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Emerging Economies as Sources of Investment and Appropriate Technology: Evidence from India

Sachin Chaturvedi*

Abstract: BICS have developed strong linkages with fellow developing countries in the realms of trade, investment and technology. This paper analyses the major trends in India's linkages with other developing countries with specific focus on technology. It has come out that there are several sub-fields of technology which are of economic importance where linkages of India in a South South cooperation framework have benefited several economies. The paper has elaborated upon select sectors with identification of possible factors facilitating these linkages. Four key drivers for South-South linkages are identified, viz. factor endowment, cost effective professional services, and ability to scale down. The collaborations have gone beyond manpower training programmes, skill upgradation to more substantive contributions like in production and exports of technology intensive goods and services.

Introduction

As the economic growth, in Brazil, India, China and South Africa (BICS) has intensified their linkages with fellow developing countries in trade, investment and technology. The expansion in the foreign direct investment from these economies is actually part of the wider global trend of South-South economic growth. It is also part of long standing trend in last decade or so even if large ethnic investments are ignored. The international expansion of large companies from emerging markets (commonly referred to as emerging economies' multinational enterprises – EMNEs) is a new and dynamic feature of the global investment landscape.¹ Unlike most North-South investment, South-South Investment is largely greenfield investment rather than for mergers and acquisitions.² In 2005 the outward flow of investment from South was of US\$120 billion. This is largely explained by the investment development path (IDP) theory (Dunning and

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Narula 1994). This theory, in line with the literature on economic catch-up and convergence, attempts to explain a country's FDI position through five stages.³ However, (OECD 2007) suggests that there are evidence which indicate that EMNEs are investing abroad at earlier stages of IDP, mainly because many such firms do not have the luxury of waiting given the fierce competition at home and export markets. This is particularly more evident in the services sector. India has launched major initiatives to facilitate linkages with other developing countries, through the liberalisation of outward investment policies. India is seen to be in the Stage 3 for FDI positioning.⁴

The Indian industry has responded favourably to the recent policy changes by enhancing their investments across the countries. It suggests that enterprises in India are building up the capabilities to compete in international markets. This is likely to further add to their domain knowledge, bring in economies of scale in marketing and help set a new growth trajectory for Indian enterprises. According to estimation, in 2007-08 investments from India were close to \$15 billion and outflow crossed the actual inflows.⁵ Indian companies particularly in information and communication technology (ICT) and pharmaceuticals companies are investing abroad largely for setting up trading outlets and distribution net-works but now several Indian companies are increasingly undertaking manufacturing activities and IT companies are opening up training centers for ensuring availability of skilled manpower.

Emerging economies are increasingly acknowledging that they share not only common social and economic challenges but would gain collectively with increase in their collaborations in science and technology. The recent signing of agreements between the IBSA members to collaborate more closely in science and technology is a reflection of this trend. Brazil and South Africa have signed a wide-ranging agreement to increase cooperation between researchers on measures to combat various health challenges confronting their two countries, including HIV/AIDS, waterborne diseases, malaria and dengue. The outcome of these projects would be extended to Namibia, São Tomé and Príncipe, Angola, and Mozambique.⁶ Similarly India has also launched a major collaboration

programme for biofuel production with Common Market for Eastern and Southern Africa (COMESA), which includes countries like Egypt, Zimbabwe, Seychelles, Madagascar, Uganda, Kenya and Libya.⁷

In the recently presented annual budget, Indian Finance Minister announced the setting of the India International Development Cooperation Agency (IIDCA) for consolidating Indian efforts in the realm of development cooperation. The FM also announced that the IIDCA would extend \$1 billion worth of development cooperation programmes to other countries. Apart from China and India, the other emerging economies like Brazil, South Africa and Mexico have also stepped up their development assistance programmes. It is being estimated that by 2010 these five developing countries would account for 10 per cent of the global flow of development aid flow.⁸ However, flow of aid from these countries is generating discussion on issues related to global governance.⁹

In this paper we explore some of these issues linked with India's emergence as a major economic player in the South, and assess how India is engaged in this milieu. Section II presents the key drivers behind the emerging South-South linkages while Section III takes an overview of the economic and technical assistance programmes launched by India. The broad trends in the investment sector are looked into the Section IV. The last section attempts to provide concluding remarks and recommendations.

Key Drivers for South-South Collaborations

The emerging economies have come-up as important partners in the development assistance programme for fellow developing countries. China has taken a major lead across other developing countries especially Africa, in terms of defining and consolidating their economic diplomacy. China, it seems, is already providing development assistance of nearly \$ 8 billion per year. Apart from China and India, the other emerging economies like Brazil and South Africa have also stepped up their development assistance programmes. South Africa actively participated in the design of new UN institutions while coordinating its positions with other member states, especially those of the African Union (AU) for providing support to fellow African countries. Brazil has focused on specific initiatives like announcing

contribution of US\$20 million over 20 years to the International Finance Facility for Immunization (IFFIm).

Table 1: Geographical Distribution of R&D Foreign Affiliates, 2004

Region/Economy	Number
Total World	2584
Developed Countries	2185
Of which Western Europe	1387
United States	552
Japan	29
Developing Countries	264
Of which Africa	4
Latin America and the Caribbean	40
Asia	216
South, East and South-East Asia	207

Source: UNCTAD (2005).

The rapid economic development at the emerging economies has triggered incremental increase in R&D investments. There is also a sharp increase in overseas R&D partnerships, investment and collaborations for product and capacity development involving these countries (Table 1). It is reported that in the time period 2002-04, of more than 1000 R&D related FDI projects 739 were based in developing countries.¹⁰ Out of this, nearly half of the total (563) were from Asia and Pacific region.

The recent economic growth in some developing countries has helped in contextualizing South-South cooperation in a new light. Kumar (1986) analyzed the various factors on which technology transfer from developed and developing country may differ from each other. There might be following key factors acting as key drivers behind the growing collaborations among different developing countries.

Factor Endowment

Factors and resource endowment and size of markets of the recipient countries differ and hence the factor proportions and scale of technologies from the two sources may be different. For instance, India has helped Indonesia for improving utilization of their natural products like pepper.

Indonesia has emerged as one of the major exporters of pepper. In recent years there has been an increased preference for a product with its natural green colour, particularly in countries like Germany, France and Switzerland. The National Research Development Corporation (NRDC) has helped Indonesia for accessing technology from the Central Food Technology Research Institute (CFTRI), Mysore for developing dehydrated pepper. The process of producing dehydrated green pepper consists of harvesting at optimum maturity, destalking, cleaning, processing, dehydration, classification and packaging. The equipment required is a steam kettle, S.S. vessels, hot air drier, air classifier and boiler. A plant with 1tpd capacity raw green pepper, working 150 days per annum, requires a capital investment of Rs.0.6 million. Similarly, Indonesia has also been helped for setting up of medium sized production plants for Triacental, a plant growth promoter. The technology for this is also developed by CFTRI.

Cost Effective Professional Services

It has been observed that the cost of consultants working on various projects hired from the developing countries is far more cost effective than from the developed countries. The scientists from developing countries are better equipped to deal with available resources and technological options, as at some stage they might have gone through similar challenges. This is very different from the environmental setting from where professionals from the developed countries come from. There are clear empirical evidences that professionals from other countries have contributed in the advancement of technology trajectory of the host country in a major way. According to the US Census 2000, it is clear that in the case of United States, 38 per cent of post-doctoral students, 29 per cent of master's degree holders and 17 per cent of bachelor degree holders are from developing countries that also from emerging economies.¹¹ In Vietnam and some African countries getting clean water is a major challenge in rural areas. Help was provided by India for setting up of small sized chlorine tablet production plant with a cost of Rs. 2.5 million in which no special expertise is required. As a result, the output is also reasonably priced, like for instance 1000 tablets for Rs. 180. This technology is far more cost effective than the usual high priced expensive aqua guards.

Limited Overseas Plans

Since most of the developing country firms have limited plans for overseas investment they are far better placed in terms of adopting country-specific strategies rather than amending strategies for bringing in more countries which is often the case with firms from developed countries which have several countries in their portfolio.

Ability to Adapt and Scale Down

Firms from emerging economies are better placed to adapt and scale down technologies as per the specific requirements in other developing countries. Moreover, technology from a developing country is not based on a highly sophisticated infrastructure, hence is easy to be absorbed in a similar setting. In countries like Senegal in Africa, simple cost effective technologies are required for coping up with day to day challenges. The NRDC helped setting up of plants for production of water filter candles in earthen pots for purification of water. The cost is as low as Rs. 15 for ordinary filter and slightly advanced filter costs only Rs. 70 per filter. The advanced version is capable of filtering bacteria as well. This way cost effective technologies in day today requirements are of immense value for fellow developing countries.

