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Intellectual Property Protection, Market Orientation and Location of Overseas R&D Activities by Multinational Enterprises

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1. INTRODUCTION

The internationalization of R&D activity of multinational enterprises (MNEs) which was first noticed in the early 1970s (US Tariff Commission, 1973), has since attracted a lot of attention in the literature. MNEs from most home countries reveal a tendency to internationalize an increasing proportion of their R&D. The R&D activities of MNE affiliates now account for a considerable proportion of national R&D expenditure in a number of host countries. Dunning (1994) noted that the share of MNE affiliates in national R&D expenditure exceeded 15 per cent in Australia, Belgium, Canada, the UK, Germany, South Korea and Singapore in the 1980s. In the US, 15.4 per cent of all R&D in industry was conducted by foreign affiliates in 1990, compared to 6.4 per cent in 1980 (OECD, 1993). In view of considerable spillovers of R&D activity, its internationalization is seen to be contributing to technological capability in host countries. The geographical distribution of the overseas R&D activity of MNEs, however, has been highly uneven across countries. The existing literature has focused on analyzing the determinants of interindustry or interfirm variation in the propensity to internationalize R&D. Relatively little attention has been paid to an analysis of factors that determine the location of overseas R&D by MNEs.

The international distribution of R&D activity of MNEs can be expected to be uneven depending upon, among other things, the extent and nature of foreign direct investment (FDI) received by the country and the resources and environment prevailing in the country for conducting technological activities. The treatment of intellectual property, among other policy instruments, may also have an important bearing on a country's ability to attract R&D investments from MNEs.

This paper develops an analytical framework for explaining the location of overseas R&D investments made by MNEs. This framework is then used to analyze the determinants of location of R&D investments by US MNEs on the basis of the Benchmark Survey data on US Direct Investment Abroad in 1977, 1982 and 1989. The analysis focuses on the potential role played by such factors as the extent, technology intensity and market orientation of US FDI in the host country, technological resources and infrastructure available, and their trade, investment and intellectual property regimes.

The structure of the paper is as follows. The following section reviews the trends in internationalization of R&D and technological activities of MNEs from US and Japan. It also summarises earlier findings on trends and patterns in overseas R&D activity of MNEs from other countries. Section 3 reviews the existing literature on determinants of overseas R&D. Section 4 reviews major motivations of setting up

R&D abroad in the light of the literature and formulates hypotheses for explaining its location. Section 5 presents empirical findings respectively for the full sample, the subsamples according to the level of development of the country, and industry level tests conducted for verifying the role of intellectual property protection on the location of R&D. The final section concludes the paper with a few observations on the policy implications of the findings.

2. TRENDS IN INTERNATIONALIZATION OF R&D ACTIVITY

Patel and Pavitt (1991) have analyzed the importance of overseas R&D in generation of technology by the 686 largest manufacturing corporations by examining the origin of the patents obtained by them in the US. They find that technological activities of large corporations were largely concentrated in home countries and not yet globalized considerably. They note a significant variation in the importance of overseas innovation across MNEs from different home countries ranging between a marginal 0.6 per cent for Japanese corporations to 82 per cent for Dutch corporations. The US corporations obtained 3.2 per cent of their patents on the basis of research abroad and German MNEs, 6.9 per cent. Cantwell (1992) further analyzed the same data on US patenting by the world's leading firms and noted variation across industry groups in the propensity of patenting from overseas R&D, in addition to those across home countries. Food MNEs were found to be the most internationalized in R&D, followed by pharmaceutical and non-metallic mineral products. Let us now review the patterns of internationalization of R&D for MNEs from the US, Japan and other major home countries.

The US Corporations

The trends in R&D activity within US corporations, as brought out by the four successive Benchmark surveys, have been summarised in Table 1. The expenditure on overseas R&D increased rapidly between 1966 and 1977, which brought its share up from 6.57 to 9.87 per cent in total group expenditures. The early enthusiasm for location of R&D activity abroad waned, however, in the period between 1977 and 1982. The concentration of R&D activity in the home country increased bringing the share of overseas affiliates in R&D down to 6.4 per cent in 1982. In the 1980s again, overseas R&D was attached increasing importance by US corporations bringing its share up to nearly 9 per cent in 1989.

