Chapter II

Review of Literature

2.1 Introduction:

2.1.1 Role of innovation in growth:

Innovative activity and capabilities are essential for economic growth and development. Given the large gap between the developed and developing countries in terms of technological advancement, the latter continue to rely heavily on technology transfer from the former in their development process. Sustainable economic development requires active, continuous technological effort by enterprises, and government policies to help firms attract technologies.

Technological innovation, put in a simple form, takes place in the following four stages; (1) acquisition of basic production capabilities to absorb and use existing technology, (2) absorption of technology, (3) adaptation of technology and (4) frontier innovation stage, when firms design, develop and test entirely new products and processes. Research and development (R&D) is one source of innovation. Empirical studies suggest a direct relationship between R&D and growth. The long-term impacts on economic growth of public R&D and business R&D have been found to be strong and significant. Business R&D undertaken in other countries also plays an important role. Moreover, increased domestic business R&D accentuates the positive impact of both public and foreign business R&D. In other words, business R&D (either domestic or foreign funded) has both a direct impact on a country's economic growth and an indirect one through improved absorption of the results of public R&D and R&D performed in other countries. Enterprises are the principal agents of innovation today, but they do not innovate and learn in isolation. They rely on intricate (formal and informal) links with other firms and with public research institutions, universities and other knowledge creating bodies like standards and metrology institutes. In undertaking innovation, they react to government policies on trade, competition, investment and innovation. They seek human resources for innovation from the education and training system, and they draw upon the financial system for funding innovative efforts.

2.1.2 Global Trends in Foreign R&D Investment:

Foreign R&D investment by TNCs

A major part of the global R&D is made by Trans National Corporations, not only through activities in their home countries but also increasingly abroad. The internationalization of R&D is not a new phenomenon. What is new is its faster pace in recent years and its spread to developing countries (albeit to only a few, mainly in Asia). According to UNCTAD, (2006) R&D activities in developing countries are no longer aimed at adapting technologies to local conditions only; they increasingly involve “innovative” R&D, including developing technologies for regional and world markets. At the same time, TNCs from developing countries are themselves investing in R&D abroad, primarily in order to access advanced technologies and research capabilities in developed countries, as well as to adapt products to new markets and tap sources of specialized expertise in other developing countries.

UNCTAD, (2006) provides an account of this trend in globalization of R&D. With $310 billion spent in 2002 (United Kingdom, DTI 2004), the 700 largest R&D spending firms of the world – of which at least 98% are TNCs – accounted for close to half (46%) of the world’s total R&D expenditure and more than two-thirds (69%) of the world’s business R&D. Table 2.1 presents R&D expenditure figures of 2003 by top 20 firms in the world and in developing countries, South East Europe and CIS.

TABLE 2.1

Top 20 Firms by R&D Expenditure in the World, in Developing Countries, South East Europe and in CIS, 2003

(Billion of Dollars)

World			
World Rank	**Corporation**	**Home Economy**	**R&D Spending**
1	Ford Motor	United States	6.841
2	Pfizer	United States	6.504
3	Daimler Chrysler	Germany	6.409
4	Siemens	Germany	6.340
5	Toyota Motors	Japan	5.688
6	General Motors	United States	5.199
7	Matshushita Electric	Japan	4.929
8	Volkswagen	Germany	4.763
9	IBM	United States	4.614
10	Nokia	Finland	4.577
11	Glaxo Smith Kline	United Kingdom	4.557
12	Johnson and Johnson	United States	4.272
13	Microsoft	United States	4.249
14	Intel	United States	3.977
15	Sony	Japan	3.771
16	Honda Motor	Japan	3.718
17	Erricson	Sweden	3.715
18	Roche	Switzerland	3.515
19	Motorola	United States	3.439
20	Novartis	Switzerland	3.426
Developing Countries, South East Europe and in CIS			
33	Samsung Electronic	Republic of Korea	2.740
95	Hyundai Motor	Republic of Korea	0.734
110	LG Elecronics	Republic of Korea	0.612
178	Taiwan Semiconductor	Taiwan Province of China	0.342
219	Petro China	China	0.265
255	Accenture	Bermuda	0.228
258	Korea Electric Power	Republic of Korea	0.27
267	KT	Republic of Korea	0.219
298	Marvell Technology	Bermuda	0.197
300	POSCO	Republic of Korea	0.196
317	Petroleo Brasileiro	Brazil	0.183
328	SK Telecom	Republic of Korea	0.172
337	China Petroleum and Chemical	China	0.167
348	Winbond Electronic	Taiwan Province of China	0.158
349	Embraer	Brazil	0.158
350	United Microelectronics	Taiwan Province of China	0.157
486	Pliva	Croatia	0.99
516	Sasol	South Africa	0.91
518	AU Optronics	Taiwan Province of China	0.91
585	Hyundai Heavy industries	Republic of Korea	0.77

Source: UNCTAD 2005

According to the UNCTAD report, (2006), the R&D spending of some large corporations is higher than that of many countries. Table 2. 2 shows that over 80% of the 700 largest R&D spending firms come from only five countries: the United States, Japan, Germany, the United Kingdom and France, in that order. Only 1% of the top 700 are based in developing countries or South-East Europe and the CIS, although several have moved up the ranks since the late 1990s (United Kingdom, DTI 2004). Almost all these firms come from Asia, notably from the Republic of Korea and Taiwan Province of China, while only one is from Africa and two are from Latin America.

Table 2.2

Home Economy of the 700 Largest R&D Spending Firms of the World 2003

Economy	Number of Firms	Percentage of largest 700 R&D spenders
United States	296	42.3
Japan	154	22.0
Germany	53	7.6
United Kingdom	39	5.6
France	35	5.0
Switzerland	20	2.9
Sweden	15	2.1
Republic of Korea	10	1.4
Denmark	8	1.1
Taiwan Province of China	8	1.1
Netherlands	8	1.1
Canada	7	1.0
Belgium	6	0.9
Finland	6	0.9
Italy	6	0.9
Spain	4	0.6
Bermuda	3	0.4
Norway	3	0.4
Austria	2	0.3
Australia	2	0.3
Brazil	2	0.3
China	2	0.3
Ireland	2	0.3
Israel	2	0.3
Luxemberg	2	0.3
Croatia	1	0.1
Greece	1	0.1
Hong Kong	1	0.1
Liechtenstein	1	0.1
South Africa	1	0.1
Total	700	100.0

Source: UNCTAD 2005

The 700 largest R&D spenders are concentrated in relatively few industries. In 2003, more than half of them were in three industries (IT hardware, automotive and pharmaceuticals/ biotechnology) (Table 2.3). Within each industry, the two largest R&D performing firms were responsible for very high shares. The two most concentrated industries were telecommunications (because of NTT) and software and computer services (because of Microsoft and IBM). The industry composition of the top R&D spenders varies by region (United Kingdom, DTI 2004, p. 5). Those in pharmaceuticals and health, electronics and ICT account for more than two-thirds of the R&D done by United States-based firms. German firms are concentrated in chemicals and engineering (64%), while Japanese firms are concentrated in electronics, ICT, engineering and chemicals (90%). In sum, TNCs dominate global business R&D. A few countries, generally the largest R&D spenders, account for a major share of business R&D. Within those countries a relatively small number of enterprises dominate R&D activity. *Most R&D is conducted by firms in the ICT, automotive and pharmaceutical industries.*