Internationalisation Incentives

There are several advantages that developed country firms can easily enjoy, given the fact that they have operations across different countries. The developed country firms have advantages in terms of brand name which invokes confidence from the buyers which is a limitation for a developing country firm. This particular advantage of brand name links up several markets and helps in generating assured consumer base. Since firms from developing countries have limited outreach this emerges as a major constraint.

India and Development Cooperation

India has been one of the major development partner for South for last several years. The focus has largely been on South Asia but has diversified over the years. It has also diversified in terms of financing

and nature of activities covered through development assistance. It has entered in a new phase where cooperation in frontier technologies has advanced at considerable pace with many developing countries. India has also expanded development cooperation linkages in various parts of Africa and has made efforts to consolidate the outflow through effective partnerships. Recently, it has been proposed that India would partner with Germany in Africa.

Concept and Measurement of Development Cooperation

In the last several years, Development Assistance Committee (DAC) of OECD has worked extensively on developing and defining various concepts related to development assistance. The official development assistance (ODA) comprises of grants or loans provided by the official sector for promotion of economic development and welfare. In this context, a concessional loan is considered welfare enhancing if it has a 25 per cent of grant as a component. Apart from financial flows, ODA also include technical cooperation and export credits.¹² The assistance of multilateral organisation is also accounted separately as a part of the overall development assistance. In most of the DAC publications a distinction is drawn between tied aid and untied aid. All the official grants or loans, where procurement of goods and services involved is confine, to donor country, is classified as tied aid.¹³

However, it is important to define contours of development cooperation to capture various activities in a relevant framework. On the basis of various DAC reports some key elements for capturing aid flow are identified in **Table 2**. As discussed, they cover both bilateral loans and bilateral grants. As a part of bilateral grant, activities such as technical cooperation, developmental food aid, humanitarian assistance, debt relief grant, aid to NGOs, and project and programme specific support are included. Aid to multilateral institutions, particularly, to UN are also covered.

Table 2: Aid Flow under Different Heads

Bilateral Grants	Contributions to Multilateral Institutions
<ul style="list-style-type: none"> • Technical Cooperation • Developmental Food Aid 	<ul style="list-style-type: none"> • UN and Others
<ul style="list-style-type: none"> • Humanitarian Aid • Debt Relief Grants • Aid to NGOs • Administrative Costs 	The Private Sector <ul style="list-style-type: none"> • Preferential Access to Markets • Export Credits
<ul style="list-style-type: none"> • Other (project and Programme Grants) 	Special Themes <ul style="list-style-type: none"> • Collaborations in S&T
Bilateral Loans	

Bilateral Economic and Technical Assistance

India has been a generous partner for economic development of fellow developing countries. As the **Table 3** shows, the quantum of development assistance in 1985-86 was Rs. 1.5 billion which has increased to Rs. 19 billion by 2005-06. The major recipients of this programme have been the neighboring countries and some of the major African economies. The table shows lot of fluctuations across different years, particularly in some cases, such as Bangladesh and Africa, which probably may be because of the funding of specific large infrastructural projects in particular years. Neighbouring countries such as Bhutan, Maldives, Nepal and Sri Lanka have shown consistent increase in inflow of Indian development assistance.

Table 3: Allocations on ITEC Programme (1985-2006)

	(Rs. Million)					
	1985-86	% Share	1995-96	% Share	2005-06	%Share
ITEC	188.8	12.13	-	0.00	555	2.88
Total No. of Trainees	-		427		2014	
Total	1556.4		2295.2		19296.2	

Note: Share in total allocation for development assistance by India.

Source: Chaturvedi (2007).

ITEC Programme

The rise in engagement of Southern economies in the science and technology sector is largely hampered by lack of adequate and trained manpower. India has made concerted efforts for enhancing technical cooperation and capacity building. As a part of this, training programmes have been the major policy plank. There are two important components of this, viz. ITEC (Indian Technical and Economic Cooperation programme) and SCAAP (Special Commonwealth Assistance for Africa Programme). India spends about Rs.500 million annually on ITEC activities. Since its inception in 1964, India has provided over US \$2 billion worth of technical assistance to developing countries through this programme.¹⁴ As the **Table 3** shows, there is a considerable increase in Indian governments allocation for ITEC programme which increased from Rs. 189 million to Rs. 555 million over the period of 1985-86 to 2005-06. During the period 1995-96 to 2005-06 number of trainees increased from 427 to 2014 as shown in **Figure 1** and **Figure 2**. The strategy of the Indian government seems to be of diversifying the focus of ITEC programme to cover many other developing countries. In Figure 1 the intake from Asian countries was 57 per cent and from Africa was 32 while from other developing countries it was just 11 per cent. This changed by 2005-06 when we find more participation of other developing countries (19 per cent) balanced with Africa (19 per cent). It shows an increase in case of Asia, but if we look at the number of countries participating in the programme one finds that the number has increased from 26 in 1995-96 to 48 in 2005-06. This includes several LDCs from the Asian region.

Figure 1: Regional Distribution of ITEC Programmes (1995-96)

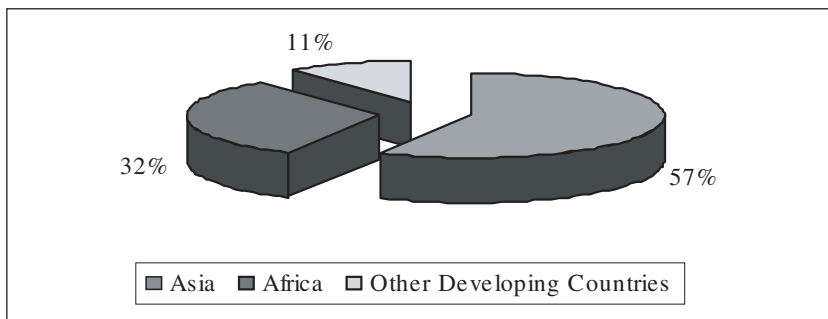
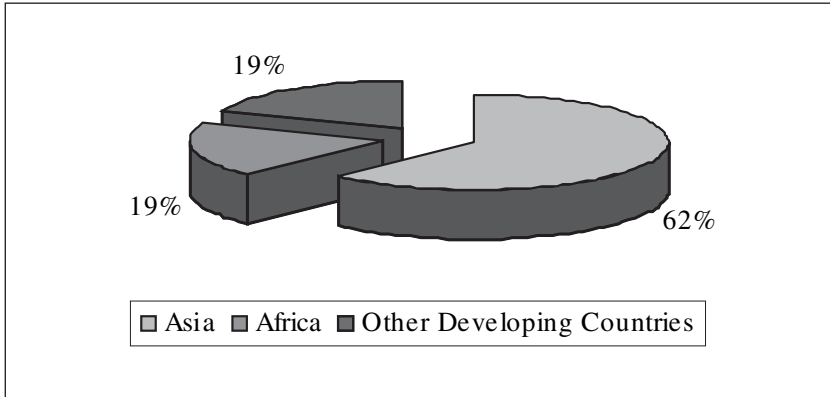


Figure 2: Regional Distribution of ITEC Training Programmes (2005-06)



Indian Technical Economic Cooperation has five components, viz. (1) Training in India of nominees of ITEC partner countries (there is a growing focus on new issues in trade, investment and technology); (2) Projects and project related activities such as feasibility studies and consultancy services (at time this is also extended to support regional programmes Under the Economic Commission for Africa, Group of 77, AARRO (Afro-Asian Rural Reconstruction Organisation), G-15 and SADC (Southern African Development Community); (3) Deputation of Indian experts abroad; (4) Study Tours; and (5) Aid for Disaster Relief (ADR).

The project related assistance varies from case to case; for instance, under ITEC programme a donation of US\$ 200,000 solar energy plant to Colombia was provided in 2002. As is clear from the Table 3, allocations for the ITEC programmes have expanded from Rs. 189 million in 1985-86 to nearly Rs. 600 million in 2005-06, though the share of ITEC programme in the total allocation for development assistance has declined. This may be because assistance to other developing countries has expanded in a major way; for instance, aid to Nepal expanded from Rs. 173 million in 1985-86 to Rs. 661 million in 2004-05, almost an increase of 282 per cent. Similarly, in case of Africa the assistance expanded from Rs. 166 million to Rs. 1068 million (543 per cent) in the same period.

