R&D FDI Inflows into India by Source Country (January 2003-April 2011)

Source Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total	Average Annual Growth
United States	25	36	34	36	13	8	13	6	3	174	-7.1%
Germany	2	1	5	3		4		1	1	17	n/a
UK		3	4	3			2			12	n/a
Switzerland	2	4	1	2		1	1	1		12	n/a
South Korea		1	1	1	3	1	1			8	n/a
Japan	2	1		1	1	1		2		8	n/a
France	1	3	4							8	n/a
Denmark					2	1		1	1	5	n/a
Australia				1	1		2	1		5	n/a
Sweden		1	2	1	1					5	n/a
* Other Countries	3	4	6	8	3	4	4	3	0	35	n/a
Overall Total	35	54	57	56	24	20	23	15	5	289	-5.1%

Source: FDI Intelligence, 2011

Table 5: Employment Generation in India

Year	Total No of Jobs Created*	Percentage Growth
2003	7,832	
2004	11,414	45.70%
2005	15,263	33.70%
2006	21,224	39.10%
2007	3,640	-82.80%
2008	4,130	13.50%
2009	5,812	40.70%
2010	3,325	-42.80%
2011	890	n/a
Total	73,530	
Average	8,170	

Source: FDI Intelligence, 2011

of skills, technology and capital, as well as about potential collaborators within the ethnic professional networks. Some remain based in Silicon Valley while tapping low-cost technical talent and finance in their home countries. Others return home to start businesses but continue to work with customers and partners in Silicon Valley. As these cross-regional collaborations multiply and deepen, both the US and developing economies benefit.

The Indian diaspora has contributed in setting up manufacturing, research and educational facilities in a wide range of S&T, medicine and health areas (High Level Committee on the Indian Diaspora, 2001). The Advanced Network Laboratory and IBM Research Centre at IIT Delhi, the Centre for Theoretical Physics at IISc Banglore, the LV Prasad Eye Institute at Hyderabad, production of affordable Hepatitis Vaccine by Shantha Biotech are but a few examples.

Recognising their role, the Indian government set up a High Level Committee (HLC) on Indian Diaspora to recommend policy options, organisational frameworks, strategies, and programmes to involve the Non Resident Indian citizens (NRIs) as well as the foreign People of Indian Origin (PIOs) in accelerating social, economic and technological development of India.

Table 6: Sectoral Distribution of R&D FDI inflows into India (Jan 2001 - April 2011)

Sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total	Average Annual Growth
Software & IT services	13	31	23	17	2	3		2		91	n/a
Pharmaceuticals	2	4	10	5	8	5	4	2	2	42	21.8%
Communications	5	4	12	7				1		29	n/a
Biotechnology		1	2	8	2	1	4	1	1	20	n/a
Chemicals	2		3	1	5	1	4			16	n/a
Semiconductors	4	1	2	7					1	15	n/a
Business Services		5			1		2	3		11	n/a
Electronic Components	1	1	2	1		2		3		10	n/a
Industrial Machinery,			1	3	2			1		7	n/a
Equipment & Tools Automotive OEM		2			2	2				6	n/a
Other Sectors	8	5	2	7	2	6	9	2	1	42	36.2%
Overall Total	35	54	57	56	24	20	23	15	5	289	-5.1%

Source: FDI Intelligence, 2011

Table 7: Sectoral Distribution of Outward R&D FDI from India (2003-2010)

Sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total	Average Annual Growth
Pharmaceuticals	2		4		4	8	1		19	n/a	n/a
Software & IT services	1	1	2	4		2			10	n/a	21.8%
Healthcare					7				7	n/a	n/a
Business Services		1		1			1	2	5	n/a	n/a
Biotechnology				2					2	n/a	n/a
Automotive Components				1					1	n/a	n/a
Communications	1								1	n/a	n/a
Electronic Components				1					1	n/a	n/a
Plastics				1					1	n/a	n/a
Overall Total	4	2	6	10	11	10	2	2	47	22.90%	n/a

Source: FDI Intelligence, 2011

Table 8: Outward R&D FDI from India (January 2003-April 2011) by Destination

Destination Country	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average Annual Growth
United States	2			2		3		1	8	n/a
Malaysia			1		1	1	1	1	5	n/a
China	1	1	1	1					4	n/a
United Arab Emirates			1		2				3	n/a
Singapore				1		1			2	n/a
Germany				2					2	n/a
Denmark		1							1	n/a
Lebanon					1				1	n/a
Bahrain					1				1	n/a
* Other Countries	0	0	2	4	4	3	1	0	14	n/a
Overall Total	4	2	6	10	11	10	2	2	47	22.90%