In 1989, the majority owned affiliates of US corporations spent nearly US$ 8 billion on R&D in their host countries. The country wise distribution of this activity is highly uneven and is concentrated in a handful of industrialised countries. Developing countries as a group account for about 5 per cent of total overseas R&D by US affiliates. Developing countries had increased their share in overseas R&D in the period between 1966 and 1977 when overseas R&D as a phenomenon expanded rapidly to 7.66 from under 5 per cent. Subsequently, their share declined to slightly over 5 per cent and does not reveal any increasing trend in the more recent period. Within each group a handful of countries account for a disproportionately large share of overseas R&D. Among the industrialised countries, Canada, Germany and the UK account for nearly 56 per cent of overseas R&D in 1989. Japan has increasingly become an important location for R&D by US corporations, with its share rising from 0.5 per cent in 1966 to 12.62 per cent in 1989. Among developing countries, Brazil, Mexico, Israel, Taiwan are major locations of R&D by US corporations.

The Japanese Corporations

Table 2 summarises the distribution of R&D activity in the Japanese corporations, as revealed by the two recent benchmark surveys of their overseas activities conducted by MITI. The R&D activity in the case of Japanese enterprises is even more heavily concentrated at the parent than their US counterparts, as also observed by Patel and Pavitt (1991) on the basis of origin of patents. But the trends show an increasing internationalization over time. The share of overseas R&D in total group expenditure has nearly doubled from 1.46 percent in the fiscal year 1989/90 to 2.57 in 1992/93. But the bulk of the overseas R&D activity is concentrated in industrialised countries with North America (largely the US) accounting for nearly 66 per cent of expenditure in 1989/90 and 44.56 per cent in 1992/3. The European (largely the EC) continent has suddenly become a favoured location for R&D by Japanese corporations in the recent period. The total R&D expenditure by Japanese affiliates increased by five times between 1989/90 and 1992/93, bringing their share in total overseas expenditure up from 21.27 to 49.25 per cent. The concentration of Japanese FDI in the EC countries over the late 1980s and early 1990s in the wake of Single European Market plan (Kumar, 1994a) seem to have been accompanied by a similar concentration of R&D investments to support their manufacturing investments. The increasing concentration of R&D expenditure in the EC countries has meant that the share of R&D expenditures of Japanese affiliates in developing countries in has come down over the past three years. In the case of Latin America and Oceanic countries, even the absolute expenditure has also declined between the two survey periods.

Other Corporations

Zejan (1990) examined the R&D activities of Swedish MNEs on the basis of the 1978 Survey of Swedish investments abroad compiled by IUI. The survey covered 118 MNEs, 43 of which undertook R&D abroad. Overseas R&D accounted for 10 per cent of total expenditure on R&D in 1978 by

Swedish industry. The overseas R&D of Swedish companies was largely concentrated in the EC countries, which accounted for 58.5 per cent and the US accounted for another 19.5 per cent. Hakanson and Nobel (1993, a,b) have analyzed the foreign R&D for a sample of 20 Swedish MNEs in 1987. These MNEs operated 170 foreign R&D units accounting for some 25 per cent of their total R&D expenditure. Zander (1994) found a rising trend in the share of US patents originating abroad obtained by Swedish companies over the 1890 to 1990. In the period 1986-90 about 30 per cent of patents originated in foreign countries. However, the bulk of overseas patents emerged in industrialised countries, with the U.S. and Germany accounting for 65.4 per cent of all overseas patents obtained between 1986-90 (and nearly 70 per cent during 1981-85).

Wortmann (1990) has examined the overseas R&D of 23 German MNEs. The sample German MNEs employed nearly 18 per cent of their R&D personnel abroad. The growth of foreign R&D employment had been faster than that in the home country. About half of total foreign R&D employment of German companies was concentrated in Europe and most of the other half in North America. The chemical and pharmaceutical industry showed a very high R&D intensity abroad largely due to requirements for clinical testing as a condition of approval in many markets. The electrical industry also revealed a relatively high propensity to do R&D abroad.

