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Technology Generation and Technology Transfers: Trends and Impacts in Indian Context

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Introduction

Technology is a crucial input in the industrialization and development of countries. In the current era of liberalization and globalization, technology has been identified as one the major factors impacting the international competitiveness of nations. A considerable proportion of technology is sourced from abroad in the early stages of a country's development. This technology comes either in the form of designs of machinery or that embodied in the skills of migrating experts or in the form of contracts under which process know how, product designs, rights to use, patented knowledge or copy righted designs or drawings transferred by their owner to another party for a fee.

The patterns in Technology generation and its transfer have undergone several changes in the last two decades due to the evolution of new core technologies such as ICT (Information Communication Technologies), Biotechnologies and advanced materials. The institutional framework for technology generation has also changed due to several forms of multilateral trade negotiations and adoption of TRIPS, GATT etc. Internationalization of Research and Development activities by multinational enterprises has become an established trend. These factors have changed the landscape of technology transfer and technology markets.

With this international backdrop, India has certain comparative advantages over other developing countries, particularly in the context of its need of promoting exports of high value added products and services. India has established strong technological and industrial capabilities in several areas which could as well be of considerable relevance and utility to other developing countries. A beginning has been made in exporting Indian technologies directly and indirectly to other developing and also to industrially advanced countries by sending experts and skilled manpower abroad, establishing joint ventures, undertaking turnkey projects, licensing of know-how, providing training to foreign personnel etc.

Keeping the above developments in view, this paper aims to examine the trends and patterns in technology transfers and generations in Indian context. The paper also sets out to understand the outcome of these processes.

The paper is organized as follows. Section 1 defines Technology generation and transfer. Section 2 presents certain stylized facts about R&D expenditure, IPR creation, FDI and Foreign Technology Collaborations in India. Section 3 examines certain growth indices and section 4 maps the relationships amongst all the variables studies while Section 4 concludes the discussion.

Section 1: Technology, its Generation and Transfer

The notion of technology embodies any combination of diverse skills,knowledge, or procedures. Technology may be tangible, for example, when it takes the form of plant or machinery, or intangible, when it consists, for example, of technical or managerial know-how. Although technology is frequently protected by the grant of exclusive intellectual property rights, it need not entail only highly complex and sophisticated information (Erstling, 1992).

Technology is generated by Research and Development (R&D) activities and Intellectual Property Rights generated out of R&D activities. These R&D activities in a country may either be carried out by Research Institutions set up by Government bodies or those carried out by Industrial units inhouse or through outsourcing.

Technology Transfer can, according to Mansfield (1975), take two forms – Vertical or Horizontal. Vertical technology transfer occurs when information is transmitted from basic research to applied research, from applied research to development, and from development to production. Needless to say, such transfers occur in both directions, and the form of the information changes as it moves along this dimension. Horizontal technology transfer occurs when technology used in one place, organization, or context is transferred and used in another place, organization, or context.

Erstling (1992) has identified different transactions that are required for successful transfer of technologies. They are:

• The grant and licensing of intellectual property rights;

• The transmission in documentary form of technical information or know-how (i.e., information and skills concerning the use and application of industrial techniques);

• The communication of technical information or know-how in the supply of services;

• The provision of support or services with respect to the creation of an industrial plant;

• The sale or lease of machinery, or the provision of support or services with respect to the sale of lease of machinery;

• The provision of support or services with respect to recruitment and training of staff or the establishment of accounting and managerial procedures; and

• The provision of support or services with respect to the marketing, sale, and distribution of the end product or service (Blakeney, 1989: 3)”

The above mentioned process of technology transfer may take place through strategic alliances between firms which agree to mutually use that technology, as in a joint venture or a cross-licensing agreement (Grosse, 1996).

The vehicles for Technology Transfer are Foreign Direct Investment (FDI), Licensing, Technical Assistance Contract, Training Contract, Exporting, Franchising, Training Contract, Turnkey Contract, Co-production agreement, R & D contract, Representation contract and Subcontracting (Grosse, 1996).

It can be broadly said that technology transfer arrangements are either in the form of FDI or Technological Collaboration or in the form being IPR licensing.