Indian industry organisations are also participating in this effort in a major way. The Confederation of Indian Industry (CII) has been undertaking several measures for capacity building and technology transfer. CII organized an International Training Programme on IT Applications in Manufacturing (ITAM) at Ebene Cybercity, Mauritius in 2006.¹⁵ The idea was to provide the participants with comprehensive understanding of the processes of IT applications in manufacturing, particularly relevant to automation and semi-automation in apparel industry and to upgrade them with abilities to introduce and manage IT applications in manufacturing areas effectively in their organizations so that they could enhance their performance and output at the minimum possible cost. Integration of information technology and communication across functional areas is actually helping companies become more productive and effective as a global competitor

India as Source of Investment and Technology

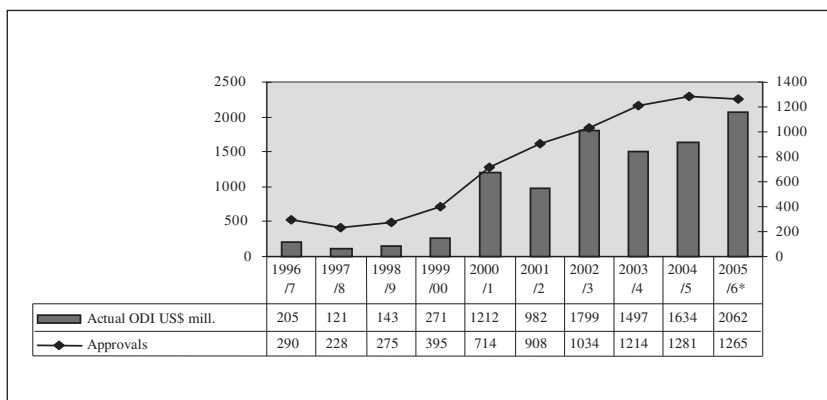
The Southern countries have emerged as an important source of investment and technology for the fellow developing countries. Out of the large outflow from the South, almost 70 per cent has gone to Asia as among the major investors were also from this region only. They included Hong Kong (China), the Russian Federation, Singapore, Taiwan Province of China, Brazil and China (UNCTAD 2006). In fact there is a growing competition between the other developing countries and the developed economies for the resources from the emerging economies. More than 90 per cent of African investment promotion agencies (IPAs) currently target FDI from other developing countries, notably from within their own region. Developed-country IPAs have also set up local offices in places such as Brazil, China, India, the Republic of Korea, Singapore and South Africa.¹⁶

In the recent past India has initiated several measures through which technologies have been made available to several other developing countries. The experience shows the supply of technology covers a wide range of options. There are high-end products requiring advance technologies and there are situations in which simple and low cost in technologies are required; for instance, on the one hand India is helping providing space research technologies through Indian Space Research

Organisation (ISRO) and at the same time is setting up a demonstration centre for small and micro-machineries in Ivory Coast in Africa. As a part of this demonstration centre, agro-based machineries would be exhibited and production would be encouraged with the help of the National Research Development Corporation (NRDC). Apart from lagging behind in technology, developing countries also have a major challenge of coping with lag of adequate number of manpower to support their R&D endeavours. In the recent past, India has also occupied an important place as a major source of investment and technology for other developing countries. As a part of liberalisation process, the Indian government has done away with stringent policy measures to check outward bound flow of foreign capital. The New Economic Policy (NEP) of 1991 proposed to facilitate outward FDI. However, some restrictions were retained for preventing capital flight and financial instability.

The evolution has taken place in a sustained manner and could be classified into two distinct phases: the pre-2003 phase and the post 2003 phase.¹⁷ The first phase was export oriented and with restrictions of cash flows from the country reflecting the need to manage capital outflows to conserve foreign exchange resources. However, the later phase had much more pragmatic vision about the ability of Indian firms. It facilitated the process of outbound Indian investment. In January 2004, government removed the upper limit of \$ 100 million and permitted private enterprises to

Figure 3: Indian Outward Investments, 1996/97 to 2005/6



invest upto 100 per cent of their net worth under automatic approval scheme. The robust macro-economic growth in the recent past, accompanied by strong corporate profitability and access to resources has facilitated a sharp growth in the outward investment. Recently the Reserve Bank of India (RBI) has further liberalized rules for overseas direct investment which now permit overseas investment upto 300 per cent of the net worth of a company, in all its Joint Ventures (JVs) and/or Wholly Owned Subsidiaries (WOSs) abroad.¹⁸

Trends in Outward Investment

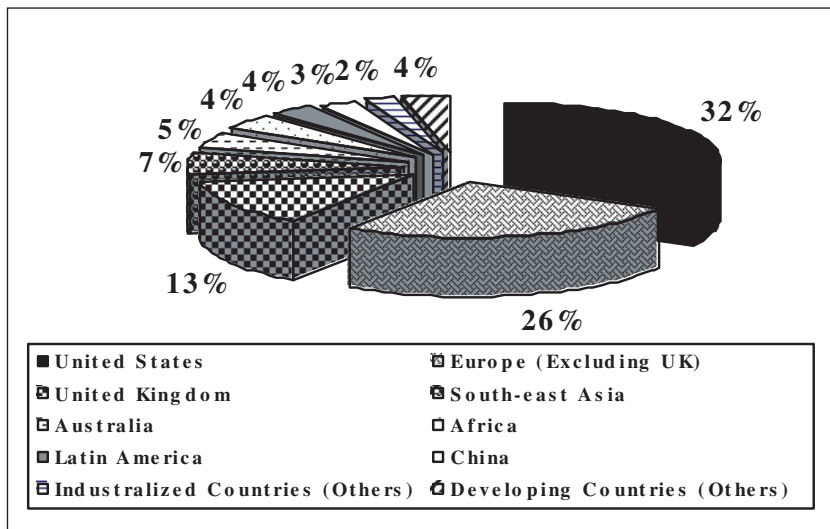
The policy changes had positive impact resulting in sharp surge in entrepreneurial endeavours. The outward investment from India has crossed US \$ 2 billion mark in 2005-06 which was just US \$ 200 million in 1996 and reached the level of US \$ 1 billion in the year 2000 (Figure 3). In 2007-08 this is likely to cross \$15 billion.¹⁹ ‘The total number of mergers and acquisitions by the Indian companies has gone up in a major way from 70 in 2004 to 170 in 2006. These mergers and acquisitions involved a transaction expansion from \$7.5 billion in 2004 to \$21.4 in 2006. The total outbound cross-border deals in the first two months of 2007 were 40 with a value of \$21 billion.²⁰

The geographical coverage of these mergers and acquisitions is clear from Figure 4. The focus of Indian companies is largely on firms in the developed countries, particularly US (33 per cent) and Europe (27 per cent). As we would see later, the objective is largely to tap on technological and marketing strength of firms from these countries. The South East Asia is emerging as potential destination for investment by Indian firms from the mergers and acquisition point of view. The outward investment figures do not reflect the actual acquisition value as many of them are taking place through overseas SPV set up to raise finances from international market and such transactions are not captured in the overseas investment statistics.²¹

Simple to Knowledge Intensive Manufacturing Goods

The Indian FDI in manufacturing sector has moved away from the production of simple traditional goods to knowledge intensive products. The private

**Figure 4: Foreign Acquisitions by Indian Firms: 2000-2006
(Geographical Distribution)**



companies have also placed themselves as source of high technology and are facilitating capacity building efforts for production of value added goods. The trade pattern clearly shows that instead of importing natural minerals and resources, investments are intended to produce with value addition. For instance, Jindal Steel and Power (JSPL) has signed an agreement with Bolivian government for production of 1.7 million tonnes of steel with investment of US \$ 2.1 billion.²² Similarly, Tata Steel has announced investment of US \$ 1.3 billion in Vietnam for value added steel production.²³ In Malaysian manufacturing sector India has 144 projects with Indian investments worth US\$ 420 million.²⁴ Indian companies are also poised to invest in Thailand (auto components sector), in Indonesia and Vietnam (motor vehicles and energy sector), and in the Philippines (ICT sector). These opportunities arise from substantial complementarities that exist between India and ASEAN in factor endowments, economic structure, skills and capabilities.²⁵

Increasing Greenfield Investment

Several Indian companies, which were earlier interested only in investing for establishing marketing networks in other countries, have now started

investing in production to tap on existing synergies with the host economies. As is clear from **Table 4**, investment in manufacturing sector has expanded in a major way from US \$ 169 million in 2000-01 to US \$ 1.5 billion in 2005-06. This is almost 57 per cent of total out-bound FDI in 2005-06. In the manufacturing sector automobiles, pharmaceutical, cement and infrastructure related investments are the leading areas in which investment is going up.

Table 4: Sectoral Distribution of FDI from India US \$ Million

Sector	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Manufacturing	169	528	1271	893	1068	1538
Financial Services	6	4	3	1	7	156
Non-Financial Services	470	350	404	456	283	531
Trading	52	79	82	113	181	215
Others	12	20	38	31	108	239
Total	709	981	1798	1494	1647	2679

Source: Nayyar (2007).

