India's S&T cooperation with the developing countries

Pranav N. Desai
Centre for Studies in Science Policy, Jawaharlal Nehru University, New Delhi, India

Abstract

Purpose – The purpose of this paper is to analyse India's international science and technology (S&T) cooperation efforts, with a special focus on the developing countries. It intends to identify the actors, magnitude, nature, routes and areas of international cooperation. Further, it probes whether the "globalisation process" is likely to change the collaboration pattern or transform India's innovation system and processes.

Design/methodology/approach – The paper is structured around five sections that include analysis of different stages of globalization in the context of an historical analysis of India's international S&T cooperation policy. An essential feature of this study is that the analysis is not restricted to R&D collaboration in the corporate sector but includes bilateral and multilateral cooperation between different countries and also inward and outward FDI flows that is expected to enhance learning process. Finally, the countervailing tendencies emanating from the structure of international S&T order and the nature of emerging technologies along with the unfolding of globalization are discussed.

Findings – It is observed that the unfolding of globalization has tended to change the nature, magnitude and routes of international cooperation in significant ways and new actors have emerged in terms of some developing countries. 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.

Originality/value – The paper provides theoretical contribution from the perspective of linkages between national and international systems of innovation.

Keywords India, Developing countries, Sciences, Technology, Globalization, Innovation, International cooperation

Paper type Research paper

Introduction

The present paper is an attempt to analyse the international science and technology (S&T) cooperation efforts with a focus on India's international S&T cooperation pattern and especially with the developing countries. India's efforts in international S&T cooperation were initiated as early as 1950s in the post-independence period. These efforts conducted through different actors and channels have been undergoing transformation through different phases of regulation and deregulation of economy. International collaboration discussed here includes not only the bilateral cooperation but also technical collaboration that has taken place between India and different countries through either inward or outward FDI and also the recent FDI flows in R&D. It is contended that the advantages and disadvantages of S&T cooperation are yet to be fully perceived by the concerned countries.

In recent years, the unfolding of globalisation has tended to change the routes, nature and magnitude of this process in significant ways. 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 (USA, Europe, Japan) so far and the East Asian Tigers (South Korea, Taiwan, Hong

World Journal of Science, Technology and Sustainable Development
Vol. 9 No. 1, 2012
pp. 28-37

2042-5945
DOI 10.1108/20425941211223606

Kong and Singapore) followed 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 have not paid due attention to other types of collaborations like bilateral and multilateral collaboration. In a developing country like India with wide socio-economic disparities, this process might introduce new challenges and opportunities for innovations and policy making. Some scholars have argued that globalisation of R&D by foreign firms 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. According to them the activities of the transnational corporations add new innovation capacity by bringing new technology, global knowledge network and the resultant diffusion of knowledge. Moreover, there are many examples cited where globalisation has helped stem brain drain from the developing countries or has at least encouraged brain circulation. Second, the collaborative efforts seem to be attracting greater citation impact from the internationally collaborated publications. Thus, a transition from international collaboration of R&D to globalisation of innovation is visualised. In the context of the extreme position often taken, it is being realised 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).

The paper is structured around five sections that include analysis of different stages of globalisation, the shifting focus in India's international S&T 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 also inward and outward FDI that adds to learning. The fourth section focuses on the recent phenomenon of FDI flows in R&D with an analysis of the areas and nature of these investments. The fifth section is the concluding section.

Stages of globalisation of innovation process

The "globalisation" process is a complex phenomenon and hence defined differently by different scholars. However, it mainly refers to "high (and increasing) degree of interdependency and interrelatedness among different and geographically dispersed actors" (Archibugi and Iammarino, 2002). In principle, therefore, a higher level of globalisation could be expected even with the same level of internationalisation. Thus, this definition seeks differentiation between the term "global" and "international". Further, the term "globalisation of innovation" denotes not only the economic application of new ideas and knowledge based on R&D or technology but it can also be based on organisational, managerial or institutional arrangements. In recent times, the emerging technologies like ICTs, biotechnology, nanotechnologies, etc., are intensifying the process of globalisation. Many theoretical and empirical efforts to explain this varied phenomenon are proving to be inadequate. For a systematic comprehension of this concept, some scholars have categorised this process mainly into three stages. These stages are international exploitation, global generation and global collaboration. "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).