The next section presents some stylized facts regarding Technology Generation (in terms of R&D expenditure and IPR creation) and Technology Transfer (through FDI or Foreign Technology Transfer) in India based on the vehicles of Generation and Transfer as identified by the above literature review.

Section 2: Trends in R&D expenditure, IPR creation and FDI in India

R&D Overview

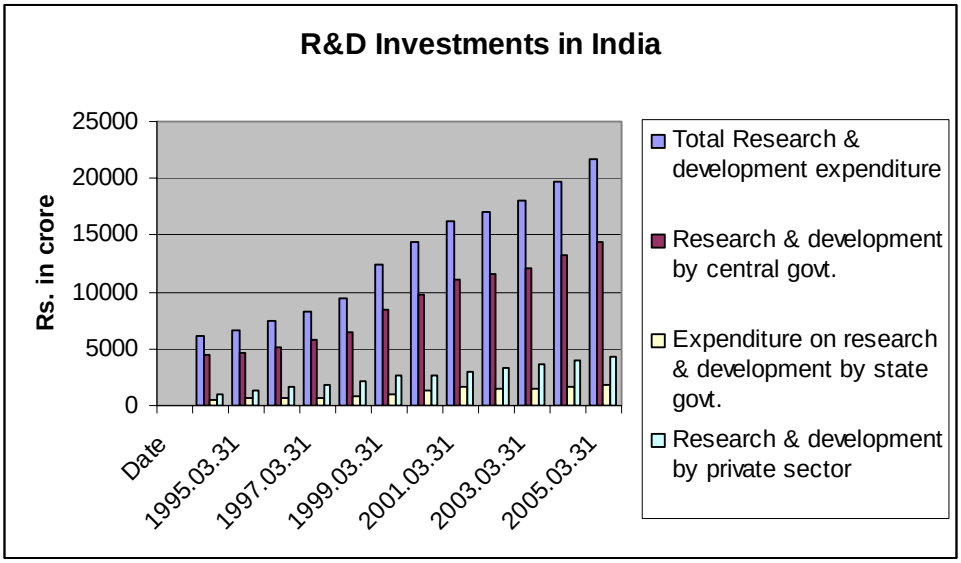
The Science and Technology Policy, 2003 of Government of India sought to achieve synergy between Industry and Scientific Research through TT and through innovative mechanisms and investments of industry in R&D either in-house or by outsourcing. Accordingly, as per the directory of R&D institutions 2006 (August) published by Ministry of Science and Technology, there are about 3960 R&D institutions in the country.

Table 1. Number of R &D Institutions in India	
Central Government R&D Institutions	707
Public Sector	115
State Government	834
Universities, Deemed Universities and Institutions of National Importance	284
Private Sector includes in-house R&D units of Private Sector Industry and SIRO of DSIR	2020
Total	**3960**

Source: R&D Overview, Department of Scientific and Industrial Research (2007)

As per the R&D statistics published by Centre for Monitoring Indian Economy (CMIE), total R&D expenditure in the country in the year 2005 was Rs.21640 crore which amounted to 0.91% of the GDP.

Fig 1



Source: CMIE

Although the R&D Investment in India has been steadily increasing as shown in Fig 1, it is much lower than the world standards. As per the R&D statistics 2004-05 published by Department of Science and Technology India is far behind various developed countries in the field of R&D. Isreal topped the chart with a R&D spending of 5.1% of its GDP.

IPR creation in India

Intellectual Property Rights includes patents, designs, trademarks and Geographical Indications. IPRs registered with the Office of Controller General Patents, Designs and Trademarks, Government of India has been witnessing a growth spurt as can be seen in Fig 2. Table 2 shows the sudden increase in patent registration from 2003-04 to 2007-08.