The top three companies in the pharmaceutical sector along with others have drawn extensive plans for investment in South East Asia. These companies are; Dr Reddy's, Ranbaxy and Cipla. In South East Asia, Malaysia is at the centre of expansion in this sector, as Malaysia has become one of the first countries of ASEAN to gain the membership in Europe's Pharmaceutical Inspection Cooperation Scheme (PICS), which would provide direct access to other markets for exports. Ranbaxy Malaysia Sdn. Bhd (RMSB), a subsidiary of Ranbaxy Laboratories Ltd, has commissioned its new manufacturing facility in Sungai Petani, Kedah, Malaysia.²⁶ This unit is expected to enhance the company's manufacturing capabilities in Malaysia. The plant will meet the growing demand for generic and branded medicines in the local markets and will also position RMSB as a significant supplier of formulations for the ASEAN region. Similarly, another company Cipla has raised US\$170mn through global depository receipts in April 2006 and is planning to invest for acquiring manufacturing possibilities in South East Asia.²⁷ Dr Reddy's Laboratories (DRL) has signed an agreement with Kunshan Double-Crane

Pharmaceutical Company of Jiangsu province. DRL will hold a 51 per cent stake in the joint venture (JV), with an investment of \$56 million over three years. The JV will produce and bulk formulations, tablets, capsules, ointments, gels etc and sell “self-made” products.²⁸

Investments in Africa

Access to Technology

As Table 4 shows, there is also a sharp increase in Indian investments in developed countries as well. Increasingly Indian firms are investing in high technology firms in the US and the EU for ensuring access to technologies and knowledge. Indian IT company WIPRO acquired the US company Nerve Wire Inc. to gain domain knowledge and other IT-related advantages including access to markets. Another Indian company, I-Flex, acquired the US company Supersolutions Corp. for access to technologies and knowledge. Access to technologies involves setting up research and development (R&D) centres in key locations. Similarly, the NIIT Group recently acquired Element K, a leading provider of learning solutions in North America, for a consideration of \$40 million. Together, NIIT and Element K have emerged as the leading global provider of comprehensive learning solutions, with more than 3,000 employees, over \$ 250 million in revenue and a presence in 32 countries.

Training of Manpower

In most of the developing countries there is a growing demand for computer professionals trained in the latest computer technologies. Some of the Indian companies have entered in the IT training and education sector. NIIT and APTECH are the leading ones apart from a few others. Aptech has 260 international centers out of a total of 3,208.²⁹ In Africa, it is active in Nigeria, Uganda, Ghana, Zambia, Mauritius and Tanzania. NIIT has opened seven centers for training of manpower in the IT sector in South Asian countries. In 2003-04 more than 12,800 students got trained in the ICT from NIIT in South Asia (excluding India). NIIT with its turn-over of USD325 million pioneered in IT education and training and has diversified in global information technology cooperation. NIIT has a presence in over 44 countries with nearly 4500 centers. NIIT has also launched specific

tailor made programmes for African economies for instance in Ghana NIIT has partnered with the Open University for their BSc. (Hons) Computing and its practice course. This Open University degree programme builds upon the study that students would have completed with NIIT. With this alliance/partnership, students in Ghana would have the chance to obtain an international degree in IT without leaving the country.³⁰

Taping on Host Strengths

In many countries Indian investments are largely dependent on the selective strength of different sectors of the host countries; for instance Reliance Energy Ltd. is among the short listed companies in the bid to buy 30 per cent stake in two Indonesian coal mines.³¹ These two mines, viz. KPC and Arutmin, have important place in Indonesia as they share nearly 40 per cent of total coal production in Indonesia. Reliance Energy is also in the race to buy 30 per cent in another Bumi-owned company, IndoCoal Resources. Similarly, Mjunction a 50:50 joint venture between Steel Authority of India Ltd (SAIL) and Tata Steel have drawn extensive plans for South East Asia for production and marketing of steel.³²

Similarly, in Sri Lanka Indian tyre manufacturing company CEAT established a joint venture with Kelani Associated Holdings Ltd, in 1992, at Nagoda, Kalutara District, with an initial investment of Rs 111 million to tap on high quality rubber. The joint venture company, Associated CEAT Pvt. Ltd (ACPL), dominates the local truck tyre market with a 45 per cent market share. It is also exporting to markets in Pakistan, Bangladesh, Africa and the Middle East

India as Emerging Source of Technology

In addition to government led initiatives, Indian academic institutions and private sector companies have established extensive linkages with other developing countries for providing access to technology. In this section we provide an overview of these linkages in different realms of technology.

Drugs and Pharmaceuticals

India so far has been a major exporter of generics to African and other developing countries. However, in the recent past Indian companies

have lunched major efforts to excel in the area of medical biotechnology. Among the established players, there is a clear work plan to move upward in the value chain. The Ranbaxy Laboratories is likely to emerge (by 2011) with the first new chemical entity (NCE) for a new drug molecule that can be patented.³³ The drug, RBX11160, developed with NGO Medicines for Malaria Venture, is undergoing Phase IIB dose range finding studies in India, Thailand and Africa.

With the advent of biotechnology, the innovation system for India's pharmaceutical sector seems to be getting set for a major paradigm shift. The shift is from chemistry driven drug development to biobased drug development with sharp focus on biotechnology and genomics. The Indian biopharmaceutical³⁴ market is valued at around \$1.05 billion and is growing at nearly 32 per cent.³⁵ In addition, public allocations for medical biotechnology have increased by 69 per cent in the time period 2001-02 to 2005-06 which may transform the innovative ability of generics producing Indian drug industry up in the value chain. The recently published draft *National Biotechnology Development Strategy* (NBDS), from the Department of Biotechnology has outlined the importance being attached to the development of the biopharmaceutical sector. The pervasive entry of biotechnology into the pharmaceutical industry would further enhance the innovation system through the processes of specialization.³⁶ This may have varied implications for the current institutional and regulatory framework, for evolution of knowledge within the pharmaceutical industry and also on inter-firm relationships. These changes eventually may provide new trajectory of inter-linkages especially in the context of growing global connections of the sector.

The companies in medical biotechnology in India can be divided into three broad categories.³⁷ One is that of small start-up companies that have indigenously developed biotech products, for example, Shantha Biotech and Bharat Biotech, etc. Then there are large companies, which have started responding to biotechnology and have, in fact, incorporated biotechnology in their work plan. They are from the pharmaceuticals and from other business background as well. Among the pharma companies, examples may include, Zydus Cadila, Nicholas Piramal, Dr. Reddy's Laboratory (DRL), Ranbaxy Laboratories and Wockhardt Ltd. Among the

non pharma firms petro-chemical giant Reliance, through Reliance Life Sciences (RLS), has entered the industry with major takeovers of foreign firms like that of the UK based biotechnology firm GeneMedix with investment of \$28 million and an unidentified US based nanotechnology firm for \$1 billion.³⁸ The third group has start-ups, which are all set to emerge as contract research organisations (CROs). Largely their work comes from TNCs. Then there are companies like Biocon India which may not fit well in this kind of classification as they have an established presence in the industrial biotechnology (the fermentation sector) and a growing presence in the biopharmaceutical sector, so eventually encompass our first and second category. Biocon and its two subsidiary companies, Syngene International Pvt. Ltd and Clinigene International Pvt. Ltd, form a fully integrated biotechnology enterprise, specializing in biopharmaceuticals, custom research, clinical research and enzymes. Clinigene International was set up to initiate longitudinal clinical studies in select disease segments.³⁹ Another major company Wockhardt has reported its sales recently. The company's business grew by 26 per cent in first half of 2006. Biotech products Wosulin (recombinant insulin) and Wepox (erythropoietin) contributed to 35 per cent and 28 per cent of the company's growth respectively.⁴⁰ In biopharmaceuticals, outsourcing is another area in which many Indian firms are engaged in. They are largely in the ambit of clinical trials, contract manufacturing and sales force solutions. At present, the turnover of CROs is very close to \$100 million.⁴¹ As is clear from the Table 5, of the 20 recombinant products approved in India there are nearly seven of these biopharmaceutical products being produced in India by six indigenous companies, rest all the products are being imported. In the vaccines market is largely focussed on Hepatitis B vaccine, for which price competition has intensified.

Similarly, domestic companies are making some headway in the therapeutics and diagnostics as well. Among the established players there is a visible urge to move upward in the value chain on their own and also with the help of alliances. The Ranbaxy Laboratories is likely to emerge (by 2011) with India's first new chemical entity (NCE) for a new drug molecule that can be patented.⁴² Apart from the anti-malaria molecule, Ranbaxy is developing two with GlaxoSmithKline and seven others on its own. Similarly Dr Reddy's is attempting to develop anti-diabetes molecule

(DRF 2593) and nine of them at various stages between toxicity studies and final human trials. Glenmark has six: two in Phase II trials, one in Phase I, and three in pre-clinical. Wockhardt too has six in the pipeline, of which the most advanced is in Phase II human clinical trials.