Cantwell and Kotecha (1994) have analyzed the internationalization of the technological activity of French corporations using US patents taken by leading enterprises. They find that the share of patents originating overseas for French corporations has been lower compared to their European counterparts. But it has also shown an increasing tendency, having risen from 8.19 per cent during 1969-72 to 15.87 per cent during 1987-90.

3. DETERMINANTS OF OVERSEAS R&D: THE LITERATURE

Lall (1979), Hewitt (1980), Hirschey and Caves (1981), and Pearce (1989) have analyzed the determinants of interindustry variation in the propensity of US MNEs to do overseas R&D using Benchmark Survey data (1966 in all the cases except for Pearce, who uses the 1982 survey). Overseas R&D had a significant positive relationship with the extent of multinationality of industry. The R&D intensity of industry also had a positive relationship with overseas R&D. It was explained in terms of a higher pressure to locate R&D abroad on cost saving reasons in more R&D intensive industries. The tendency of industry to use licensing as a means of exploiting their knowledge abroad was positively related to the extent of overseas R&D. Lall also found some difference in the performance of multinationality and R&D intensity variables across process and engineering industry subsamples. In addition, Hirschey and Caves found the scale economies in R&D (captured by a proxy of efficient scale of production units) discouraging overseas R&D. The tendency to centralize production for foreign markets at a few overseas locations (captured by affiliate exports to other than the US) favoured overseas R&D. The R&D expenditure per employee as a measure of relative cost of doing R&D in the US was also positively related with the overseas R&D. The industries producing durable goods were undertaking more overseas R&D because of the need to adapt their products to local conditions. In addition, Hewitt found affiliate exports to US parents to have a positive influence on overseas R&D.

A number of firm level studies have analyzed the phenomenon of overseas R&D, as well. Mansfield, Teece and Romeo (1979), in a study covering a sample of 55 US and middle Atlantic firms, found the proportion of overseas R&D to be positively related to the proportion of subsidiary sales (as in the industry level studies), negatively related to exports, and positively related to firm size (in view of economies of scale involved in R&D). Drug industry firms revealed a higher propensity to locate R&D abroad than other firms in order 'to avoid FDA regulations' in the US. Pearce (1989) analyzed the determinants of overseas R&D performed by 122 leading MNEs in 1982. The overseas production ratio had a positive relationship with overseas R&D, and exports a negative, as expected. The relationship between overseas R&D and firm size was found to be an inverted-U shaped. Natural resource based industries (viz. building materials, and paper and wood products) showed a lower tendency to perform R&D overseas than other industries.

Zejan (1990) found R&D intensity of affiliates positively related with that of parent in a cross section tobit model explaining the R&D intensity of foreign affiliates of Swedish MNEs. The host country characteristics (viz. size of the market and per capita income as a proxy of level of development in the host country and scientific resources available) were both found to have a positive and significant influence on affiliate R&D. The affiliates exporting to markets other than Sweden revealed a greater tendency to do R&D. Hakanson (1992) analyzed the determinants of distribution of foreign R&D employment by 20 Swedish companies across 21 countries. The relative levels of foreign R&D across sample companies were positively related with the extent of foreign employment and international acquisitions of firmsas expected. The overall R&D employment by Swedish firms in a country was found to be positively related with the size of the market, as measured by manufacturing employment. Predictably, the R&D intensity of a country had a positive influence on R&D motivated to exploit R&D resources of foreign countries. The size of market and the US dummy favoured local market-oriented R&D. The size of market also favoured political and local production supporting R&D. The six founding members of EC have attracted politically motivated and local production supporting R&D. The index of psychic distance from Sweden was negatively related with all types of foreign R&D except for the research resource oriented R&D.

Pearce and Singh (1992) analyzed the determinants of overseas subsidiary patent ratio (share of US patents attributable to the R&D units outside the home country) in 1981/83 for 432 leading firms. The prominent explanatory variable was overseas production ratio with the predicted positive and significant influence. Firm size and export ratio came up with mixed results often with poor levels of statistical significance across subsamples. They also did not observe a systematic influence of country or industry characteristics other than the firm level factors. Continental European firms revealed a greater, and Japanese firms a lower, tendency to innovate abroad than their US counterparts holding other things constant in tune with other literature.