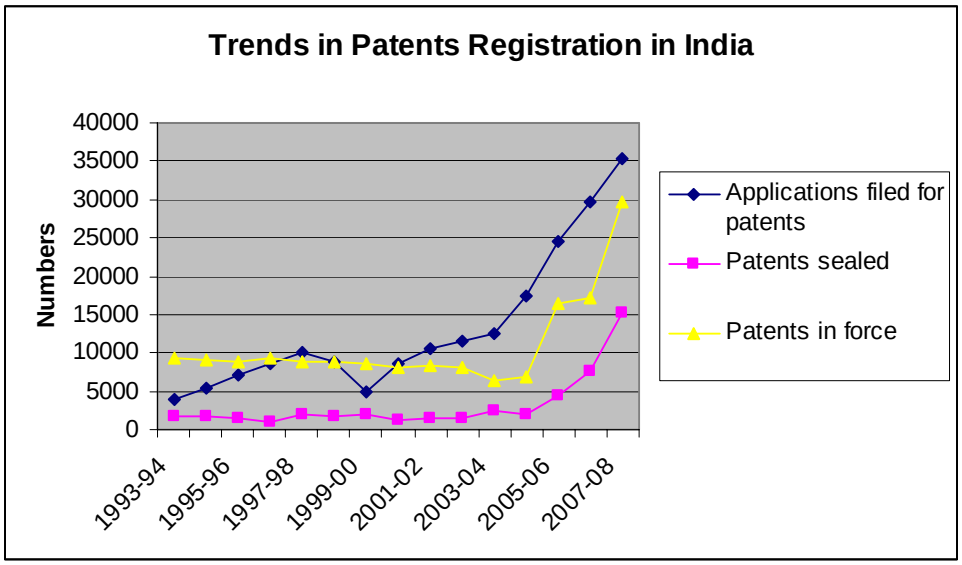
Table 2 Comparative Trends Of IPRs Granted/Registered

	2003-2004	2004-2005	2005-2006	2006-2007	**2007-2008**
Patents	2469	1911	4320	7539	**15261**
Designs	2547	3728	4175	4250	**4928**
Trade Marks	39762	45015	184325	109361	**100857**
G.I.	-	11	19	3	**61**

Source: www.ipindia.nic.in

Patent generation is a key indicator of technology generation in a country. From the year 2004-05 onwards, the number of patents registered has been increasing every year. Fields that have evidenced maximum patent registrations are Chemical, Mechanical, Drugs, and Computers and Electronics (Table 3 and 4).

Fig 2



Source: www.ipindia.nic.in

Table 3: Number of Patent Applications Filed During Last Five Years From 2003-04 To 2007-2008 Under Various Fields of Inventions

Year	Chemical	Drug	Food	Electrical	Mechanical	Computer/ Electronics	Biotechnology	Other fields	Total
2003-2004	2952	2525	123	2125	2717		23	2148	12613
2004-2005	3916	2316	190	1079	3304	2787	1214	2659	17466
2005-2006	5810	2211	101	1274	4734	5700	1525	3150	24505
2006-2007	6354	3239	1223	2371	5536	5822	2774	1621	28940
2007-2008	**6375**	**4267**	**233**	**2210**	**6424**	**4842**	**1950**	**7110**	**35218**

Source: www.ipindia.nic.in

Table 4: Number Of Patents Granted During Last Five Years From 2003-04 To 2007-2008 Under Various Fields Of Inventions

Year	Chemical	Drug	Food	Electrical	Mechanical	Computer/ Electronics	Biotechnology	Other Fields	Total
2003-2004	609	419	110	396	539			401	2469
2004-2005	573	192	67	245	414	71	71	278	1911
2005-2006	1140	457	140	451	1448	136	51	497	4320
2006-2007	1989	798	244	787	2526	237	89	869	7539
2007-2008	**4071**	**1469**	**88**	**1078**	**3230**	**2052**	**314**	**2959**	**15261**

Source: www.ipindia.nic.in

Foreign Direct Investments

FDI inflows into India have improved noticeably since 2001-02 (Table). One of the reasons behind the improvement is the broadening of the definition of FDI from 2000-01.

Prior to 2000-01, data on FDI into India used to reflect only equity flows through the automatic approval route, various schemes earmarked for expatriate Indians, the government route (that is, proposals approved by the Foreign Investment Promotion Board) and acquisition of shares[4] by non-residents in Indian companies under the Foreign

Exchange Management Act (FEMA) of 1999. Since 2000-01, equity capital of unincorporated bodies (mostly foreign bank branches in India) is also included as part of overall equity flows. Furthermore, reinvested earnings (retained earnings of FDI entities) and other capital (essentially inter-corporate debt transactions between FDI entities) are also considered as part of FDI (RBI, 2007). Thus, the underreporting in FDI statistics has now been taken care of and the data reporting is in line with international norms.