The resurgence of private sector is largely backed by a growing number of alliances with the public sector institutions and laboratories. Most of the firms mentioned in the [Table 5](#) have entered in to the joint ventures with the public sector institutions for transfer of technology. Most of these JVs have proved out to be a win-win situation. This was a rare possibility till few years back. One of the explanations is the fast changing work culture at the public sector institutions. Encouraged by the government for revenue generation the Indian scientists from leading institutions are now actively floating their own companies. For instance, two scientists from Indian Institute of Scientists (IISc), Bangalore have floated a company called Metahelix Life Sciences with \$1.5 million venture capital funding. The company would focus on providing contract research services in genomics, molecular markers and bioinformatics, to begin with and eventually developing new molecules on its own.⁴³ Similarly, three public sector laboratories working under the Council of Scientific and Industrial Research (CSIR), viz. Central Drug Research Institute, Indian Institute of Chemical Technology and National Chemical Laboratory, and the University of Hyderabad in collaboration with a private company Lupin Pvt. Limited developed a new therapeutic molecule for Tuberculosis. This molecule has shown the potential to cure TB in around two months, as against the standard treatment of six to eight months. After completing the pre-clinical studies, the molecule transformed into a drug called Sudoterb is scheduled to undergo clinical trials in humans. India is also working on emulating the Patent and Trademark Law Amendments Act more commonly known as the Bayh-Dole Act, 1980 of the US.⁴⁴ In India, a similar Act is likely to boost R&D efforts and promote technology transfer by creating incentives for university researchers to consider the practical applications of their discoveries, and for universities to search out potential companies to develop them. It is expected that an Act on the lines of the Bayh-Dole will enable corporations to negotiate exclusive licenses of promising technologies.

Table 5: Biopharmaceutical Products in India

Sector	Type	Product Name	Application	Producer ^a
Vaccines	Recombinant hepatitis B surface antigen	Shanvac-B	Hepatitis B	Shantha Biotechnics
	Recombinant hepatitis B surface antigen	Revac-B	Hepatitis B	Bharat Biotech
	Recombinant hepatitis B surface antigen	Gene Vac-B	Hepatitis B	Serum Institute of India
	Purified capsular polysaccharide Vi of <i>Salmonella typhi</i>	Typbar Vi	Typhoid	Bharat Biotech
Therapeutics	Recombinant human insulin	Wosulin	Diabetes	Wockhardt (Mumbai)
	Recombinant human erythropoietin á	Epox	Anemia	Wockhardt
	Recombinant human interferon á-2b	Shanferon	Cancer	Shantha Biotechnics
	Recombinant streptokinase	Shankinase	Cardiovascular	Shantha Biotechnics
		Indikinase	Cardiovascular	Bharat Biotech
	Liposomal amphotericin B injection	Fungisome	Visceral leishmaniasis	Lifecare Innovations (New Delhi)
	Recombinant human granulocyte colony-stimulating factor	Gramstim	Neutropenia	Dr. Reddy's Laboratories
Diagnostics	Immunoblot assays using recombinant HIV-1 antigens gp41 and C-terminus of gp-120 and HIV-2 antigen gp-36	HIV TRI-DO	HIV-1 and THIV-2	J. Mitra (New Delhi)
	Immunoblot assay using recombinant HIV-1 antigens gp-41 and gp-120, HIV-2 antigen gp-36, and HCV antigens NS-3, NC-4 and NC-5	HIV-HCV Combo	HIV and hepatitis C	Bhat Biotech India (Bangalore)
	Enzyme-linked immunosorbent assay for recombinant HCV core antigens 1b &3g, together with peptides for HCV antigens NS-3, NS-4 1, NS-4 2, and NS-5	HEP-Chex C	Hepatitis C	XCyton Diagnostics (Bangalore)
	Enzyme-linked immunosorbent assay for recombinant version of <i>Taenia solium</i> excretory/secretory antigens	Cysti-Chex	Neurocysticercosis	XCyton Diagnostics

Source: Chaturvedi (2007).

Information and Communication Technology

India has undertaken several measures to support adoption and diffusion of ICT in the developing world. There are several products developed in India which are of direct relevance to the catching up process. One of them is simputer.

Simputer stands for “simple, inexpensive, multilingual computer”. One of the important contributions from India is the Simputer which may prove out to be an effective instrument for overcoming digital divide.⁴⁵ It is often described as a low cost portable alternative to PCs but the ‘Win-tel’ architecture of the *de facto* standard PC is quite unsuitable for deployment in the low-cost mass-market of any developing country. The Simputer is targeted as a shared computing device for a local community of users. A local community such as the village panchayat or the village school, or a kiosk, should be able to give this device out to individuals for a specific period of time and then pass it on to others in the community. The Simputer specifications are released under an open distribution license called the Simputer General Public License or the SGPL. Free software developers are being actively encouraged to port their applications to the Simputer.

This machine would have greater relevance for the South as it ensures that illiteracy is no longer a barrier to handling a computer. It is an outcome of a research project at the Indian Institute of Science, Bangalore. The production and marketing is managed by a Simputer Trust, in which academics from Indian Institute of Science (Bangalore) and technologists from Encore Software Ltd (Bangalore), work together. The key to bridging the digital divide is to have shared devices that permit truly simple and natural user interfaces based on sight, touch and audio. The Simputer meets these demands through a browser for the Information Markup Language (IML). IML has been created to provide a uniform experience to users and to allow rapid development of solutions on any platform. Encore Simputer has observed a quantum jump in sales of its handheld computer from the level of 4,000 units to 50,000 in the time period 2002 to 2004. Out of this almost 15 per cent is being exported to other developing countries. The cost of the unit has remained around \$250. The Simputer is now being manufactured in Mauritius by a company which hopes to target both Indian and African markets.

The recent introduction of third-generation mobile technology in Asia has further raised the concerns about the widening digital divide as countries in South and Southeast Asia, are still struggling just to get a dial tone.⁴⁶ Moreover, in Bangladesh, there is one telephone line for every 100 people, while in India and Pakistan, the ratio is only a little better. These fixed line obstacles also ring true in the wireless world. The access in wireless is still more limited. It is difficult to have high-speed communication in China, India and Indonesia. In this regard, most of the South Asia is in a difficult spot. Some of the countries do not have the resources to get the equipment and develop the applications.

This also limits the application of new trade instruments like e-commerce. The importance of e-commerce is that it allows enterprises to become efficient in all the stages of their production and distribution processes. While more and more people are using the internet which is a prerequisite for e-commerce, the increase is not indicative of increase in e-commerce. The importance of e-commerce is that it allows enterprises to become efficient in all the stages of their production and distribution processes. According to the International Telecommunication Union (ITU), the number of Internet users worldwide stood at 500 million people at the end of 2001 while in South Asia, the number is very low. In 2007 in India the total number of internet users is seven million and one million in Pakistan. The number in other South Asian countries is just in few thousands.

Therefore, there is an urgent need in South Asia for developing a regional information infrastructure which may be called as South Asia Information Network that could facilitate the unique ability to market goods and services, provide consumers with timely information and an additional means of guiding consumers to the producers. The South Asia Information Network may also work towards the development of small businesses so that they manage their finances and expenses online and place orders online through business-to-business portals where farmers and producers may ensure getting best prices. However, this may require additional resources, expertise and broadband connectivity to take full advantage of the information technology. The agenda at this network may

also include developing software packages in the regional languages which then may be made available to farmers and other marginal sections of the society also develop low cost equipment/computers, which can be used in the rural areas. Similarly, development of graphic interface/touch screen to make them accessible to relatively less educated rural folks. India has already initiated work on establishing e-Africa network with large scale supply of technical know-how and gadgets like optic fibre cables, etc.

There are on-going programmes for upgrading skills in the ICT sector. However, with the availability of a strong IT- related skill base in India, it can undertake joint workshops and impart technical training in related fields to the African counterparts. Some of the initiatives have already been launched. As for example, the Ghana-based India Kofi Annan Centre for Excellence in ICT, set up in the year 2003 may be further upgraded to work as a sub-regional centre for training of semi-skilled people. The centre in any case seeks to promote ICT growth in ECOWAS, and envisages enhancing of the environment for innovation, training and learning. It is time to consolidate these initiatives so that other countries of the African region also gain effectively. The private sector in India particularly can set up IT training centres in different African countries and impart training on software development, web designing, web programming, database management, business computing and networking.

Some of the major Indian educational enterprises are already there in different African cities. Global Indian giants NIIT and Aptech have been in Khartoum for ten years and five years respectively in the training sector. During this period, thousands of Sudanese have trained with “the Indians” and found high-paying jobs. NIIT is now aiming to enter South Sudan.