Source: FDI Intelligence, 2011

5.4 Changing Nature of India's International S&T Cooperation Policy

Different countries conduct International S&T cooperation through different actors and channels. Usually, there are formal bilateral and multilateral agreements or academic and corporate R&D alliances. The third channel is the FDI investments that might differ in scope and emphasis. The output of scientific cooperation can be measured in terms of publications, patents, designs and exchanges. Co-authorship is one of such indices that reflect the level of cooperation through formal or informal channel. In recent years, India's share of world publications and the relative number of citations these papers received have both increased and across all subjects (Evidence, 2010). As far as international collaboration during 2001-10 is concerned, the trend indicates a sharp and steady increase from 27 percent share of internationally collaborated papers in 2001 to 34 percent in 2010. During this period, though the Indian scientists have collaborated with almost all countries in the world (more than 150 countries). India collaborated with internationally-based co-authors on 79,526 publications. The USA was the largest collaborator during this period with 16,420 collaborative papers or 21 percent of the total collaborative papers. The next biggest partners were Germany, Japan and the UK. Out of the top ten partners, China, Japan, South Korea and Taiwan were the only Asian countries and China the only developing country. The preceding analysis points to the increasing significance of international collaboration, and the fact that collaborators are attracted by the developed S&T infrastructure and not deterred by any cultural, linguistic or geographic differences or size of any country.

5.5 India's Bilateral S&T Cooperation

As far as bilateral S&T cooperation is concerned, India has entered into bilateral agreements with 78 countries (Desai, 2009). Out of these, 29 countries were developing countries and 66 percent or 19 countries were Non-Aligned countries. Thus, this reveals predominance of the foreign policy objectives. These countries have heterogeneous background in terms of income levels, S&T infrastructure and resource endowment and market conditions. During the period 1947-1997, the pattern of India's bilateral cooperation (government-to-government) in S&T revealed that India had pursued a "diversified cooperation" (especially after the 1970s) in terms of geography and S&T. However, agriculture and atomic energy had attracted greater cooperation. These were highly endowed areas in terms of human and financial resources. Hence, a country with stronger innovation system is expected to benefit more from this type of cooperation. It also suggests that cooperation was not inversely proportional to the size of a country or R&D. Moreover, during this period, cooperation was confined to capacity building and scientific research did not directly lead to innovations as commercialisation of results was not pursued. This highlights the fact that a fine balance between different objectives such as scientific, socio-economic and diplomatic objectives was hard to attain. 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, security concerns or political objectives have at times side tracked S&T objectives; and many European countries had integration of Europe as a major objective. East Asian countries have energy security as a prime objective and economic objectives dominate other developing Asian countries. Even the other type of cooperation, multilateral cooperation or bilateral Official Development Assistance, are similar in terms of its nature and agriculture remained the top priority. Hence, India had no other options but to depend on the TNCs for other productive sectors.

The cooperation efforts were concentrated in the North American and European region during the first three decades in the post-independence period (1950-1970s) and the geographical diversification took place later. It was only when India started focusing on commercialisation of R&D results in late 1990s that these kinds of programmes started appearing in the S&T agreements with European countries and later with China, Singapore, and Israel. Some programmes were also initiated recently in industrial research, and its application targeted the SMEs of the cooperating countries. One such example is a mechanism of Bridge projects, a product of Indo-French collaboration in the year 2001 with a limited budget (Desai, 2010). There has been a historical reluctance among industry and scientific institutions to collaborate and the sharing of patent benefits has also contributed to this. It is because of these reasons that it has taken so long to evolve a mechanism to exploit the results commercially.

A need arose to create a permanent organisational mechanism as a result of growing interest in international S&T cooperation with some of countries such as USA, France, Uzbekistan and the Non-Aligned Countries. This mechanism was perhaps created to involve greater commitment and insulate international S&T cooperation from ups and downs in the diplomatic relations. The foregoing analysis has revealed the transformation of innovation structure and the process leading to changing export structure of India. This phenomenon reflects changes in a host of factors such as the changing nature of technology, greater need of the developed country MNCs for S&T human resources closer to their markets & developing country MNCs need for R&D and technology, changing nature of bilateral cooperation and heightened significance of the professional Indian diaspora.