However, such changes in data reporting also imply that aggregate data on FDI inflows from 2000-01 onward is strictly not comparable with the previous years (RBI, 2007).

Table 5 FDI Inflows (US $ million)

Year	Equity	Reinvested earnings	Other capital	Total
1991-92	129	…	….	129
1992-93	315	…	….	315
1993-94	586	…	….	586
1994-95	1314	…	….	1314
1995-96	2144	…	….	2144
1996-97	2821	…	….	2821
1997-98	3557	…	….	3557
1998-99	2462	…	….	2462
1999-2000	2155	…	….	2155
2000-01	2400	1350	279	4029
2001-02	4095	1645	390	6130
2002-03	2764	1833	438	5035
2003-04	2229	1460	633	4322
2004-05	3778	1904	369	6051
2005-06(p)	5820	1676	226	7722
2006-07	16481	5828	517	22826
2007-08 (P) +	26867	7168	327	34362
2008-09 (P) +	27,973	6426	747	35146

Source: India FDI Fact Sheet (May 2009); http://dipp.nic.in

Despite the difficulty in comparison arising out of change in the basis of calculation of FDI, it is evident from the above table that FDI flow into India has seen sudden spurt since 2006-07. India has emerged as one of the leading FDI destinations in Asia in recent years. Annexure 1 gives details about top investing countries through FDI in India and the sectors attracting highest FDIs.

Foreign Technology Collaborations (FTC):

India has recorded 8060 Foreign Technology Collaborations from 1991 to March 2009 out of which Electrical Equipments sector which includes Computer Software and Electronics has recorded highest number of Technology Transfers.

Table 5. Number of Cumulative FTC Approvals:

No. of Cumulative FTC approvals (from August '91 to March '09)	**8060**
No. of FTC approvals during 2007-08 (from April '07 to March '08)	95
No. of FTC approvals during 2008-09 (from April '08 to March '09)	**98**

Sectors-Wise Foreign Technology Transfer Approvals:

Ranks	**Sector**	**No. Of Technical Collaborations Approved**	**% Age With Total Tech. Approvals**
1	Electrical Equipments (Including Computer Software & Electronics)	1,259	15.62
2	Chemicals (Other Than Fertilizer)	903	11.20
3	Industrial Machinery	872	10.82
4	Transportation Industry	755	9.37
5	Misc. Mach. Engineering Industry	444	5.51
6	Other Sector	3,827	47.48
Total Of All Sectors		**8,060**	**100.00**

Source: India FDI Fact Sheet (May 2009); http://dipp.nic.in

Section 3: Some Development and Growth Indices

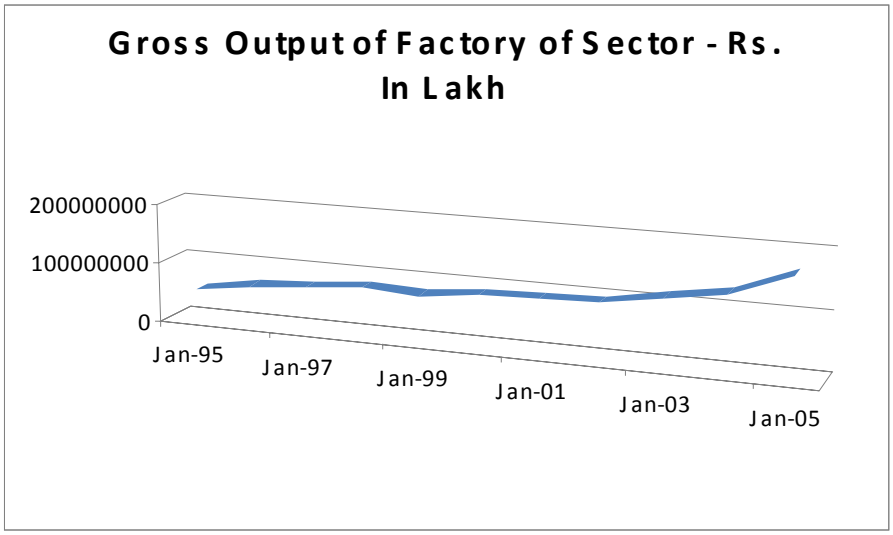
The Gross Output of Factory of all manufacturing sectors has shown marked improvement over 10 years starting from 1995 to 2005. Some of the development indices such GNP, NNP etc. detailed in Annexure -2 are also witnessing an increasing trend. It can be said that Technology generation and transfer are some the only factors impacting these development indices.