TABLE 2.3

Industry Breakdowns of the 700 Largest R&D Firms, 2003 [percentages]

Industry	Share of companies' R&D expenditure	Share of two largest spenders within the Industry
Aerospace and defence	3.9	35
Automotive	18.0	21
Biotechnology & Pharmaceuticals	17.5	18
Chemicals	4.8	23
Electronic and Electrical	10.4	31
Engineering	2.9	20
Healthcare Products and services	2.2	33
IT Software and Computer Services	6.3	44
IT Hardware	21.7	13
Telecommunications	2.2	58
Others	8.2	--

Source: UNCTAD 2005

FDI in R&D in Developing countries

The increasing internalization of R&D is evident from the growing role being played by foreign affiliate in the R&D activities of many countries. Though, developed countries remain the main host locations of foreign R&D activities by TNCs, but there is a clear trend towards locating more R&D activities to developing economies, South- East Europe and the CIS. The total R&D expenditure in the world in 2002 was $676.5 billion whereas the total business R&D expenditure was $449.8 billion and the total R&D expenditure of foreign affiliates was $67 billion. Table 2.4 shows the R&D spending by foreign affiliates in some select countries.

Table 2.4

R&D spending by Foreign Affiliates In select Economies in 2003

(Share in Business R&D)

Country	Total R&D($ b)	Business R&D Industry ($b)	Foreign Affiliate R&D (% of Business R&D)
USA (2002)	276.2	194.4	14.1
Japan (2001)	133.0	92.3	3.4
UK	29.3	19.6	45.6
China	15.6	9.5	23.7
RoK (2002)	13.8	10.4	1.6
Canada	13.8	7.9	34.8
India	3.7	-	3.4
Singapore	19.0	12.0	59.8
Thailand	-	-	28.1

Source: WIR 2005, Page No- 105,127

As per World Investment Report 2005, the kind of R&D being undertaken by TNCs in developing countries is also changing. While it has traditionally involved mainly product or process adaptation to meet local market demands, recent developments suggest that some developing, South-East European and CIS markets are emerging as key nodes in the global R&D systems of TNCs. At the same time, the extent to which developing countries participate in these systems varies considerably, and large parts of the developing world remain de-linked.

Industry composition of R&D by TNCs in developing countries

The industry composition of R&D by foreign affiliates differs by region and economy. The world trend in this regard can be roughly apprehended from the industry composition of R&D by foreign affiliates of United States TNCs. Table 2.5 gives R&D performed by US TNCs in some select countries in Asia. While transportation equipment cover the largest proportion [28%] of R&D owned by foreign affiliates of United States TNCs, in “all host countries”, in Asia (excluding Japan) Computer and electronic products cover more than three fourth of the amount spent. The table also shows the % spending on the sectors in each of the selected countries.

Table 2.5

Industry Composition of R&D performed by foreign affiliates of US TNCs by country, 2002

	All Host Countries	Asia (excluding Japan)	India	China	RoK	Brazil
R&D Performed (Millions of dollars)	21151	2113	80	646	167	306
Transportation equipment	28%	2%	4%	NA	16%	30%
Computers & Electronic products	25%	78%	6%	NA	54%	10%
Chemicals	23%	4%	10%	5%	6%	22%
Professional, Scientific &Technical	6%	2%	52%	NA	4%	1%
Machinery	3%	1%	4%	<1%	7%	9%
Others	15%	13%	24%	<1%	13%	28%

Source: Deduced from WIR 2005, pages 137 &294

Types of R&D

R&D carried out by TNCs in developing countries can be categorized in various ways. One relates to the types of R&D undertaken by TNCs' affiliates in host countries, reflecting the different technological functions assigned to foreign affiliates. The foreign affiliates may undertake:

1. Adaptive R&D;
2. Innovative R&D linked to production for local or regional markets;
3. Global innovative R&D for new products or processes, or for basic research;
4. Technology-monitoring R&D;

There can be many varieties of *adaptive R&D*, ranging from basic production support to the upgrading of imported technologies. Much depends on the size and growth of the local facility, the differences between local conditions and those for which the technology was designed, and the availability of local technical skills. The extent to which adaptive R&D evolves into *innovative R&D* depends even more on the availability of suitable technical skills along with supplier R&D capabilities and institutional support. *Innovative R&D for local or regional markets* can evolve into *global innovative R&D* when the host economy is able to meet even more stringent skill and institutional needs. However, this evolution is not the only way for TNCs to launch R&D in developing countries. Some developing countries are attracting "pure" TNC R&D, not related to production. *Technology monitoring units* are another example of R&D. The main roles of technology monitoring units are to keep abreast of technological developments in foreign markets and to learn from leading innovators and consumers there.

The literature on the internationalization of business suggests a number of different reasons for undertaking technological activities outside the home country. Categorization of the motivations for foreign direct investment in R&D can be one in different ways.

Depending *on levels of technological activities* carried out in foreign locations, three kinds of motivations may be outlined. For example,

1. Vernon (1966) argued that having established a new product or a new production process in the home market, firms would subsequently export and/or locate production facilities in foreign locations. This process would inevitably involve some foreign R&D activity mainly concerned with adapting the products (e.g., to account for differences in consumer tastes) and the production processes (e.g., to account for differences in the labour market) to suit the local market conditions. Thus the main purpose of foreign technological activities would be to support foreign production and to service the foreign market. In such a scenario, companies would be mainly exploiting technological advantage created within the home country.

   However, more recent analyses (Cantwell, 1992 and Cantwell, 1995; Chesnais, 1992; Hakanson, 1992; Pearce and Singh, 1992; Granstrand and Sjolander, 1992; Dunning and Narula, 1995, sited in Patel and Vega (1999)) suggest that two other factors have become increasingly important.

2. The need to monitor new technological developments (In this case a company would be active abroad in technologies where there is complementarity between the strength of the host country and its own domestic strength).

3. The ability to generate entirely new technologies and products from foreign locations. (In this case a company is simply interested in exploiting the technological advantage of the host country in order to alleviate technological weakness at home.i.e., substitutes)

The following table (Table 2.6) provides a summary of these three main functions of foreign R&D, together with an indication of the scale of activity involved and whether this is based on exploiting advantages created at home or those present in the host country, as given in Patel and Vega (1999). It is based on a detailed examination of information on the US patenting activities of the world's largest firms.