Communication Technology

India is presently working close with the NEPAD e-African Commission for improving the telecom infrastructure. Africa lacks about 52040 km of backbone infrastructure related to the ICT industry. As different African countries embark upon projects related to structuring and development of ICT infrastructure, there is bound to be a huge demand for telecom equipment and related products, which may be made available by India at

competitive costs. It is also important to note that the Pan Africa e-network project launched by the Government of India to develop ICT infrastructure in Africa is a very positive initiative. India is likely to contribute US\$ 1 billion under this programme, which is being acknowledged as the biggest infrastructure project in Africa. Although the mobile telephony segment in Africa has witnessed unprecedented growth over the past five years, there is still a huge potential for further expansion. As mentioned earlier, the penetration rate for mobile telephony in Africa in the year 2007 was 28 per 100 inhabitants compared to 35.9 in Asia, 64.2 in the Americas, 97.7 in Europe, and 72.1 in Oceania. There is thus a tremendous potential for the Indian companies to venture into mobile telephony in Africa. There also exists a similar opportunity for Indian companies in the fixed line telephony segment.

Some Indian companies have already expanded their operations in Africa. For instance, Tata Africa and VSNL made a bid for and acquired a 26 per cent stake in South Africa's second largest national fixed line operator. The company seeks to provide a whole range of telecommunication services in Africa (basic voice and data services, high speed internet and true broadband, virtual private network, network management and hosting services), except for the full mobile services. The company has already started laying down cables and putting a wireless network in place. Similarly, the internet market in Africa is very competitive, allowing for both full as well as partial competition. With access to internet scattered in a few countries, there is a huge potential to expand the coverage of internet services so that these can be made available to the common people. Also with tremendous scope for Africa to venture into e-governance, e-banking, e-education, etc. there is an immediate need to widen the broadband access in the continent. India can provide very useful assistance in the development of this segment to Africa.

E-Governance Applications

The advent of IT as a tool for delivery of products and services has also brought a fundamental shift in the manner of public governance with the emergence of e-governance.⁴⁷ Information technology can empower rural people by allowing access to information and by providing tools for

analyzing it. In agriculture, for instance, the technology may help in keeping the information about the land records readily available for farmers. This may also provide details about market demand, prices, rainfall conditions and details about various inputs required on the farms.

The Gyandoot project (Messenger of Information), attempted in Madhya Pradesh, India is one of the prominent examples of e-governance for rural areas.⁴⁸ The project was proposed as a low cost, self-sustainable and community owned rural intranet project on the G2C model (government to citizen). During the course of the project computers in 20 village centres were wired through a intranet network. These are being managed by local youth, on commercial lines, without any salary and stipend. This project has helped farmers in various ways, for example, farmers in the Bagadi village were getting a rate of Rs. 300 per quintal from local trader for their potato crop. Through the intranet the farmers found that the current rate in the Indore market was Rs. 400 per quintal. They now take their produce to the Indore market directly. Similarly, sometime back epidemic among cattles in a particular block in this village was immediately informed in the whole district within half an hour. This could save several lives and helped farmers in coping up with the adverse production conditions.

Alternative Energy Sources

The 'New and Renewable Energy Policy Statement' 2005, from the Ministry of Non Conventional Energy Sources proposes a direction and strategic vision for developing renewable energy sources to meet medium to long-term requirements. The statement proposes a policy direction for making the new and renewable energy sector a net foreign exchange earner by 2021-22. However, some allocations are being made at different levels, which may help in facilitating the production process. The Indian government has earmarked Rs. 500 million (US\$ 10.7 million) to support the cultivation of jatropha. Apart from this, the government is also providing support to nine states for production of jatropha seeds. The estimation is that by 2009 India would have 3.1 million hectares of jatropha plantations. However, with the growing emphasis on jatropha plantation for biofuel production, the prices of jatropha seeds have gone up, which government is considering to address on priority.⁴⁹ In 2004, the price of jatropha bought from tribal areas was Rs. 6 per kg while now it has gone upto Rs. 26 per kg.

As the **Table 6** shows, states have established institutional structures to overhead the development plans. Most of the States have identified a clear role for the development of the private sector. In fact some of them have tied up with select public sector banks to support jatropa plantation; for instance, Tamil Nadu has tied up with the Indian Overseas Bank to support private enterprise in the state for jatropa production. One of the first firm to get such a support is Classic Jatropa Oil Limited.⁵⁰ Chattisgarh is taking lead in several ways in terms of establishing the usage and production of biodiesel. This state has established a Biofuel Development Authority with clear guidelines for private sector participation. The other leading states are Andhra Pradesh and Tamil Nadu.

Table 6: Independent Initiatives Launched by Select States in India

Proactive States	Strategy and Objective	Institutional Structure
Chattisgarh	20,000 hectare under jatropa. Clear plantation guidelines for private sector	Biofuel Development Authority
Andhra Pradesh	728,000 hectare land under jatropa	Separate Department to monitor and guide.
Tamil Nadu	Policy objective is to derive full diesel requirements from Jatropa.	

Source: Chaturvedi (2006).

R&D Initiatives

The research regarding biofuels is still at an initial stage and commercial production is yet to begin.⁵¹ The Department of Scientific and Industrial Research (DSIR) has taken some initiatives to produce biofuel, especially from ‘Jatropa Curcus’ plant in large tracts of wasteland in the country, which can be utilized and the farmers can benefit a lot from the commercial production of this plant.

The Department of Biotechnology (DBT) of Government of India has also launched the Mission Programme on Bioenergy and Biofuel and a Micro-mission Project for developing quality planting material of Jatropa.⁵² As a part of this the collection and characterization of germplasm and establishment of nurseries and demonstration plots, using

superior quality material, based on yield and oil content, has been initiated. Over 770 accessions have been collected so far from different parts of the country and they are being grown in an area of nearly 185 hectares. Central Salt and Marine Chemical Research Institute (CSMCRI), Bhavnagar, has successfully cultivated good varieties of *Jatropha curcus* on marginal land to assess practically realizable seed yields. The Daimler Chrysler (DC) India has signed an agreement with CSMCRI to develop biofuel for their C-Class Mercedes- Benz. This would be at the 30 hectares being cultivated by DC in Orissa and Gujrat with a cost of Euros 600,000. Indian Oil has worked on establishing the production parameters of transesterified jatropha oil and use of biodiesel in its R&D Centre at Faridabad.

The recently held India, Brazil, South Africa trilateral summit, attended by heads of state, discussed ways and means to promote ethanol as IBSA members announced their joining of the International Ethanol Initiative launched by Brazil. The leaders from the three countries agreed to boost cooperation on energy, including the development of alternatives to oil and possibly nuclear power. The Summit was held in Brasilia, the capital of Brazil, after the trio established the IBSA Forum to serve the interests of emerging markets.⁵³

Indian state-owned oil companies have shown a keen interest in acquiring sugarcane acreages either on their own or in collaboration with Brazilian state firms to produce bioethanol. Indian state-run Bharat Petroleum Corporation Limited is all set to buy stakes in Brazilian sugarcane projects to secure ethanol imports. There is also an interest in Common Market for Eastern and Southern Africa (COMESA) led by Mauritius to come up with a proposal of feed production for ethanol and biodiesel. India is likely to sign a Comprehensive Economic Partnership Agreement (CEPA) with COMESA, which includes Egypt, Zimbabwe, Seychelles, Madagascar, Uganda, Kenya and Libya. India would help the transfer of techniques for jatropha cultivation.

In light of this, the Asian economies should also consider initiating similar programmes and consolidating the ongoing efforts, based on the complementary nature of the region for their collective advancement.

Seeds and Agro Food Chains

India has emerged as major seeds market in the recent past. The United States has continued to remain major supplier of seeds. In 1991 the value of imports from US was US \$ 1.49 million which increased to US \$ 5 million in 2005 (Table 7). In 2008, India imported seeds worth US \$ 11 million. The other major suppliers in 2005 were Turkey (US \$ 7 million), Thailand (SU \$ 4 million), the Netherlands (US \$ 4 million) and Indonesia (US \$ 3 million). The key difference from 1991 is that the total number of seed suppliers has gone up from 20 to 52 in 2005. Unlike in exports there is no consolidation in the import sector. Smaller quantity of imports from large number of countries continued as a major trend except for a few top countries which continued in the top ten seed suppliers. These were the US, the Netherlands and Afghanistan. Thailand and Turkey have emerged as major sources of imports in recent years. Thailand is a major source for vegetable seeds amounting to US \$ 2.16 million while Turkey emerged as major supplier of oilseeds amounting to US \$ 7 million.