Section 4: The relationships among Technology Generation, Technology Transfer and GNP

The success of different types of Technology Transfer depends upon the development stage in which a country is. In the initial stages, a developing country will benefit through acquisition of 'packaged' foreign technology, which includes assembly processes, product specifications, production know-how, technical personnel and components and parts.

Production at this stage is merely an assembly operation of foreign inputs to produce fairly standard, undifferentiated products. However, in later stages the success of a TT will depend upon the ability of developing countries to strengthen their own absorptive capacity for a long term solution. Local absorptive capacity enables developing countries to identify relevant technology available elsewhere, strengthen their bargaining power in its transfer to them in more favourable terms, assimilate it quickly once transferred, produce creatively imitative new products around IPRs, and generate their own IPRs (Kim, 2003).

Fig 3.



Source: CMIE database

An earlier study (Lall, 2001) reaches a similar conclusion that developing countries can reap long-term benefits from strong IPRs only after they reach a certain threshold level in their industrialization.

In Indian context, it is important that along with TT, inhouse Technology generation through R&D and IPR creation be strengthened. According to a Report prepared by Department of Scientific and Industrial Research (2007), Government of India, during the formative years, Indian Industry had to perforce depend on imported technologies, and, the Science and Technology infrastructure facilitated rapid

assimilation and indigenization of such technologies. Now the policy framework is working towards technology creation within the country.

R Palit and Nawani (2007) have inferred in their empirical study that technological capabilities, particularly R&D-driven innovation capacities, are a major factor in attracting FDI and have found that with production processes becoming increasingly complex and technology-intensive, developing countries like India, must devote greater attention to the development of R&D and frontier technologies, failing which, they might lose out in the race for FDI.

Table 6 shows high correlation among Technology Generation (as measured by R&D expenditure and Patents) Technology Transfer (as measured by FDI) and GNP based on 12 year data from 1993-94 to 2004-05.

Table 6: Correlation among R&D expenditure, FDI, Patent Generation and GNP

Correlations

		GNP	FDI	RDExpre	PATENTS
GNP	Pearson Correlation	1	.872**	.988**	.852**
	Sig. (2-tailed)		.000	.000	.000
	Sum of Squares and Cross-products	1E+012	6E+009	2E+010	1E+010
	Covariance	1E+011	6E+008	2E+009	1E+009
	N	12	12	12	12
FDI	Pearson Correlation	.872**	1	.850**	.867**
	Sig. (2-tailed)	.000		.000	.000
	Sum of Squares and Cross-products	6E+009	4E+007	9E+007	6E+007
	Covariance	6E+008	3184891	8265617	5827309
	N	12	12	12	12
RDExpre	Pearson Correlation	.988**	.850**	1	.781**
	Sig. (2-tailed)	.000	.000		.003
	Sum of Squares and Cross-products	2E+010	9E+007	3E+008	2E+008
	Covariance	2E+009	8265617	3E+007	2E+007
	N	12	12	12	12
PATENTS	Pearson Correlation	.852**	.867**	.781**	1
	Sig. (2-tailed)	.000	.000	.003	
	Sum of Squares and Cross-products	1E+010	6E+007	2E+008	2E+008
	Covariance	1E+009	5827309	2E+007	1E+007
	N	12	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Discussions and Conclusions

The paper examines the trend in TT and Technology Generation in India and finds that the country is experiencing a phenomenal growth in technology generation and transfers. The growth indices are also seeing an upward movement.

Previous research reveals that for technology transfer to be successful in a country there must be strong technology generation and assimilation capacity. Recognizing this fact, the regulatory environment in India in terms of Science and Technology Policy, 2003 has been instituted to facilitate technology generation and assimilation.

A quick look at the correlation amongst technology transfer, generation and growth index reveals that India is on the path of creation of a strong technology generation and assimilation path and that is reflected both in terms of strong growth indices and increasing trend in FDIs.