Table 2.6

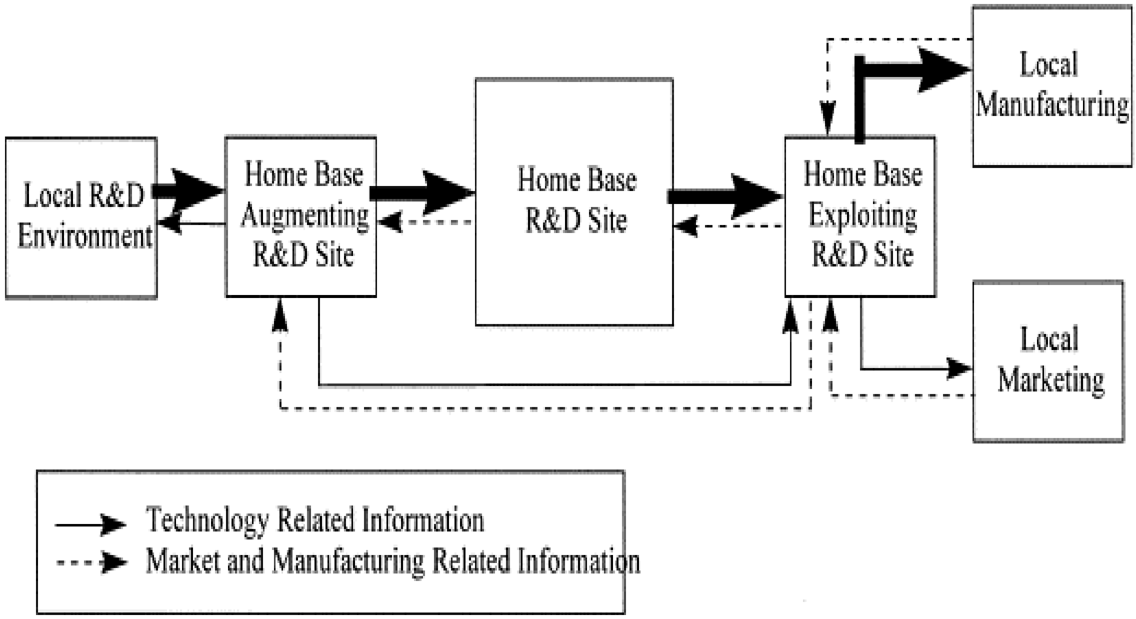
Three Main Functions of Foreign R&D

Purpose	Scale	Exploitation of home or host country advantage	Major determinant of location
Adapting products, processes, and materials to suit foreign markets and providing technological support to off shore manufacturing plants.	Small	Company advantage at home	Scale of host market
Monitoring scientific and technological developments in foreign countries	Small	Company advantage at home, host country advantage	Quality and scale of science and technology of both the host country and the home country
Generating entirely new products and core technologies outside the home countries	large	Company weak at home, host country advantage	Quality and scale of science and technology of both the host country and the home country, Cost advantage

Another categorization that Walter Kuemmerle (1999) has developed is a dichotomous distinction into home-base-exploiting (HBE) and home-base-augmenting (HBA) FDI in R&D. Firms establish home-base-exploiting sites in order to exploit firm-specific capabilities if this mode of exploitation offers higher payoffs than the licensing out of processes or products to local firms. Firms establish home-base-augmenting sites in order to augment firm-specific capabilities if this mode of augmenting the firm's knowledge base offer higher payoffs than licensing in. Fig.(1) summarizes the flow of knowledge between sites. It is prima facie efficient to carry out both activities in one location. However, the two types of activities are subject to different locational pulls.

Figure: 1

Direction of information flows between home base R&D site and two types of laboratory sites abroad.



3. Location characteristics for FDI in R&D:

A number of researchers have examined location characteristics of R&D sites at the local level (Hood and Young, 1979; Howells, 1990; Pearce, 1989 sited in Walter Kuemmerle, (1999)). Generally, these researchers have found that laboratories are established close to existing firm facilities or in close proximity to an institution that creates externalities which the investing firm hopes to capture. Hood and Young surveyed 140 foreign companies in the UK. 83 of them operated laboratories. 78% of the laboratories were located close to production facilities, 9% close to administrative offices, 13% close to other locations. Asakawa (1996) examined a sample of Japanese firms' R&D sites in Europe. Most of the sites examined by Asakawa fall primarily under the HBA category. He found that all sites sought to develop external linkages and that the number of external linkages depended on the degree of autonomy the laboratory had from the firm's home base.

Kuemmerle (1999) surveyed all laboratories regarding location-characteristics at the local level and also investigated proximity at the time of laboratory establishment during interviews. Table 2.7 summarizes their findings.

In the survey 'Proximity to an important market' was expressed through questions regarding proximity to major customers or institutions that shape demand, such as drug approval authorities. 'Proximity to a university' refers to both universities and public or non-profit research institutions connected to universities. Political pressure by host country governments at the national or regional levels also affected choice of location. The survey did not include questions regarding proximity to competitors, although subjective evidence suggests that firms of all five nationalities considered the proximity to competitors as an attractive location characteristic.

Table 2.7

Location characteristics of R&D sites

Location Characteristics (Count of Times Mentioned)	HBA Facilities	HBE Facilities
Site in Proximity of a University	52	20
Site in Proximity of existing factory	11	46
Site in Proximity of Important market	22	79
Site Location chosen because of host country government pressure	6	11

The results show that HBA sites are significantly more likely to be located in proximity to a university than HBE sites. HBE sites are significantly more likely than HBA sites to be located in proximity to an existing factory and to an important market. There is no significant association between HBA versus HBE and the location chosen because of political pressure.

The survey by Walter Kuemmetrle (1999) found that the median distance from the 'magnet' location was 34 km for HBA sites and 10 km for HBE sites. HBE facilities are significantly closer than HBA sites to the 'magnet' institution. There are at least two possible explanations why HBE sites are located more closely to the 'magnet' location than HBA sites. First, HBE sites need to interact very closely with manufacturing facilities or customers, whereas HBA sites often have the character of independently creative organizations. While HBA sites recruit scientists and engineers from universities and work with universities on joint research projects, they are often somewhat detached from their own firm's day to day operations. Therefore, often a somewhat more distant and quiet location is chosen. Second, affordable real estate in close proximity to the magnet is more often available in the case of HBE sites. Particularly if firms operate manufacturing or other administrative facilities, HBE facilities can be established on the premises or in close geographical proximity. On the other hand, ‘magnets' for HBA facilities have often created a densely populated landscape by the time a foreign firm decides to invest there. When the Japanese pharmaceutical firm Eisai decided to establish an R&D site in the Boston area, the primary magnet was Harvard University's chemistry department. A professor from that department acted as the main scientific advisor for the new site. Eisai decided on a location close to Andover about 30 km from Cambridge, MA. The site location in Andover was a combination of the two reasons mentioned above. First, Eisai felt that a quiet somewhat distant location would enhance research creativity. Second, appropriate real estate in closer proximity to Harvard and MIT would have been much more expensive.

4. Evolution over Time in FDI in R&D:

Prior research suggests that FDI in R&D has been increasing over the last years and that origin and destination of FDI in R&D are primarily industrialized countries. Walter Kuemmerle (1999) examined the evolution of FDI over time for multiple origin- and-destination countries and also investigated the relative importance of home-base-augmenting (HBA) versus home-base-exploiting (HBE) FDI in R&D. The survey suggests that for US, Japanese and European firms in the sample FDI in R&D have been a monotonically rising phenomenon, at least until 1995. The results show that US firms were pioneer investors in R&D facilities abroad. Their investments are distributed almost evenly across the whole 38 year period (1957 – 1995). European firms followed. Their investments reached US levels in the late 1970s. Japanese firms in the sample invested only in 2 R&D sites before 1976, but in 68 thereafter. There is a significant tendency for Japanese firms to establish foreign R&D sites later than US firms. When compared to Japanese firms, the tendency for European firms to establish foreign R&D sites later than US firms is less significant. As a result of their intensive investment activity since 1986, Japanese firms in 1995 operated 32% more R&D sites abroad than US firms and more than twice as many sites as European firms.