Another strand of the literature has looked at the impact of the presence of MNEs on local R&D activity in host countries. In a study covering 43 Indian manufacturing industries by Kumar (1991), the MNE affiliates appeared to be spending a significantly lower proportion of their sales on R&D than their local counterparts in univariate tests. But the statistical significance of these differences vanished in a multivariate context and apparently was on account of extraneous factors. Veugelers and Vanden Houte (1990) found a negative effect of the presence of MNEs on the innovative efforts of domestic firms in Belgian manufacturing, especially if their products were less differentiated.

The existing literature, therefore, has brought out the factors explaining internationalization of R&D activity. The internationalization of production, R&D intensity of industry and economies of scale in R&D emerge as major factors explaining internationalization of R&D across industries. The intensity of overseas production and firm size explain the extent of overseas R&D across firms. The limited attention that has been paid to an analysis of locational factors brings out the importance of size of the host country market and its level of development. A more detailed analysis of factors that make a country more attractive as a potential location for R&D investments by MNEs remains to be made.

4. EXPLAINING THE LOCATION OF OVERSEAS R&D: THEORY AND HYPOTHESES

MNE decision making with respect to the location of R&D is determined by the balancing of factors that encourage concentration at headquarters and those that favour location abroad. The economies of scale in innovative activities (which are often considerable), agglomeration economies, and the risk of dissipation of trade secrets tend to encourage concentration of R&D. A number of factors; such as the need for product or process adaptations for specific markets, cost rationalizations and appropriation of knowledge spillovers from technological activities of rival firms; may encourage overseas R&D.

The overseas R&D of firms may be motivated by one or more of the following three broad reasons. The first and foremost reason is to support their foreign production by adaptations necessary for specific markets. Some of these adaptations are best undertaken closer to the markets for which they are meant; for instance, adaptations of consumer goods to the local cultural environment. The location of this type of R&D investment will be influenced by the market orientation of foreign affiliates and the size of local markets. The second motivation for overseas R&D could be to rationalise it according to cost considerations. Availability of abundant trained R&D personnel or other resources required for technological activities at relatively lower cost than in the home country may prompt MNEs to locate a part of their R&D activity to such locations to reduce their global R&D costs. It may also include rationalization of development of certain products and processes at an overseas R&D unit in view of economies of scope or scale. The location of this type of R&D would be explained by the relative abundance and cost of technological resources. Astra's major biotechnology research centre set up in India in the late 1980s, for instance, has been primarily designed to tap abundant trained manpower available at low cost. Finally, MNEs also locate R&D in other countries advanced in their own fields to benefit from the knowledge spillovers or to simply keep track of the activities of their competitors. The examples of this type of R&D include investment in R&D or in high technology start up enterprises in biotechnologies and microelectronics in the US by European and Japanese enterprises, the US chemical enterprises investing in R&D in Germany, and European and US companies investing in semiconductor development in Japan. Dunning (1988) argued that US MNEs were likely to invest heavily abroad in R&D in the sectors where they were confronted with major international rivals whose home countries were sources of innovative activity. These R&D investments would be directed toward the most technologically advanced countries in the world.

4.1 Hypotheses

The location of the R&D activities of a corporation which has decided to internationalize its R&D could be influenced by several factors. In what follows a few major factors determining the location of R&D by MNEs, especially those from the US, are identified with predictions on their likely role. These factors include the scale and type of foreign direct investment in the country, availability of resources and conditions conducive for innovative activities in potential host countries in terms of their structural characteristics and the policy environment. The empirical verification of the predictions is made in the following section.