6. Concluding Observations

In the recent period, India has enhanced its innovative performance and the unfolding of globalisation has strengthened the linkages between the NIS and ISI. The changing nature of emerging technologies has accelerated this process. There has been discernible change in India's technology-intensive exports structure with increasing level of technological capability. In particular, the following observations are made: Between 2002-03 and 2007-08, the proportion of low-tech export declined from 66 percent to 56 percent. Medium and high-tech exports rose to 30 percent from 22 percent and 7 percent to 14 percent respectively. The corresponding patenting activity filed under PCT also reveals a high share of 56 percent in the high-tech sector; the sectoral composition of technology intensive export reveals the dominance of drugs and pharmaceutical and electronics goods in the high-tech sector. As far as total merchandise export is concerned, textiles, chemicals, machinery, metal manufactures, transport equipment, pharmaceutical product, electronic goods, plastics, machine tool, consultancy services and project goods remained at around 50 per cent of India's total merchandise exports from 2002-03 to 2007-08; high-tech services such IT and IT-enabled services have emerged as noteworthy sectors. R&D service export is also an emerging sector; transformation in innovation processes such as the institutional changes, nature of international S&T collaboration, inward and outward FDI flows, increasing geographical spread, changing sectoral composition and destination and actors have provided greater opportunities for deepening technological learning for India; India has emerged as one of the top destination for R&D offshoring. These activities are not restricted to supporting domestic manufacturing or market seeking but are extended to capacity building programmes including R&D exports, training and contract research and have generated significant R&D employment; as far as FDI investment inflow in R&D is concerned, companies from the USA, Germany and UK were the main investors. Some of the developing countries have also emerged as new actors in India. Software & IT services and Pharmaceuticals were the main sectors that attracted FDI investment followed by Communications, Biotechnology and Chemicals; similarly, India is also one of the top players in R&D FDI investment outflows. Pharmaceuticals and Software & IT services were the dominant sectors followed by Healthcare, Business Services and Biotechnology. The major destinations of FDI outflow were not only the developing countries such as Malaysia, China and UAE but also the United States and UK; the nature of bilateral cooperation has undergone a transformation and has been extended to R&D-based innovative activities and industrial application instead of remaining confined to scientific research. It seems that this type of collaboration is more diversified in terms of S&T areas and types of organisations. This type of cooperation will continue to play a significant role; the Indian diaspora has emerged as a significant factor transforming the innovation process; finally, the new trade theories might require integrating the global networking relationship in the innovation process rather than interpreting North-South technology trade mainly in the context of innovator-imitator relationship. In this context, India might require a greater level of coordination and policy interventions at all levels to translate the technological capabilities into higher levels of high-tech exports by taking advantage of expanding markets in this sector.

Acknowledgement

The author wishes to express his gratitude to Professor G. S. Bhalla, Professor Emeritus, JNU for his helpful comments and suggestions. The earlier version of the paper was presented at the 9th Globelics 2011 held at Buenos Aires, Argentina.

Notes:

1 Technological intensity reflects R&D intensities employed at different levels. Some of the sectors such as aerospace, electronics and pharmaceuticals usually require high level of R&D investments. The following are examples of manufactures of low, medium and high technology intensity; **Low technology manufactures-**Agro/forest based products: Prepared meats/ fruits, beverages, wood products, vegetable oils and Other resource based products: Ore concentrates, petroleum/rubber products, cement, cut gems, glass, textile/fashion cluster: Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods and Other low technology: Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products; **Medium technology manufactures -** Automotive products, Medium technology process industries, Passenger vehicles and parts, commercial vehicles, motorcycles and parts, Synthetic fibres, chemicals and paints, fertilisers, plastics, iron, pipes/tubes and Medium technology engineering industries, Engines, motors, industrial machinery, pumps, switchgear, ships and watches; **High technology manufactures -** Electronics and electrical products Office/data processing/telecommunications equip, TVs, transistors, turbines, power generating equipment, pharmaceuticals, aerospace, optical/ measuring instruments, and cameras.

2 Some of the important multilateral organisations that provide international institutional environment are for instance UN organisations including World Trade Organization (WTO), Trade-Related Intellectual Property Rights (TRIPS), the Agreement on Trade-Related Investment Measures (TRIMS), the General Agreement on Trade in Services (GATS), Information Technology Agreement (ITA), Technical Barriers to Trade (TBT). Some international agreements such as Regional Trade Agreement, Free Trade

Agreement, Bilateral S&T Agreements and even other agreements relating to environment, safety and standards also hold significance in the international institutional context.

[3] To understand this concept better, some scholars have categorised this process as involving three stages namely international exploitation, global generation and global collaboration.

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