The results also show that US firms invested first in Europe and, to a lesser degree, in Japan and only later but increasingly in the rest of the world. European firms invested first in other European countries, then in the US and then in Japan. Overall however, European firms established fewer sites in Japan than US firms did even if one accounts for the fact that European firms established fewer laboratories abroad than US firms overall. European firms also established only 3 sites in the rest of the world. The surge of Japanese investment to the US, Europe and the rest of the world started simultaneously in the early 1980s but rose strongly only in the late 1980s and 1990s.

Overall, the US was the recipient of almost twice as many foreign-owned sites (33) as Europe (18) and almost five times as many as the rest of the world (7). The data show that Japanese firms clearly made an effort to close the gap to Western firms in terms international R&D presence. Thus, it could be said that the wave of Japanese FDI in R&D followed the wave of Japanese FDI in manufacturing with a time lag of 5 to 10 years. This survey by Kuemmerle confirms earlier research that industrialized countries are the dominant recipients of FDI in R&D. There were 23 investments in the 'rest of the world' (outside the US, Japan and Europe). The 'rest of the world'-investments by sample firms do not include any investments in Africa (except Israel) or South America. If one excludes 11 investments in Australia and Canada and one in Israel, all remaining 11 investments were carried out into Asian countries. Respondents expected the trend of FDI in R&D in Asia to continue.

In particular, more firms expected to carry out home-base-exploiting investments in China and India because of the future attractiveness of these countries' markets. It should be noted that the results of this survey might have been influenced by the choice of industries. In the vehicle industry, for example, a number of R&D facilities have been established in South America (particularly in Brazil) and in other Asian countries. In the chemical industry a number of home-base-exploiting facilities exist in India.

5. Modes of entry:

A firm basically has three choices when investing in R&D abroad: (1) establishment of a green-field site, (2) an acquisition or a (3) joint venture. It has been argued by some that multinational enterprises will refrain from FDI through joint ventures when the protection of intangible assets is important to the firm (Caves, 1996). In another study of FDI in R&D it was found that firms are more hesitant to transfer process technology abroad than product technology because it is more difficult to protect process technology from appropriation by local entities and because process technology often manifests unique firm capabilities while product technology just represents the outcome of these capabilities (Mansfield, 1984). In a study of Japanese manufacturing FDI into the US, it was found that Japanese firms were hesitant to acquire US firms if the ratio of non-desired to desired assets was high. In that case, firms chose green-field investments (Hennart and Reddy, 1997). One can argue that in the case of FDI in R&D, investing firms are inclined against acquisitions because the risk of attrition of desired assets is high. Desired assets in technologically intensive acquisition target firms are primarily human assets who can easily leave the firm. Key employees in R&D might dislike the strategic direction set by the acquiring company or the loss of a small-company culture after the acquisition.

Walter Kuemmerle shows that green-field sites are clearly the dominant mode of entry. 79% of all sites are green-field investments, followed by acquisitions (15%) and joint ventures (6%). This distribution changed only minimally over time. Also, the propensity of firms to use acquisitions and joint ventures was equally low in the case of HBA and HBE sites. A comparison of investments by firm nationality revealed that European firms acquired R&D sites abroad about 3 times as often as Japanese and European firms did. An alternative explanation for the low propensity of acquisition in Kuemmerle's sample could be that there are few firms that would be worth acquiring because of the quality of their R&D efforts.

6. Organizational Concepts and trends in R&D Organizations:

An analysis of the new concepts and trends in R&D organizations can be found in Gassmanna and Maximilian von Zedtwitz (1999). Their results are based on 195 semi-structured research interviews in 33 technology-based companies between 1994 and 1998 in the electrical/ electronics, automotive/ turbines/ heavy machinery, and chemicals/ pharmaceuticals industries with home bases in Europe, USA and Japan. Based upon this work and empirical observations, Gassmanna and Maximilian von Zedtwitz discerned five ideal forms of structural and behavioural orientation in international R&D organization. These are as follows:

(1) Ethnocentric Centralized R&D
(2) Geocentric Centralized R&D
(3) Polycentric Decentralized R&D
(4) R&D Hub Model
(5) Integrated R&D Network

The organizational structures and behavioural orientation of each type of R&D organization is summarized in Table 2.8

Table 2.8

Five typical forms of international R&D organization

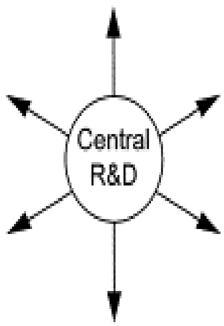
Type of R&D Organisation	Organisational Structure	Behavioural Orientation
Ethnocentric Centralised R&D	Centralised R&D	National inward Orientation
Geocentric Centralised R&D	Centralised R&D	International Cooperation
Polycentric Centralised R&D	Highly dispersed R&D, Weak Centre	Competition among independent R&D units.
R&D Hub Model	Dispersed R&D, Strong Centre.	Supportive role of foreign R&D units
Integrated R&D network	Highly dispersed R&D, several competence centres	Synergic integration of International R&D units

In the **(1) *ethnocentric centralized*** R&D organization, all R&D activities are concentrated in the home country. It is assumed that the home country is technologically superior to subsidiaries and affiliated companies in other countries, a notion which also defines the asymmetrical information and decision structures between home base and peripheral sites. Central R&D is the protected ‘think tank' of the company, creating new products which are subsequently manufactured in other locations and distributed worldwide (e.g., *Toyota in Great Britain, Volkswagen in China, Nippon Steel, Microsoft).* The core technologies, which ensure long-term competitiveness of the company, are retained as a ‘national treasure' in the home country base (Fig. 2).

Besides providing protection against uncontrolled technology transfer, this concept demonstrates high efficiency due to scale and specialization affects, which results in lower R&D costs and reduced overall development times. An efficient R&D unit therefore requires a certain critical mass of capital and personnel. Physical collocation of R&D employees, standardized management systems and a common understanding of R&D vision and values promote the flow of information between scientists at the R&D centre and facilitate the control of R&D activities. The main drawbacks of ethnocentric centralized R&D are the lack of sensitivity for signals from foreign markets and its insufficient consideration of local market demands. Furthermore, the Not-Invented-Here syndrome occurs frequently, and the organizational structure tends to be very rigid.

Figure: 2

Ethnocentric centralized R&D is characterized by a lack of transnational R&D processes as all R&D activities are concentrated at the home base.