A further detailed investigation into sectoral trends in technology generation and transfer and growth indices will be interesting and can a suggestive topic for future research.

References:

Ann Bartel Saul Lach Nachum Sicherman (2008),, Outsourcing and Technological Innovations:A Firm-Level Analysis IZA Discussion Paper No. 3334,

Cantwell J. (1991), The theory of technological competence and its application to international production. In D. G. McFetridge (Ed.), Foreign Investment, Technology and Economic Growth, Calgary: University of Calgary Press.

Cantwell, J. (1995), The globalization of technology: What remains of the product cycle model? Cambridge Journal of Economics, 19: 155-179.

Dan Li, Manuel Portugal Ferreira, Fernando Serra (2007), Technology Transfer within MNEs: An Investigation of Inter- subsidiary Competition and Co-operation, Working Paper No. 1/2007, globADVANTAGE, Center of Research in International Business & Strategy, Portugal.

Farris (2007), Research on innovation management and technology transfer in China, J Technol Transfer 32:123–126

Kim Linsu (2003) , Technology Transfer and Intellectual Property Rights- The Korean Experience, UNCTAD-ICTSD Project on IPRs and Sustainable Development

Mansfield Edwin (1975), East-West Technological Transfer Issues And Problems International Technology Transfer: Forms, Resource Requirements, And Policies, American Economic Association, Vol. 65.

Jay Erstling (1992), International Technology Transfer and Intellectual Property Rights: Some Essentials and Options for Technology Transfer Partners, International Executive, Vol. 32

Nagesh Kumar (1997), Technology Generation and Technology Transfer in the World Economy: Recent Trends and Implications for Developing Countries, Discussion Paper Series, INTECH, The United Nations University.

R&D Overview (2007), A report by Departtment of Scientific and Industrial Research, Government of India

Sidonia von Ledebur (2008), Technology transfer offices and university patenting – a review, JENA Economic Research Paper ISSN 1864-7057, www.jenecon.de.

Website resources:

www.ipindia.nic.in

www.dipp.nic.in

Annexure -1

SHARE OF TOP INVESTING COUNTRIES FDI EQUITY INFLOWS(Financial Year-Wise)

Ranks	Country	2006-07 **(April-March)**	2007-08 **(April-March)**	2008-09 **(April-March)**	2009-10 **(April-March)**	Cumulative Inflows **(April'00 to May'09)**	% age to total Inflows(in terms of
1.	**MAURITIUS**	28,759 **(6,363)**	44,483 **(11,096)**	50,794 **(11,208)**	12,428 **(2,515)**	173,700 **(39,379)**	**44 %**
2.	**SINGAPORE**	2,662 **(578)**	12,319 **(3,073)**	15,727 **(3,454)**	1,280 **(260)**	35,132 **(8,071)**	**9 %**
3.	**U.S.A.**	3,861 **(856)**	4,377 **(1,089)**	8,002 **(1,802)**	852 **(173)**	28,811 **(6,508)**	**7 %**
4.	**U.K.**	8,389 **(1,878)**	4,690 **(1,176)**	3,840 **(864)**	306 **(62)**	23,210 **(5,289)**	**6 %**
5.	**NETHERLANDS**	2,905 **(644)**	2,780 **(695)**	3,922 **(883)**	540 **(110)**	16,392 **(3,701)**	**4 %**
6.	**JAPAN**	382 **(85)**	3,336 **(815)**	1,889 **(405)**	1,498 **(303)**	12,722 **(2,834)**	**3 %**
7.	**CYPRUS**	266 **(58)**	3,385 **(834)**	5,983 **(1,287)**	1,521 **(307)**	11,571 **(2,579)**	**3 %**
8.	**GERMANY**	540 **(120)**	2,075 **(514)**	2,750 **(629)**	999 **(205)**	10,488 **(2,378)**	**3 %**
9.	**FRANCE**	528 **(117)**	583 **(145)**	2,098 **(467)**	29 **(6)**	5,511 **(1,233)**	**1 %**
10.	**U.A.E.**	1,174 **(260)**	1,039 **(258)**	1,133 **(257)**	366 **(75)**	4,372 **(995)**	**1 %**
TOTAL FDI INFLOWS		**70,630 (15,726)**	**98,664 (24,579)**	**122,919 (27,309)**	**21,876 (4,434)**	**415,002 (94,274)**	-

Note: (i) *Include inflows under NRI Schemes of RBI, stock swapped and advances pending for issue of shares

(ii) Cumulative country-wise FDI inflows(from April 2000 to May 2009)-Annex-'A'.