Table 7: Key Developing Countries Supplying Seeds to India (US \$ Million)

Top 10	1991	% Share	Top 10	2005	% Share
Pakistan	1.45	9.87	Turkey	6.69	6.76
Nepal	0.9	6.13	Thailand	4.26	4.30
Afghanistan	0.62	4.22	Indonesia	3.33	3.36
			Ghana	3.25	3.28
			South Korea	2.7	2.73
			Afghanistan	1.78	1.80
Top 10 total	7.03	47.86	Top 10 Total	34.7	35.06
Grand Total	14.69		Grand Total	98.98	

Source: CMIE, India Trades.

In the last decade or so the stagnation in productivity of major food crops has become a cause of concern in the rural areas. Several national and international research agencies are already working in this direction. However, there is a scope for initiating joint research projects at the regional level to address these concerns. Biotechnology offers several ways by which average yields can be directly increased. One is through improvements in the “architecture” of the plant to enable it to absorb more photosynthetic energy or convert a larger portion of that energy into grain rather than

stem or leaf. This was, in essence, the “Green Revolution” approach of breeding dwarfing genes into plants so that the plants could make better use of fertilizer and water and produce more grain. This approach is being pursued again in the new rice architecture being studied by the International Rice Research Institute (IRRI), as well as by some private sector interests undertaking research in the fundamental mechanisms that control plant architecture. Another approach, for climates where this is useful, is to modify the plant for a shorter growing season by enhancing its efficiency in the use of fertilizer, pesticides and water. Molecular hybridization has also been demonstrated to increase the productivity of several crops, including rice and wheat, by 15 to 20 per cent. But it must be noted that the on-farm yield improvements observed so far have been for transgenic varieties developed to reduce on-farm production costs rather than for the purpose of increasing yields.

However, it is not yet clear whether yield increasing experiences so far reflect a one-time advance, or the first stage of a continuing increase in yields. In this regard, regional cooperation may be considered as there are many new technologies that will, over time, be applicable for plant improvements. The most reasonable conjecture is that the new technologies will continue to provide yield increases, which would benefit all the stakeholders and may be introduced on a regular basis. One may be sure that each of the associated yield increases will be somewhat more than historical trends.⁵⁴ In this sector, with linkages of these markets, further focused South-South research would be far more emphatic and useful in the days to come.

Establishing Regional Gene Banks

In the recent years, increasing evidence of commercialization of products based on biodiversity and related knowledge systems have come to light. India in this context may provide major technical support to the fellow developing countries. A major contribution to this trend has been the rapidly expanding biotechnology industry. An associated development has been the increase in the number of patents and other forms of IPRs based on biodiversity and traditional knowledge system. As a result of these developments it has become imperative for the developing

countries to ensure that they get their share of benefits arising from the commercialization of biodiversity and related knowledge system. In light of the above, the Asian countries should aim at establishing an IPR Data Bank, which should have two functions.

In the first instance, the Gene Banks should develop detailed documentation of the accessions that they have made. Secondly, the Gene Banks should coordinate their activities with the IPR granting authorities in the countries of the respective regions so as to keep an account of the IPRs based on biodiversity and the related knowledge that have been taken. The information generated should be made publicly available through internet in order to support all organizations engaged in the policy making in IPR and also in technology and product development. FAO and other agencies have helped in capacity building for conservation of germplasms in the region. This needs to be further strengthened so as to make indigenous application of biotechnology in these countries possible. The region may develop mechanisms to pool and access the germplasms for cereals and other primary crops and jointly work for improvement of these varieties. This would save on the cost of establishing additional *ex situ* facilities and would also facilitate tapping of R&D synergies in the region.

R&D for Nutritional Enhancement

There are many possibilities by which new technologies may help in improving the nutritional value of cereals by enhancing the presence of special nutrients or chemicals. India may get the developing countries together to tap the potential of biotechnology for addressing food and nutritional insecurity related challenges. In this endeavour, the relationship between the public-private research institutes assumes key importance. A commercial example is the increase in the levels of biotin (vitamin H) for application in animal and human nutrition. Biotechnology has been targeted at rice for improving Vitamin A content in rice to overcome the related iron deficiencies.⁵⁵ Vitamin A deficiency, which also interferes with the bio-availability of iron, affects 413 million children worldwide that is, 7 per cent of the world population. Rice endosperm does not contain any pro-vitamin A. However, through different techniques transgenic plants carrying the genes produced seeds with yellow endosperm have been developed. The

biochemical analysis has confirmed that this yellow colour indicates the presence of pro-vitamin A.⁵⁶ Public sector breeders have also been looking into similar special purpose applications, such as inserting genes so that vitamin A and iron becomes available through the consumption of rice.⁵⁷ Regional cooperation in this area may further strengthen the efforts being made for nutritional security through the management of micronutrients.

Promoting Technical Work on IPM for Sustainability

In the past few years, the twin agricultural problems which have received constant attention in developing countries are the rising cost of agricultural production and environmental pollution caused by agricultural inputs.⁵⁸ Increase in pesticide use has been one of the major contributing factors in this regard. The global pesticide market is now being estimated at \$ 38 billion, of which the Asian market accounts for roughly \$ 7 billion.⁵⁹ The adverse social and economic implications of chemical pesticides are very well documented in most of the international environmental reports. In this context, integrated pest management (IPM) has been a widely recognized alternative technique towards the development of an environmentally sustainable agriculture. India has widely adopted IPM as a major policy option. A significant advancement in biotechnology has been the integration of traditional techniques with modern technology for production of biopesticides.

In India, biopesticides are being produced by a handful of private companies and, at present, it accounts for only 3 to 4 per cent of the global pesticide market. There are global experiences from which we may derive insights for future. In this regard, experience of cocoa producers from Indonesia is worth noting. Cocoa holds a great value for the livelihoods of the countless villagers who grow it in the countries like Indonesia where it is the second largest produce. The farming is concentrated on the island of Sulawesi where cocoa is mainly grown on plots of 1.5 hectares or less. The supply of cocoa beans to American chocolate manufacturers was valued at over \$140 million, and about 85 per cent of them came from Sulawesi. In the year 2000, the infestation of the cocoa pod borer (CPB), a pest that has destroyed up to 40 per cent of the Sulawesi crop, threatened the livelihood of the smallholder farmer. CPB infestation also reduced the quality of cocoa. However, timely access to techniques like Integrated Pest

Management (IPM) has helped farmers to retain their export share without compromising with the quality and environment.

This could become possible with the formation of a group called ‘Success Alliance’ comprising of importers and donor agencies. South Asian countries could also think of a similar network. Some of the non profit organizations like ACDI/VOCA have also played an important role in Indonesia. So far more than 37,000 farmers have been trained in integrated pest management. Crop losses have dropped by nearly 30 per cent, and incomes have increased by an average of \$541 per year. Due to this success and the strong partnership with the chocolate industry, ACDI/VOCA has received USAID funding to train an additional 40,000 farmers and to expand the activities to a new province West Papua.

The Alliance has also received funding from the Dutch government to train farmers and traders on grading and quality selection and on farmer organization and leadership, so that farmers can begin group selling and buying of inputs. Under the “Success Alliance” project, ACDI/VOCA’s private sector partners, including Hershey’s, ADM and Master foods, have agreed to purchase at least \$10 million per year in cocoa beans from Sulawesi. This guarantees a market for smallholders’ cocoa, and ensures chocolate companies’ access to more and better beans for their products. The “Success Alliance” in Indonesia has also served as the model for new projects in the Philippines and Vietnam. This may also be considered for the rest of the Asian region.

Sharing Experiences for Meeting Food Standards

The regional cooperation could be effective in sharing costs of compliance with the emerging environmental standards. The regional cooperation could also cover creation of regional institutional infrastructure such as test laboratories where the costs are high. The geographical contiguity in the region would facilitate the optimal utilization of such infrastructure. Joint training programmes and other measures to build local capacity would also be fruitful. The regional cooperation could cover joint development of products which meet the new regulations and hence sharing the costs.

In this context, a case in point is a highly successful project for development of aflatoxin risk free groundnut jointly conducted by the Indian Council of Agricultural Research and the UNDP. This project successfully brought down the aflatoxin levels to 0-5 PPB in 80 per cent of the samples at the end of three-year term project in a high risk area of Andhra Pradesh, India against the permissible limit of 15 to 20 PPB in developed countries such as Australia, Canada, and USA.⁶⁰ Such projects could be fruitfully undertaken at the regional level. Similarly, UNCTAD along with ESCAP supported a project in Bangladesh to help marine industry cop up with new standards.⁶¹ The project has facilitated and effectively transferred new technologies in fish handling, processing, packaging, quality control and marketing. These were done through various training programmes namely, Training Programme in Fish Handling, Quality Control and Value-Addition, HACCP Verification and Audit Training Programme, Training Programme in Laboratory Techniques and Advanced Training in Laboratory Techniques. The training and exposure imparted during the programs enabled the Bangladesh industry to address various product safety related issues through the implementation of new quality/safety assurance systems such as HACCP.