Scale and Nature of Local Production

a) Scale of Direct Investment in the Host Countries

The industry and firm level studies, as reviewed above, have generally reported a significant linear relationship between overseas R&D and overseas production ratio. The extent of R&D performed by MNEs in a host country may also be related to the extent of their market penetration in it. This is because the extent of penetration of FDI in an economy reflects the relative attractiveness of the host economy for doing business in terms of policy environment and availability of infrastructure. It can be expected that countries that are attractive for US FDI are also relatively more attractive locations for doing R&D. Therefore, a positive relationship is predicted between overseas R&D and the extent of US MNE participation (*USSALES*) in an economy.

b) Market Size

In view of economies of scale involved in research, the size of the host country market may exercise an important influence on the decision to set up an R&D unit to assist local production. Regional R&D units are often set up closer to the major markets for the firms. Hence, affiliates operating in countries with larger markets should have better chance of hosting a R&D unit, holding other factors constant. Market size has been found by Zejan (1990) and Hakanson (1992) to be an important determinant of location of R&D for Swedish corporations. The market size (*MSIZE*), as captured by the national income of a country, is thus expected to add to the attractiveness of a country as a location for overseas R&D.

c) Technology Intensity of Local Operations

More technology intensive affiliates generally need more technological inputs than others. Hence, countries hosting technology intensive affiliates are more likely also to be hosting R&D establishments of MNEs, other things held constant. Technology intensity of affiliates (*TECHINT*) is proxied by the significance of technology payments by affiliates.

d) Market Orientation of Local Production

The market orientation of affiliates may have implications for the relative need for doing local R&D. An affiliate serving entirely the local market may have different demand for technological inputs than one having a global product mandate from the parent. Production for local markets may require adaptations and hence need for local R&D. An affiliate exporting to the US parent may be producing to the given designs and may not require significant R&D inputs. The capability for adaptations may also be required to support the affiliates exporting to regional or (non-US) global markets. Hirschey and Caves (1981) found the exporting to non-US markets to be an important influence on overseas R&D in industry level studies. Therefore, the affiliate R&D intensity in a country is expected to be positively related with the proportion of local (host country) sales (*LOCASAL*) and that of non-US exports (*NUSEXP*) but not with exports to US (*USEXP*).

Host Country Resources

e) Technological Resources and Infrastructure

A considerable proportion of overseas R&D activity of MNEs is geared toward internalizing knowledge spillovers from ongoing research in a host country and toward benefiting from the technological infrastructure and resources available there. A high concentration of overseas R&D in a few technologically advanced countries lends support to this expectation. If that were so, countries with greater technological effort will have greater likelihood of attracting R&D activity of foreign MNEs, other things held constant. The technological resources and infrastructure of countries will be captured with the help of three measures reflecting the scale and environment conducive for technological activities namely, the share of national resources devoted to R&D activity (*RDGNP*), proportion of residents in patent grants (*RESPAT*), and a measure of attainment of higher education (*HED*). The latter captures the availability of R&D personnel.

f) Supply of Low Cost Personnel

A considerable proportion of overseas R&D could be motivated by the push for cost reduction and hence rationalized to locations having a low cost supply of S&T personnel. Hence, other things being same, countries with a low cost supply of R&D personnel are likely to attract more overseas R&D activity of MNEs than others. In the absence of data on wage costs of R&D personnel in different sample countries, we employ two variables to capture the possible effect of this factor; the average wages rates (*WAGE*), and R&D expenditure per R&D worker by affiliates of US MNEs (*RDEXEMP*) in different countries. Both of these measures have obvious limitations in capturing the effect of the factor under discussion. These limitations have to be kept in mind while interpreting the findings.

g) <u>Communications Infrastructure</u>

R&D activity requires a constant interaction with different production and research units within a corporation at different locations. Hence, availability of adequate communication infrastructure may be a minimum requirement for a country to be able to attract investment in R&D by MNEs. The relationship between availability of communication infrastructure and the extent of overseas R&D activity, however, need not be linear and continuous, but only a necessary condition. Nevertheless, an indicator of telecommunication infrastructure in the country (*PHONES*) would be included among the potential factors explaining the location of overseas R&D.