(iii) % age worked out in rupees terms & FDI inflows received through FIPB/SIA+ RBI's Automatic Route + acquisition of existing shares only.

SECTORS ATTRACTING HIGHEST FDI EQUITY INFLOWS:

Ranks	Country	2006-07 **(April-March)**	2007-08 **(April-March)**	2008-09 **(April-March)**	2009-10 **(April-March)**	Cumulative Inflows **(April'00 to May'09)**	% age to total Inflows(in terms of
1.	**SERVICES SECTOR** (financial & non-financial)	21,047 **(4,664)**	26,589 **(6,615)**	28,411 **(6,116)**	5,308 **(1,073)**	89,761 **(20,322)**	**23 %**
2.	**COMPUTER SOFTWARE & HARDWARE**	11,786 **(2,614)**	5,623 **(1,410)**	7,329 **(1,677)**	733 **(149)**	40,229 **(9,103)**	**10 %**
3.	**TELECOMMUNICATIONS** (radio paging, cellular mobile, basic telephone services)	2,155 **(478)**	5,103 **(1,261)**	11,727 **(2,558)**	3,055 **(612)**	31,422 **(6,989)**	**8 %**
4.	**HOUSING & REAL ESTATE**	2,121 **(467)**	8,749 **(2,179)**	12,621 **(2,801)**	2,801 **(566)**	26,583 **(6,078)**	**7 %**
5.	**CONSTRUCTION ACTIVITIES** (including roads & highways)	4,424 **(985)**	6,989 **(1,743)**	8,792 **(2,028)**	2,694 **(551)**	24,871 **(5,742)**	**6 %**
6.	**AUTOMOBILE INDUSTRY**	1,254 **(276)**	2,697 **(675)**	5,212 **(1,152)**	497 **(101)**	15,564 **(3,489)**	**4 %**
7.	**POWER**	713 **(157)**	3,875 **(967)**	4,382 **(985)**	777 **(159)**	14,789 **(3,349)**	**4 %**
8.	**METALLURGICAL INDUSTRIES**	7,866 **(173)**	4,686 **(1,177)**	4,157 **(961)**	113 **(23)**	11,618 **(2,746)**	**3 %**
9.	**PETROLEUM & NATURAL GAS**	401 **(89)**	5,729 **(1,427)**	1,931 **(412)**	869 **(174)**	11,046 **(2,567)**	**3 %**
10.	**CEHMICALS** (other than fertilizers)	930 **(205)**	920 **(229)**	3,427 **(749)**	247 **(50)**	9,814 **(2,184)**	**3 %**

Note: **Cumulative Sector - wise FDI inflows**(from April 2000 to May 2009) -

Annexure – 2

TABLE 2 : MACROECONOMIC AGGREGATES (At Constant Prices) (Contd.) (Rupees crore)				
Year	GNP at Factor Cost	NNP at Factor Cost	GNP at Market Prices	NNP at Market Prices
1	9	10	11	12
1990-91	1067694	967773	1177772	1077851
1991-92	1082459	976319	1189732	1083592
1992-93	1141240	1028643	1255672	1143075
1993-94	1208545	1088897	1317853	1198205
1994-95	1286594	1159227	1406348	1278982
1995-96	1380321	1243724	1512800	1376202
1996-97	1492406	1346276	1629066	1482936
1997-98	1560236	1404018	1698708	1542490
1998-99	1664570	1497195	1803912	1636537
1999-00	1771094	1589672	1936604	1755182
2000-01	1841755	1647903	2008165	1814313
2001-02	1951935	1743466	2115980	1907511
2002-03	2029482	1805830	2198329	1974677
2003-04	2204913	1963544	2384883	2143514
2004-05	2366886	2104520	2580132	2317766
2005-06	2593160	2306894	2822280	2536014
2006-07	2845156	2530495	3098218	2783557
2007-08	3109361	2767682	3385267	3043588

Source : RBI