Synergizing S&T with Judicial Processes

India has launched some unique programmes for achieving synergy between science and technology advancements and judicial processes. As part of this, efforts are being made to brief people connected with judiciary about the areas such as forensic sciences and information and communication technology related to juridical processes. As part of this, TIFAC (Technology, Information, Forecasting and Assessment Council) organizes regular courses for judiciary, investigating agencies and S&T organisations. Apart from this, TIFAC has developed some gadgets in collaboration with private sector agencies.

Digital Pen and Paper Technology for Capturing Information at Police Station:

This project is initiated in partnership with Mumbai police and M/s. Impact Systems Pvt. Ltd., Pune. The project envisages that the information that is created at police stations through Integrated Investigation Forms (IIFs)

is to be captured through Digital Pens to facilitate its storage in a digital format, and its rapid transmission to supervisory officers along with swift retrieval of this information based on key words.

Tamperproof and Secure Courtroom Digital Recording and Video Conferencing System

A tamperproof, secure and integrated Courtroom Recording system for digitally recording and storing the courtroom proceedings and hearings along with the retrieval and authentication system have been developed. A video conferencing system amongst a court room, forensic lab, police station and jail is also envisaged. This is being implemented by CDAC, Noida, Directorate of Forensic Science, New Delhi and Directorate of Forensic Science, Gandhi Nagar.

Crime Scene Recording System

This project is being implemented in partnership with M/s. Encore Software Ltd., Bangalore and Bangalore Police. The project envisages using a portable computing device for tamper-proof acquisition, storage, and retrieval of crime scene audio and video data and to transmit and archive them in realtime for use in judicial processes

The programme currently has generated a lot of interest among the judiciary, Investigating organisations and forensic labs in the country. Use of forensic sciences and Information and Communication Technology has a huge potential to support judicial and investigative processes and improve their efficiency, transparency and reliability. As is evident, the judicial processes have all along needed and will continue to need science and technology interventions and TIFAC would continue to explore such synergy between S&T and judicial processes.

Concluding Remarks

India has launched major programmes for establishing linkages with other developing countries which have facilitated adoption of new technologies among the fellow developing countries. As has emerged from the earlier discussion, developing countries are far better placed to supply appropriate technologies with the South. The common nature of factor endowment

available with southern countries and their ability to provide cost effective professional services with appropriate size of plants and ability to scale down production as per the requirements are some of the factors helping in establishing strong linkages among the large developing countries and other developing countries. With the fast economic expansion and rapid growth of southern transnational corporations some of the specific limitations like international incentives may well be overcome. The northern TNCs could establish brand value of their products which is getting some competition only recently from South.

The fact that India focused on technical cooperation in a major way, reflects on the desire to share comparative strength with other developing countries. The changing geographical focus of ITEC training programme and diversification of thematic areas may help in further strengthening science and technology linkages with economic advancement. In this context, India needs to focus on programmes which may provide not only trained manpower to absorb advances in technologies in national economies but also help in developing integrated and sustainable approaches to minimize adverse environmental implications.

Yield Enhancement and Soil Sustainability

Some of the recent experiments undertaken and coordinated by TIFAC are specifically important. Under “Umbrella Scheme on Technology Vision 2020 Projects in Mission Mode” TIFAC undertook a “Systems Approach for Increasing Agricultural Productivity and Cattle Development” project covering 45 villages in the Walajabad panchayat union at Kancheepuram partnering with OASIS (Organic Agricultural Scientific Society for Integrated Services) at Coimbatore.⁶² A detailed village level survey was undertaken to identify gaps in technology adoption, introduce improved varieties, soil testing and networking with agricultural experts for extension support. Farmers were trained on scientific agricultural practices, sensitized on using appropriate seeds and fertilizers and Integrated Pest Management. Four hundred and fifty crop demonstrations were made in 0.5 ha plots at lead farmers’ field – each for rice, groundnut, sesame, sugarcane, brinjal, bhindi and other crops. Yield increase for rice (35-44 per cent) and groundnut (33 per cent) were achieved.

Technical Support for Production of Organics

In recent past, most of the developing countries have faced tremendous pressures related to environmental standards. These have led to rejection of several consignments from Africa, South Asia and other parts of the developing world. One way could be to get access to technologies to minimise contents of chemicals and monitor them closely. The other way could be to focus on emerging markets of organic products which has recently expanded very fast. The US is the largest single-country market for organic foods, with \$4.2 billion in sales for 1997. The organic food market in the EU is estimated to be worth \$4.5 billion. In Europe, Germany (\$1.6 billion), France (\$508 million), and the United Kingdom (\$445 million) have large organic retail sales. Consumer preference for organics is strong throughout the EU, with 20 per cent to 38 per cent regularly or occasionally purchasing organic foods. Retail price premiums in Europe vary between 10 per cent to 50 per cent above conventional products. Import shares are highest in Germany and the United Kingdom, which are major food processors, in the Europe.

However, in this regard, some constraints have come up which need to be addressed on priority.⁶³ These limitations range from industrial processing to export of these products. These impediments are in the area of production, marketing and infrastructure. Certification is seen as a barrier to small growers due to its costs. Asian regional cooperation may be explored to address challenges like coming from standards which are too high and are creating unfair barrier to production and trade. In the region there is no local certification systems for organic products, and farmers have to depend on foreign certification agencies like IFOAM and SKAL. This is very expensive and is feasible for big holdings only. Regional arrangements may reduce the cost of certification. Some regional agencies may also consider launching of regional Eco labels to reduce the cost of certification.

Focus on Appropriate Technology

There is need to assess at length specific requirements for selection of appropriate technology, for instance, among the most of the developing

countries and LDCs. The crop production is largely rain-fed which poses several challenges for the agriculture. Indian experience shows that within south several technologies are available which may help fellow developing countries. In terms of priority agriculture, food security may be seen as top priority.

Joint efforts may be made at different levels to explore possibilities for introduction of new traits in plants and crops, for instance, addressing draught and salinity resistance. In this regard, joint partnership may be explored at the different level. In this context, public sector-led efforts for development and adoption of biotechnology in food grains may help in addressing specific productivity related challenges. These developments may have significance for rice and other cereals, which are more widely grown in developing countries.

Another important possibility is to work out advancement of technology frontier in other areas like manufacturing through the usage of ICT and other advanced technologies. Many of such possibilities are discussed previously in the paper.

Endnotes

- 1 OECD (2007).
- 2 *ibid.*
- 3 The first group consists of the LDCs which are in the most backward stages of the IDP (stages 1 and 2). The newly industrialized countries are in the 3rd stage of IDP while developed countries are kept in the stages 4 and 5 depending on their respective policy frameworks.
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- 5 ASSOCHAM (2006).
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- 7 Chaturvedi (2006).
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- 9 Chaturvedi (2007).
- 10 UNCTAD (2005).
- 11 Narula (2005).
- 12 OECD (2006).
- 13 *ibid.*
- 14 Annual Report, Ministry of Finance, 2005-06.
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- 16 UNCTAD (2006).
- 17 Gopinath Shyamala (2007).
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- 27 Pharma and Healthcare Insight (2006).
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- 29 Dataquest, Tuesday, September 14, 2004.
- 30 Ghanaian Chronicle, Sep 17, 2006.
- 31 Asian Age (2007).
- 32 Business Standard (2007).
- 33 Sinha K Suveen (2007).
- 34 Biopharmaceuticals are therapeutic or preventative medicines that are derived from living cells, using recombinant DNA technology. Conventional pharmaceuticals are generally small molecules, whereas biopharmaceuticals are typically proteins, peptides, nucleic acids or inactivated viruses/bacteria. The biopharmaceuticals include insulin, Hepatitis B vaccine, Erythropoietin, Human Growth Hormones. See Chaturvedi (2007) for details.
- 35 Dogra (2006).
- 36 Quéré (2003).
- 37 This section is based on Chaturvedi (2005).
- 38 Business World 2007; Business Standard (2006).
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49 The Hindu Business Line, September 15, 2006.
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51 Rajaya Sabha (2005).
52 DBT (2006).
53 Chaturvedi (2007a).
54 G. Toenniessen, “Potentially Useful Genes for Rice Genetic Engineering,” in G. Khush & G. Toenniessen, *Rice Biotechnology* (CABI 1991).
55 In many developing countries Vitamin A is also distributed in form of pills. Perhaps these are cheaper than the GM golden rice varieties.
56 Agbiotech (1999).
57 Op. cit
58 RIS Biotechnology and Development Review (1998).
59 See Chaturvedi (2004).
60 Basu and Radhakrishnan (2001).
61 Subasinghe (2001).
62 TIFAC News (2006).
63 Saqib and Kaushik (2001).

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