Policy Environment in the Host Country

h) <u>Intellectual Property Protection</u>

There has been a considerable controversy on the role of intellectual property protection in influencing the FDI inflows to a country in the literature (see e.g., Frischtak, 1989; Ferrantino, 1993; Mansfield, 1994). The issue of intellectual property protection links more directly with R&D activity. MNEs may be apprehensive to locate their key R&D centres in countries with weak intellectual property regimes. Therefore, the relative strength of intellectual property protection available in a country may be a factor in determining the overseas R&D activity by MNEs. If, on the other hand, overseas R&D is directed to local adaptations and providing other support to local production of MNE, and not directed to new product development, intellectual property regimes may not be of much consequence for its location. Therefore, the effect of intellectual property protection on location of R&D may depend on the type of R&D that is conducted.

The empirical examination of its role is complicated by the fact that the level of intellectual property protection offered by different countries varies across different products. Therefore, unless the R&D activity of foreign affiliates in the country is broken down according to products or industries and nature of R&D activity, a rigorous examination of its role can not be made. The data for this level of disaggregation, however, is not reported. We attempt a two step process wherein the importance of intellectual property protection in determining R&D by US affiliates is first examined at the country level using an index of overall strength of patent protection (*IPP*). This index measures the strength of patent protection on a six point scale constructed by Rapp and Rozek (1990) based upon conformity of each nation's patent laws to the minimum standards proposed by the US Chamber of Commerce. Being based on subjective assessment of individuals, such an index has its own limitations. The inferences drawn on the basis of it should be treated with caution and be taken as indicative rather than definitive. Since the nature of overseas R&D conducted by MNEs in technologically advanced nations and developing countries could be different, the role of IPP is examined for subsamples of countries as well.

The second step involves a verification of the role of IPP in location of R&D for two process industry groups, viz. processed foods and chemicals (also covering pharmaceutical). A number of countries do not provide for product patents in one or both of these industries. The information on whether or not patent protection on products is provided is used to examine their role in determining R&D location.

i) Trade Policies

The role of trade policy regime of host countries in influencing the R&D intensity of MNEs is also less straight forward. An economy protecting intermediate products and capital goods may create greater demand for technological inputs by increasing the need for indigenization. On the other hand, a restrictive trade regime may discourage MNEs from undertaking R&D activity in the economy because of perceived difficulties in importing equipment, personnel, components and other inputs for R&D and other handicaps of a restrictive atmosphere. Hence, *TRBARR*, a variable capturing both tariff and non-tariff barriers on intermediate and capital goods is included among potential explanatory variables without a prediction of the direction of impact.

j) Host Country Performance Requirements

The role of different restrictions imposed by the host governments on the conduct of foreign affiliates, more generally called Trade Related Investment Measures (TRIMs), has been debated in recent years in connection with the recently concluded multilateral trade negotiations (see Guisinger et al., 1985). One set of performance requirements that may have a bearing on R&D intensity of foreign affiliates is the requirement to transfer technology (*TTREQ*) to the host country.

5. EMPIRICAL ANALYSIS

In light of the above predictions, the R&D intensity of majority owned US affiliates ($AFRDS_{jt}$) in *j*th country in *t*th time is expected to be a function of the following variables.

$AFRDS_{jt} = AFRDS_{jt}$ ($USSALES_{jt}$, $MSIZE_{jt}$, $TECHINT_{jt}$, $LOCASAL_{jt}$, $NUSEXP_{jt}$, $USEXP_{jt}$, $RDGNP_{jt}$, $RESPAT_{jt}$, HED_{jt}, $WAGE_{jt}$, $RDCOST_{jt}$, $PHONES_{jt}$, IPP_{jt}, $TRBARR_{jt}$, $TTREQ_{jt}$, u_{jt})

where *u* represents unspecified and random influences.

j = 1..........nth country;

t = 1977, 1982, 1989.

An empirical test of these predictions is conducted with the help of the Benchmark Survey data on Direct Investments Abroad conducted by the US Department of Commerce. These surveys provide information on expenditure on R&D by majority owned affiliates of US enterprises in different host countries in the industrialised and developing countries. The country coverage in the Surveys extend to 54 countries which are significant hosts of US FDI. The R&D information on a considerable number of countries, however, is suppressed either for confidentiality or other reasons. The data from the 1977, 1982 and 1989 benchmark surveys are pooled to allow examination of overtime trends in addition to increasing the degrees of freedom available. Annex 1 provides more details of the data set and measurements and sources of variables. The effect of time dimension will be detected by including dummy variables for 1977 and 1989 and using 1982 as a benchmark.