The first category refers to the efforts of innovators to obtain economic advantages through the exploitation of their own technological competence in markets other than the domestic one. In this category of "international exploitation" as against the category of "global" (interdependent and integrated), the actors introducing the innovations preserve their national identity even while the innovations are diffused and sold in multiple countries. However, further explorations are required to analyse these changes and the complexities of the interrelationship between the three categories in its historical context. 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 favour of the countries where S&T resources are concentrated but it is also shaping the same (Desai, 2009). To provide a focus on the contentious issues of globalisation of innovation process, an attempt has been made here to analyse whether the "globalisation process" is likely to change the collaboration pattern or introduce any discontinuity in the international cooperation policy. 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 of international collaboration and innovations requires to be analysed. As far as developing countries are concerned, the exploitation of nationally produced innovations from the developed countries was facilitated by several factors. First, 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 organisations including United Nations Expanded Programme for Technical Assistance was allocated for surveys, education and organisational work in the pre-globalisation period. Hence, no direct economic benefits accrued 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 transnational corporation (TNC) 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 the developing countries as some of the studies have indicated, the R&D conducted by the TNCs was also primarily of adaptive in nature to suit local conditions and not necessarily leading to any significant innovative activity. Nonetheless, the spillover effects of the home-base-exploiting strategy of the TNCs on science base and local R&D institutions of the host country may require further exploration.

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 per cent during 1975-2004 (Doz *et al.*, 2006). Recently in the last five years or so, there was a wider geographic dispersion and India and China are emerging as the major destination. This phenomenon is taking place between the countries with stark differences in their political, socio-economic, cultural and innovation systems. It is also reported that by 2007, India and China will account for 31 per cent of the global R&D staff. This will be a sudden jump from a figure of 19 per cent in 2004. The major companies involved responded by stating that 41 per cent of all new sites will be in India and China. 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 defence, automotive and non-biotechnology chemicals (National Science Board, 2002). Thus, the emergence of new technologies is also influencing the unfolding of globalising forces. The vast majority involved companies from the USA, Japan and countries of western Europe. Companies from the USA remains the top investors and India has emerged as the major destination with R&D in the ICT sector as the major focus of investment. The European TNCs had high levels of R&D internationalisation (41 per cent on average).

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 (United Nations, 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. 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. In particular, 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 southeast 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.

Shifting focus in India's international S&T cooperation policy

Different countries conduct international S&T cooperation through different actors and channels like formal bilateral and multilateral agreements or through academic and corporate R&D alliances or FDI investments and with different emphasis. The output of scientific cooperation can be measured in terms items such as publications, patents, designs, exchanges. Co-authorship is one of such indices that reflect the level of cooperation activity whether conducted through formal or informal channel. In recent years India's share of world papers and the relative number of citations these papers received have both increased and across all subjects (Evidence, 2010). As far as international collaboration during 2001-2010 is concerned, the trend of the same indicates a sharp and steady increase from 27 per cent share of internationally collaborated papers in 2001 to that of 34 per cent in 2010 (ISI Web of knowledge, 2011). During this period, though the Indian scientist have collaborated with most of all countries in the world (more than 150 countries), the following were the main collaborators, ISI Web of knowledge (2011). India collaborated with an internationally based co-author on a total of papers with 79,526. The USA was the largest collaborator during this period with 16,420 collaborative papers or 21 per cent of the total collaborative papers. Germany, Japan and the UK were the next largest partners. Out of the top ten partners, China, Japan, South Korea and Taiwan (re-designated as advanced countries after 1997 by IMF) 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 collaboration is attracted by the developed S&T infrastructure and not deterred by any cultural, linguistic or geographic differences or size of any country. India's innovative performance has not only improved calculated on the basis of the preceding variables but 28 variables listed by the World Bank (2011) over the last decade (www.worldbank.org./kam). 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 per cent of its GDP.

India's bilateral S&T cooperation

As far as bilateral S&T cooperation is concerned India has entered into bilateral agreements with 78 countries ranging from low to high tech (Desai, 2009). Out of these countries, 29 countries were developing countries and an overwhelming portion of 66 per cent 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 in terms of geographical dispersion and areas of S&T. However, areas like agriculture and atomic energy had attracted greater cooperation. These were highly endowed areas in terms of human and financial resources. Due to this, it is argued that a country with stronger innovation system is expected to benefit more from such type of cooperation. It also suggests that cooperation was not inversely proportional to the size of country or R&D. Moreover, during this period cooperation was confined to capacity building or scientific research was not directly leading to innovations as commercialisation of results was not pursued. This has also highlighted the fact that a fine balance between different objectives like 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 it is observed that the security concerns or political objectives have at times sidetracked S&T objectives or many European countries had integration of Europe as a major objective. As against this, many East Asian countries have energy security as a major objective or other developing Asian countries economic objectives can dominate.