Behavioral Orientation

Ethnocentric inward orientation
Think tank as national treasure in home country
Protection of core technology against competitors
Homogeneous R&D culture

Configuration

Central R&D in home country
Central and tight coordination and control of R&D program

Examples

Balzers
British Gas
General Dynamics
Microsoft
Nippon Steel
Sigg
Toyota
Volvo

Strengths

High efficiency
Low R&D costs (scale effects)
Short cycle times
Protected core technologies

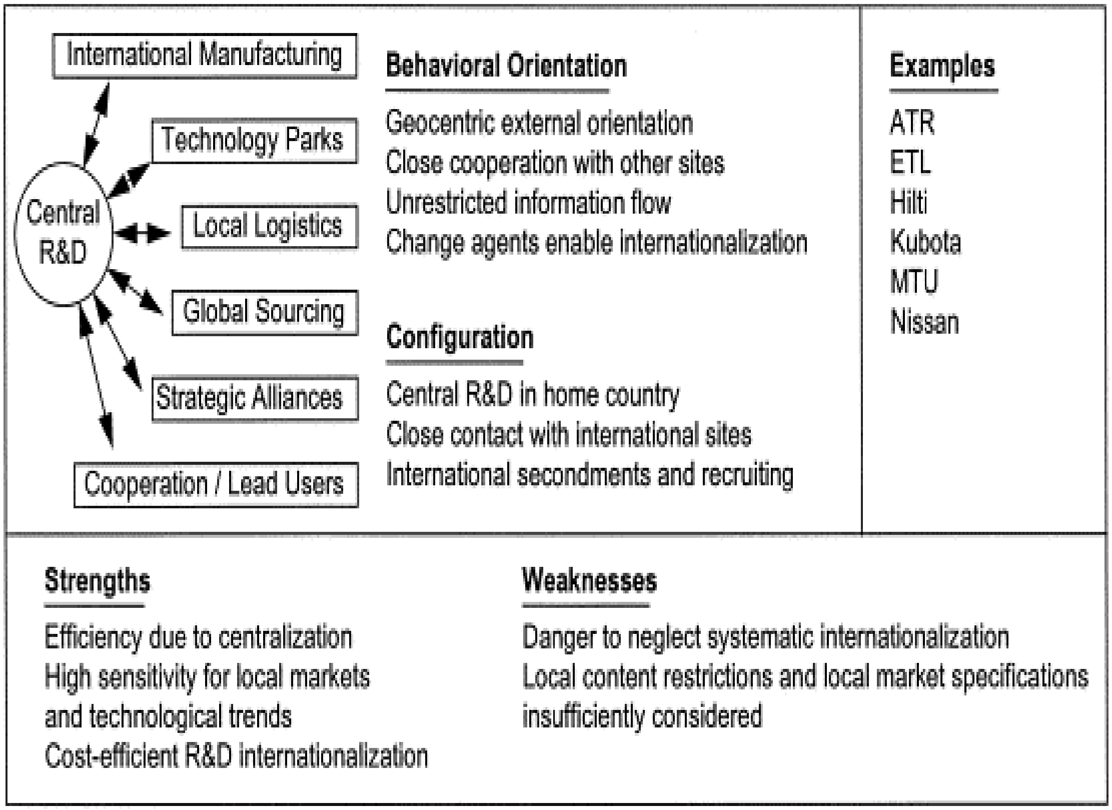
Weaknesses

Lack of sensitivity for local markets
Danger of missing external technology
NIH syndrome
Tendency towards rigid organization

The ethnocentric organization becomes inappropriate when a company becomes more dependent on foreign markets and local competencies. **The (2)** ***geocentric centralized*** (or physically centred R&D) organization overcomes the ethnocentric home-base orientation while retaining the efficiency advantage of centralization. This requires extra investments in R&D personnel in order to increase their international awareness. At the central R&D site, knowledge of worldwide and externally available technologies is accumulated. R&D employees' sensitivity for international markets increases. This can be achieved by sending R&D employees abroad to collaborate and intensively communicate with local manufacturing, suppliers and lead customers. International awareness can be further improved by recruiting multi-lingual or foreign engineers with working experience abroad (Figure 3). *[Examples: Nissan, Kubota]* Geocentric centralized R&D offers a quick and inexpensive way to internationalize R&D without giving up the advantage of physically centralized R&D.

Figure: 3

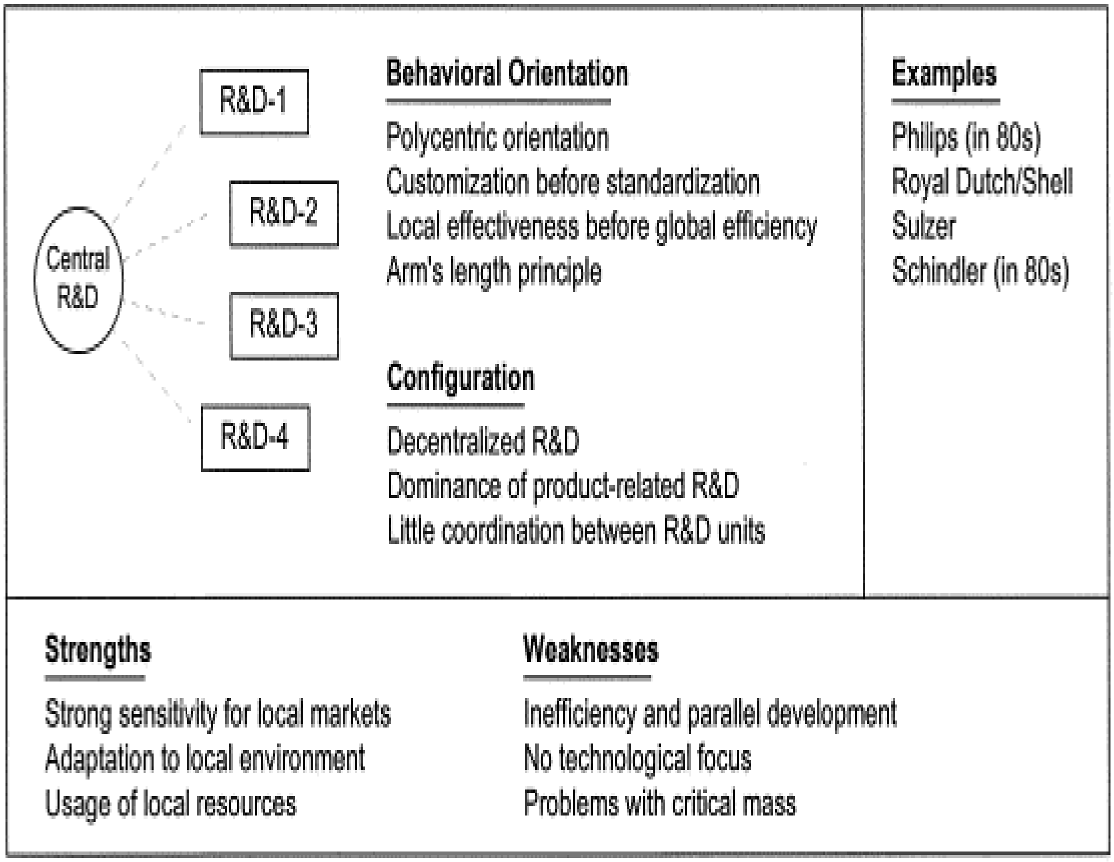
Geocentric R&D organizations overcome the lack of market sensitivity.