Even the other type of cooperation like multilateral cooperation or bilateral ODA had similar nature of cooperation 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 in terms of frequency were concentrated in the North American and European region during the first three decades in the post-independence period (1950s-1970s) and the geographical diversification took place later. It was only during the late 1990s that India started focusing on commercialisation of R&D results that these kinds of programmes started appearing in the S&T agreements like with some European countries and later with some Asian countries like China, Singapore and Israel. Some programmes were also initiated recently in industrial research and its application that targeted the SMEs of the cooperating countries. There has been traditional reluctance to collaborate between industry and scientific institutions and second 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.

A need was also felt to create a permanent organisational mechanism after growing interest in international S&T cooperation with some of the countries like 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.

FDI and technical collaboration

Learning and knowledge accumulation through inward and outward FDI is feature de-emphasised by the NIS approach evolved during the definite historical context. 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 was observed by many that even the outward FDI and licensing activity had a role in learning and positive influence on R&D intensity.

In India, the policy governing outward FDI has been progressively liberalised and with recent amendment, Indian enterprises are now permitted to invest abroad upto 100 per cent of their net worth on automatic basis. This has resulted into 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 per cent of the total FDI was concentrated in the Asian developing countries and now the share of the same has been reduced to about 30 per cent. Against this, the share of the developed countries has risen to about 60 per cent. Similarly, India's outward FDI was concentrated in manufacturing sector accounting for over 65 per cent. After 1991, nearly 60 per cent of these flows have gone to services and other major sectors where OFDI is concentrated. These sectors are drugs and pharmaceuticals, IT, communication, software, media, broadcasting and publishing services. This geographical and sectoral shift illustrates greater technological competence through learning and not only a result of liberalisation.

India's inward FDI flow pattern in the regulated economic regime had revealed a higher level of technical cooperation but this pattern reversed after the mid-1990s with higher proportion of financial over technical collaboration. During the post-liberalisation period, the export-import ratio became unfavourable and declined from 78 to 68 per cent indicating no improvement in global competitiveness if 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 pre-liberalisation period, the FDI pattern revealed a higher level of technical cooperation and this pattern reversed after the mid-1990s with higher level of financial over technical collaboration.

In the second stage of global generation of technologies the TNCs' R&D 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 primarily of adaptive nature to suit local conditions and not particularly leading to any significant innovative activity. Due to institutional changes during the 1990s, both in India and other Asian countries, the southeast Asian countries emerged as significant investors. However, the proportion of the technical collaboration reduced from 39 per cent (1991-1995) to 26 per cent (1995-2000). As far as the Asian developing countries are concerned, countries like Korea, China, Malaysia and Thailand had significant level of technical collaboration.

FDI inflows in R&D

R&D so far was treated as the least fragementable 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 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 not only of the increasing liberalisation in various developing countries and changing nature of technology but also because of shortage of highly skilled S&T human resources. This was revealed in many studies and surveys conducted on the subject. One of the examples is the chip design that has witnessed a rapid expansion in leading Asian electronics exporting countries, a process that creates the high value in the IT industry and that requires complex knowledge. Similarly, biotechnologies that require local resources and local trials require conducting R&D in the target region.

India has not remained untouched with this phenomenon and a discernible change has been observed in India during the period 1998-2007. A new dimension has been added by the offshoring of R&D services. During the five-year period 1998-2003, a major FDI inflow in R&D worth of US $1.13 billion has already been approved and a much higher level has been planned. These companies have filed at least 415 patents from India in the USA. Nearly half the FDI companies have relocated their in-house R&D in home country to offshore location in India. Though TNCs from USA, Germany, UK and France figure prominently, a number of firms from China, Republic of Korea and Taiwan have also appeared with noticeable R&D activities in India (Academy of Business Studies, 2006).

More than 50 per cent of the companies that have invested in R&D sector in India are from the USA and account for about 72 per cent of the total FDI. These companies have also filed an overwhelming portion of the patents filed in USA. Korea has emerged as one of the major investor second only to USA. The Korean companies that have invested R&D have established themselves in IT and automobile production network. Similarly, Chinese firms in telecom and IT and Taiwanese in agro-biotechnology. Some of these companies have domestic partner from developed country TNCs like Korean companies Hyundai has Daimler Chrysler and Tyco Electronics has Siemens as domestic partners in India. Thus, these efforts are also creating a global R&D network. These companies in addition to supporting own manufacturing activities were also found to be engaged in exports including R&D exports benefiting the host economy. However, compared to other TNCs from the developed countries, these Asian TNCs have limited capacity building programmes. These programmes could be categorised as training programme for R&D employee, contract research, collaborative research with universities/firms, supporting own manufacturing activity (Agarwal and Sarkar, 2006). None of these companies have so far entered into any research contract with any local research organisation neither that they have felt the need of any training programme for the R&D employee nor that they had any collaboration with any universities. These requirements seem to be varying with the specific sectoral characteristics. In sectors like agriculture, automobile and chemical, 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. It is also important note here that some of the interviews conducted by the author revealed that in the ICT sector some of the Asian companies had problems in recruiting or retaining middle-level technical personnel. This problem could be categorised as the problem of high mobility of the sector or as some of the personnel reported that the management style of these companies did not provide adequate autonomy in decision making as compared to other western companies.

While exploring further the period between 2007 and 2011, the global data on R&D inflows reflect a slowdown in the investment activity (FDI Intelligence, 2011) and 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 per cent of projects. This period also indicated a negative annual average growth rate of −1.7 per cent. It is despite this that China followed by India remained the top two destination markets in the world for inward investment attracting 13 and 11 per cent of investment projects, respectively. Moreover, both the countries recorded a negative average annual growth rate around −5 per cent despite implementing TRIPS compatible IPR laws. The top three source markets for outward investment were USA, Germany and Japan, providing 46, 9 and 7 per cent of investment projects, respectively. India and South Korea also figured as one of the top ten investors with 2 per cent of the total outward investment projects each.

As far as India is concerned, India attracted 289 inward FDI investment projects in R&D during the same period (FDI Intelligence, 2011). The USA emerged as the major investor followed by Germany and UK. This also helped generate employment for 73,530 persons. Software and IT services sector attracted the highest number of projects followed by pharmaceutical sector. Most of the inward investment has flowed into high-tech R&D projects. Similarly, India's outward FDI in R&D pharmaceutical sector emerged as the leading sector followed by software and IT services sector and the total outward FDI investment also suggest that mainly it is high-tech sectors that attract R&D investment (FDI Intelligence, 2011). The geographic distribution of this outward investment indicate that the Indian companies have not only invested in the developing countries like Malaysia, China, Kenya, Lebanon, Bahrain and Saudi Arabia but in the USA and UK as well that have emerged as leading destination countries.

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 bioresources are overshadowing other determinants like cost, geographic proximity and cultural affinities, market conditions. It seems that strengthening of the NIS and building up high-tech sector infrastructure will further the process of globalisation rather than developing capacity to prevent it. Hence, it would be difficult to ignore the linkages between NIS and ISI. 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 India's collaboration policy:

(1) During the period 2001-2010, India has witnessed a steady increase in co-authorship in international collaboration in scientific publications reflecting increasing significance of international collaboration and the fact that collaboration is attracted by the developed S&T infrastructure and not deterred by any cultural, linguistic or geographic differences or size of any country.

(2) India's main collaborators were the USA, Germany, Japan and the UK. The only developing country that figured as one of the top ten collaborators was China.

(3) 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 and that it will continue to play a significant role.

(4) A need for collaboration is felt irrespective of size of the investing country or R&D. However, the R&D flows are directed towards countries with developed R&D infrastructure and availability of human resource irrespective of geographical proximity.

(5) As far as FDI flow in R&D are concerned, these activities are not restricted to supporting domestic manufacturing but are extended to capacity building programmes like exports including R&D exports, training, contract research and have generated significant R&D employment.

(6) The TNCs from the European and Asian countries are also forming global R&D network by partnering in India. Thus, geographical boundaries of the NIS are getting blurred.

(7) The Asian TNCs had no training programmes for their R&D employees, which reflects the suitability of S&T human resource. However, compared to the developed country TNCs, these companies had limited interactions with the local R&D organisations in terms of contract research, collaboration with universities and firms.

(8) As far as FDI investment inflow in R&D is concerned, some of the developing countries have also emerged as new actors in India. Similarly, India is also one of the top players in R&D FDI investment outflows.

(9) Some significant knowledge spillovers are expected from this activity. To take advantage of these benefits, India will have to gear S&T policies towards facilitating such knowledge flows.

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About the author

Pranav N. Desai is Professor, Centre for Studies in Science Policy, Jawaharlal Nehru University (JNU) and is engaged in teaching analysis in science and technology policy and technology futures analysis. He received his PhD in Science Policy Studies in 1985 from JNU and has conducted research in diverse areas of science policy, including emerging technologies, intellectual property rights, energy and environment-related issues. He specializes in science, technology and international affairs and some of his publications include *Science, Technology and International Cooperation* (Har-Anand Publications, 1997) and *Science, Technology, Coastal Zone Management and Policy* (Allied Publishers, 2003). Pranav N. Desai can be contacted at: dpranav@hotmail.com