Frequently, companies with a strong orientation towards regional markets (e.g., many European MNCs in the 1970s and 1980s) adopt a **(3)** ***polycentric decentralized*** R&D organization. Local R&D laboratories have been established by local distribution and manufacturing units, mainly in order to respond to customer product adaptation requests. Some firms exhibit a polycentric R&D structure because they have been formed by M&A activities and the synergy potential in R&D reorganization was not exploited. The organizational structure is characterized by a decentralized federation of R&D sites with no supervising corporate R&D centre. Information flow between foreign sites and the home base is limited with reports on current R&D activities often being late (Figure 4).

Figure: 4

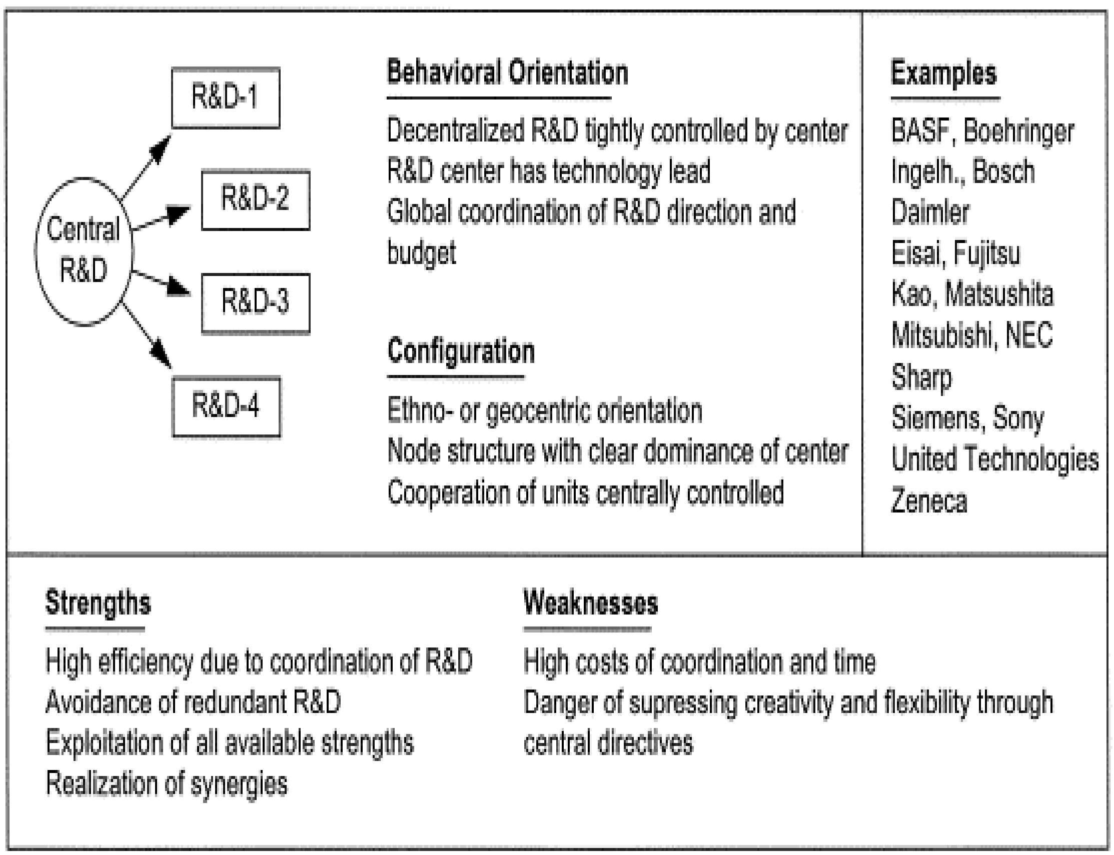
The major challenge of polycentric decentralized R&D organizations is to overcome the isolation of formerly independent R&D units and to integrate them into a wider R&D network.



The R&D director of a subsidiary in a polycentric decentralized R&D organization reports to local management. Although this configuration is optimal for local market sensitivity and the exploitation of local resources, its disadvantages are high autonomy and little incentive to share information with other R&D units (in particular central R&D) in early project stages. Efforts to preserve autonomy and national identity impede cross-border coordination, and therefore lead to inefficiency on a corporate level and redundant R&D activities. Furthermore, the company is in danger to lose the focus on a particular technology and technology convergence is difficult to achieve. *[Examples: Royal Dutch/Shell, Phillips (in the 80s), Schindler]* **(4)*The R&D hub model*** with its tight central control reduces the risk of suboptimal resource allocation and R&D duplication. The R&D centre in the home location is the main laboratory for all research and advanced development activities, retaining a worldwide lead in relevant technological fields. Foreign R&D which usually evolves from technological listening posts sites focus their activities on predefined technological areas. The R&D centre tightly coordinates decentral R&D activities by means of long-term R&D programs as well as resource and personnel allocation. This model guarantees an efficient technology transfer and permanent technical assistance. An R&D centre may be formed as a legal entity which owns all of the technological knowledge and intellectual property (Figure 5). *[Examples: Daimler–Benz, the United Technologies Corporation, Zeneca, Sony]*

Figure: 5

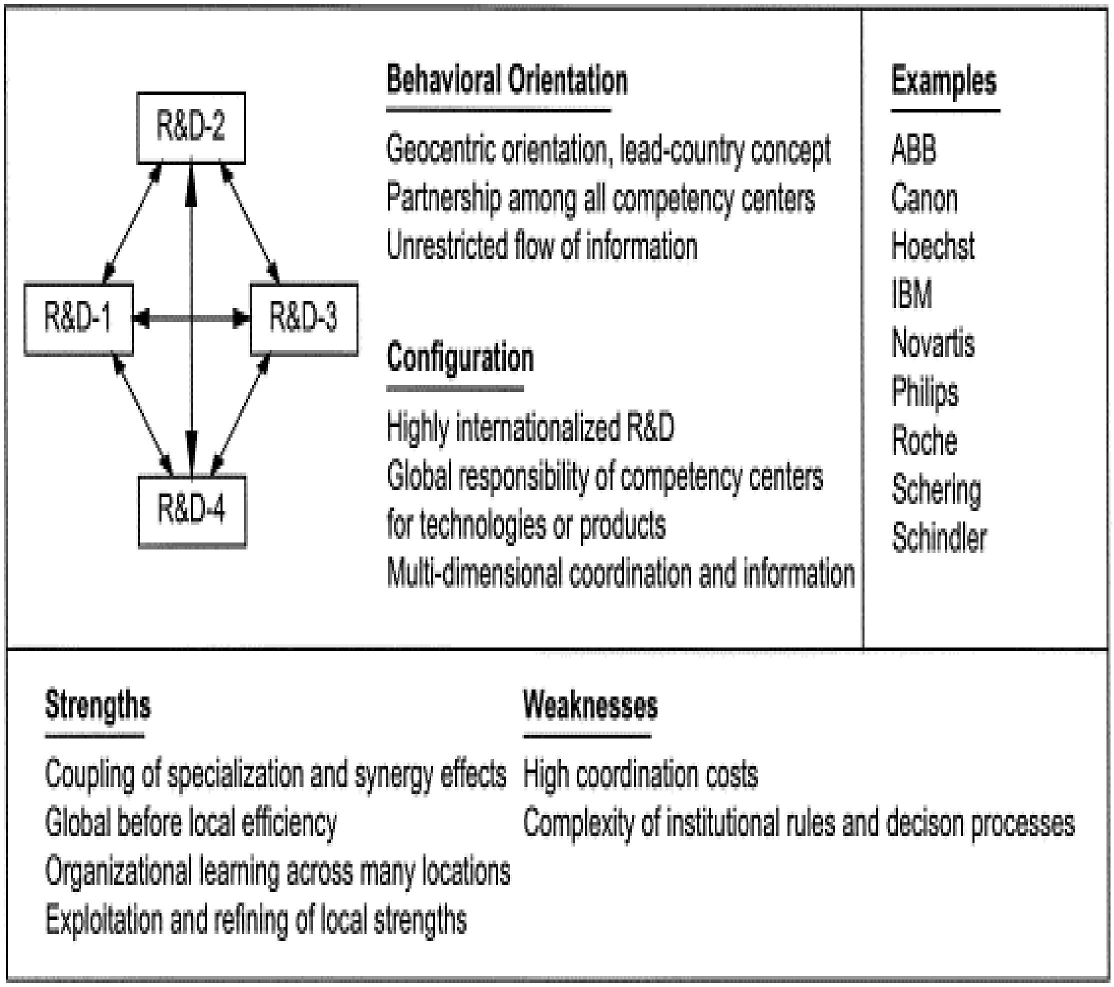
The R&D hub model is usually a reaction by centralized companies to the internationalization of resources.



In the **(5)** ***integrated R&D network*** model, domestic R&D is no longer the centre of control for all R&D activities. Central R&D evolves into a competency centre among many interdependent R&D units which are closely interconnected by means of flexible and diverse coordination mechanisms (Figure 6)

Figure: 6

The Integrated R&D network is characterized by authority for technology or component development based on individual



MNCs that assumed a network organization were often organized along a hub or polycentric configuration. In contrast to the hub model, foreign R&D units in the integrated R&D network assume strategic roles affecting the entire company: A competence centre should not only act as a sensor for possible change in its respective area, but should also engage in defining appropriate strategies and new business development. While the major effort in this case is to improve the authority and competency of R&D units, the shift from a polycentric to a network configuration is based on exploiting potential synergy between newly connected R&D sites. A prerequisite condition for effective network operations is a sophisticated global information technology infrastructure. *[Examples: Nestlé, Philips (in the 90s), Bayer, Hoffmann-La Roche, Novartis, Hoechst and Schering]*

Gassmann and Zedtwitz (1999) further observed five principal trends in the organizational structure of R&D firms. These are as follows:

1. Orientation of R&D processes towards international markets and knowledge centres;
2. Establishment of tightly coordinated technology listening posts;
3. Increase of autonomy and authority of foreign R&D sites;
4. Tighter integration of decentralized R&D units; and
5. Increased coordination and re-centralization of R&D activities in fewer leading research centres in order to improve global efficiency.

2.1.3 Studies on India:

(a) Globalization of R&D and its impact on industrial R&D in India:

Hirwani, (2004)[1] studied how the globalization process has affected the industrial R&D in India and its impact in terms of evolution of content level of R&D. According to the framework adopted in this work, domestic R&D evolves from technology support function to technology up-gradation to technology capacity exploitation in foreign markets. This framework is illustrated with the example of Indian chemical Industry.
Major findings of this study are given below:

1. Data suggests there is an increase in FDI in R&D in India for which both market, availability of human capital and technology oriented factors are important.

2. Many subsidiaries of TNCs established R&D units in India to support local manufacturing operations. (Unilever, ICI). With change in the global strategy theses R&D units are integrated to their worldwide R&D network of innovation.

3. The domestic organic chemical units involved in manufacture of drugs and pharmaceuticals, agrochemicals, fine chemicals and intermediates are beneficiaries of this phenomenon. The Indian Patent Act of 1970 that

1 Globalization of R&D and Its Impact on Industrial R&D in India – submitted as Ph. D Thesis to IIT Bombay in 2004.

recognizes only the process patent has helped them to build world class skills in organic synthesis and process chemistry. Their current R&D portfolio reveals a movement away from imitative research to original research.

4. With a few exceptions foreign affiliate R&D and domestic R&D are practically at the same level of evolution, possibly due to inward looking restrictive environment in which MNCs operated in India between 1960 and 1990. Foreign affiliate's incentives to create new technology were muted in such an environment.

5. Only a few publicly funded research and technology organization in India have been able to exploit the opportunities of globalization. These organizations are now playing an increasing role of supplier of R&D services to the MNCs outside India.

6. Patent data analysis shows that Indian organizations, including some pharmaceutical companies have been obtaining increasing number of product patents.

7. There is increasing generation of innovation funded by foreign organizations and exploitation of domestic technological capabilities by way of export of high tech products and R&D services.

(b) TIFAC Study – FDI in the R&D Sector: Study for the Pattern in 1998-2003

The purpose of this study has been to list the major players in R&D sector and analyse their behaviour in terms of investment, R&D effort, choice of industry, employment and future plans. In addition, the relation of the S&T policy in India and FDI is to be analysed in the light of study findings. 100 top companies making FDI in R&D in India have been studied, out of which 53 are from USA, 7 each from Japan, Germany and UK, 5 from France, 3 each from Netherlands Canada and Korea, 2 each from Switzerland, Sweden, Mauritius and China, 1 each from South Africa, Norway, Denmark and Australia. Information for some of these companies on their planned investment and workforce are given in this report.

(c) DST Study – Research and Development (R&D) in India: A Prospect and Validity Study [DRAFT REPORT]

This study especially focuses on R&D activities (by both domestic and foreign firms, public or private) in the following sectors – Chemicals and Pharmaceuticals, Nanotechnology, Engineering & Automotive, Electronics and Biotechnology. It gives a comprehensive view of the present situation in R&D in these sectors in India and the activities of the key stakeholders in India's R&D setup. The key stakeholders are identified as government ministries, government science and technology departments, in house R&D by private companies – R&D centres, alliances with public research institutions etc., contract research organisations, independent research institutes. The findings of this study for each sector are as in the following Table 2.9

Table 2.9

Chemicals and Pharmaceuticals	
Primary drivers for foreign companies	1. High quality of scientific manpower. 2. Ability to scale up quickly. 3. Familiarity with the operating environment.
Primary drivers for Indian companies	1. Competition and access to expanded markets.
Operational parameters	1. Approvals have not posed a problem 2. Companies can work with universities and academic institutions to nurture talent. 3. Companies have not faced any major problems 4. Most of the companies import laboratory equipment 5. Companies do not see IPR protection in India as a challenge
Critical Success Factor	1. Tie ups with public research institutes. 2. Tie ups with public educational institutes. 3. Import equipment to provide world class infrastructure. 4. Hiring non resident Indians.
Engineering and Automotive	
Primary drivers for foreign and Indian companies	1. High quality of engineering manpower. 2. Ability to learn quickly. 3. Ability to device simple and cheap solutions. 4. Fluency in English.
Operational parameters	1. Finding experienced managers has not posed a major problem but some training is required in specialised areas.

	2. Flight of Talent to Information Technology. This can be countered by technical rewards and recognitions. 3. Engineering companies have not significantly used public funded institutions.
Critical Success Factor	1. Reward engineering talent. 2. Companies have to continuously challenge and build pride in their teams. 3. Companies that have looked beyond the tier one institutes. have found this strategy rewarding.
Electronics	
Primary drivers for foreign and Indian companies	1. Novel ideas and continuous work cycle 2. Tradition of electronic and software development
Operational parameters	1. Supportive governmental policies. 2. Start up problems with telecom now resolved but infrastructure and customs processes exert a drag on manufacturing. 3. Insufficient electronic hardware experience and unavailability of electronic R&D managers. 4. But dedication and scientific orientation more than compensate. 5. Collaboration with publicly funded institutions have been helpful.
Critical Success Factor	1. Valuing ones employees. 2. Building a sense of global competition. 3. Bring high end Indian talent back from overseas. 4. Building a global R&D team. 5. Institutionalise relationships with entrepreneurial design firms.
Biotechnology	
Primary drivers for foreign companies	1. The vast Indian market
Operational parameters	1. No policy or ministry to approve biotech products 2. Bankers were earlier reluctant to lend, but now being completely reversed 3. Land acquisition did pose some issues 4. Abundance of labour, but there is strong competition from the rest
Critical Success Factor	1. Building a sense of mission 2. Treating employees as family 3. Hiring women gives benefits in terms of loyalty, stability, and employee bonding. 4. Public private co-operation

Source: Compiled by CITT

(d) High light of the existing policies in India to promote R&D activities:

1. Traditionally India's Science and Technology policies have emphasized self reliance and equitable development. Until recently, these policies were mainly targeted at the enhancement of R&D 'supply' through investment on basic research. The new Science and Technology policy 2003 have several measures to provide incentive for innovation in the private sector and promote public private partnership. The core objective of the policy is to raise the national expenditure on R&D. To promote international science and technology, co-operations have been an important part of this science and technology policy.

2. Several programs to promote R&D have been in place. At this moment the government has a multitude of schemes to support private sector R&D in the country. These includes programs to (1) support the absorption of imported technologies by industry, (2) develop and demonstrate indigenous technologies, (3) help individual innovators to become technology based entrepreneurs and (4) commercialise indigenous technologies.

3. There are also programs to support collaborations between technical institutions (like national laboratories / institutions of higher education) and industrial enterprises.

4. The incentives available to companies undertaking R&D can be summarised as follows:
   - (i) For in house R&D centres – write off on revenue and capital expenditure, duty free import of analytical and speciality equipment for R&D.
   - (ii) For private sponsored research programs in public funded institutions – weighted tax deduction of 125%.
   - (iii) For companies engaged in business / manufactures / production in areas such as biotechnology, drugs and pharmaceuticals, electronic equipments, computers, telecommunication equipments, chemicals, aircraft and helicopters – weighted tax deduction of 150%.

(iv) For commercial R&D companies – Ten year tax holiday for DSIR approved companies.

(v) Investment in plant and machinery based on indigenous technology – accelerated depreciation allowance @ 40%.

(vi) For wholly owned Indian subsidiaries – Excise duty exemption for 3 years on goods designed and developed and patented in India and any two countries out of USA, Japan, and any one country of EU.

5. Intellectual Property Regime in India -

India has adopted the IPR regime (TRIPS) under the World Trade Organisation. The agreement provides for norms and standards in respect of following areas of intellectual property – Copy rights and related rights, Trade marks, Geographical indications, Industrial designs, Layout designs and integrated circuits, protection of undisclosed information, Patents and Plant varieties. The Patent regime permits product patents valid for 20 years.

2.1.4 A comparison between three important destinations (China, Korea and India) of FDI in R&D is given in Table 2.10

Table 2.10

Foreign R&D Activities: A Comparison between India, China and Korea

	Korea	India	China
Objectives	•Proximity to local market •Proximity to North East Asian hub •Access to technology •Access to manpower •Reducing R&D expenditure	•Proximity to local market •Access to highly skilled manpower •R&D cost reduction •Proximity to R&D hub	•Accessing a large export base •Access to huge domestic market
Sectors	Food, Transport, Machinery Parts, Pharmaceuticals	Biotech & Pharmaceuticals, Agriculture, Computer Software and Hardware, Automobile, Electrical, Electronic, Communication Equipment	Computer hardware, Pharmaceutical Production Instruments, Telecom Equipments, Transport Equipment, Chemical
Major home countries	USA, Japan, Germany	USA, UK, Saudi Arabia, Denmark, Germany, Switzerland, Japan, Sweden, France, Netherlands	USA, UK, Japan, Germany, Canada, Singapore, Switzerland
Conducive factors	•Status of S&T •High skilled manpower •Easiness of R&D funding •Facilities and infrastructure	•Skilled manpower •S&T infrastructure •Conducive govt. policy •English speaking R&D personnel •Literate patient base with commercially significant deceases •God patient cmpliance •Less expansive clinical trials	•Low R&D costs •Quality R&D workforce •Protection of IPR •Shortening of duration from R&D to technological commercialization

Source: Compiled by CITT

2.2 Summary of Learning from the Review of Literature

From the set of literature on the issue of internationalisation of R&D reviewed above some observations can be highlighted. Some of these observations hold true almost across all countries and organisations. These are :

1. Foreign direct investment in R&D activities is on a rise currently, not only towards the developed countries but also towards the developing countries.

2. Developing countries are no more only recipients of FDI in R&D activities, they are increasingly taking the role of investors.

3. Proximity to markets, supporting the subsidiary manufacturing unit, recruiting high skilled personnel are the most predominant reasons behind choosing an FDI destination for R&D activities.

4. Some of the sectors that receive most of FDI in R&D activities are pharmaceuticals, biotechnology, Computer hardware and software, and electronic components.

2.3 Existing Literature and Our Present Study

As we see above, the literature on the issue of internationalisation of R&D activities is varied and growing. The various country studies enlightens us about the motives and implications of internationalisation of R&D in various countries making FDI in R&D activities and those receiving FDI for R&D purposes. The Studies on India, throw light on the operational issues faced by R&D firms in India, the reasons for the success for those who have succeeded. The beneficial effect on India of internationalisation of R&D has also been discussed in this set of literature. However, there are some issues that still need to be brought to light. These are, for example, (1) what kind of Research activities the international R&D organisations are undertaking; (2) what kind of infrastructural facilities the international R&D organisations are providing; (3) what are the different ways these R&D organisations are contributing to the capacity building of the downstream industries in the host countries etc. This study attempts to address these very issues for some international R&D organisations operating in India.