A number of our variables have high collinearities among themselves (especially the alternative measurements of technology resources factor). That implies that all the variables can not be tried together. Hence a number of alternative combinations are tried and reported. As is clear from the variable measurements given in Annex 1, all the variables have been normalized except for *MSIZE*. *MSIZE* is transformed into natural logarithms to suppress the scale of variation. Nevertheless, heteroscedasticity could be a problem in a sample comprising a heterogeneous mix of countries such as this. In the situations where the precise form of heteroscedasticity is unknown as is generally the case, use of neither ordinary least squares nor of generalised least squares is appropriate (Greene, 1993). However, it is possible to correct the covariance matrix for the ordinary least squares using White's consistent estimator. Greene provides a ready procedure for OLS estimation with revised covariance matrix in his LIMDEP econometric software (see Greene, 1991). We use this procedure for correcting for the potential heteroscedasticity in the present exercise. First the results for the overall sample are presented. Later findings pertaining to the subsamples of industrialised and developing countries are discussed which reveal a considerable variation in the performance of variables.

5.1. Full Sample

Table 3 presents the estimated equations for the full sample. The US penetration in the host country market as captured by *USSALES* has a predicted positive sign throughout but generally falls short of acceptable levels of statistical significance in terms of t-test. It would appear from this that a higher degree of penetration of US investments in the country does not necessarily make it a more attractive location for R&D.

MSIZE turns out to be a significant determinant of affiliate R&D with a predicted positive sign. MNE affiliates operating in countries with larger markets are more likely to have their operations supported by local R&D, other things held constant.

Technology intensity of local production captured by *TECHINT* has a negative coefficient that is not significantly different from zero in statistical terms. It appears that the decision pertaining to R&D location, being a part of global decision making of the organization, is taken independently of the technological requirements of a particular affiliate or operation. Being a host to technology intensive manufacture does not seem to ensure a proportionately greater attraction as an R&D location.

The market orientation of US FDI in the country was expected to have some influence on the R&D activity of affiliates. The proportion of local sales (*LOCASAL*) has an expected positive sign and just misses a 10 per cent level of statistical significance. The intensity in exports to third countries (*NUSEXP*) has a negative sign and very poor t-values. The intensity of exports to the US (*USEXP*) to comes up with a similar result (not included in the reported equations. It appears that export oriented affiliates produce largely to the designs supplied to them by parent. Hence, R&D facilities for supporting them are not necessary. The affiliates producing for local market are more likely to have a R&D laboratory to support them in product and sometimes process adaptations according to local conditions or specifications, holding other things constant.

RDGNP, one of the variables tried to capture aspects of technological resources and infrastructure available in the country, is generally significant with a positive sign at 1 per cent level in most combinations. It tends to support the prediction that a considerable proportion of overseas R&D of MNEs is motivated to benefit from technological environment and resources in other countries. Hence, countries with more developed technological resources are more likely to attract overseas R&D of MNEs, other things held constant. The others viz. *RESPAT* and *HED* do not achieve statistical significance.

Among the two variables employed to capture the cost of personnel, *WAGE* which measures average industrial wages prevailing in the country, performs very poorly in terms of t-values and was dropped from the reported equations. It had an obvious limitation as an indicator of relative levels of remuneration of R&D employees. The other variable *RDEXEMP*, measuring R&D expenditure per R&D employee comes up with a positive and significant coefficient. This would tend to imply that internationalization of R&D in general is not driven by cost saving considerations. Given the limitations of measurement, however, one is wary of drawing that inference. This variable measures research costs and salaries per R&D employee. It in not possible to infer from the performance of this variable anything meaningful about the role of wage rates of R&D personnel in explaining location unless nonwage R&D costs are held constant across observations. That is obviously not the case as research costs are affected from industry composition, the nature of R&D, as well as the location. Therefore, further work is necessary before a judgement could be made on the role of availability of cheap trained manpower on location of R&D by MNEs.

PHONES is consistently significant with a negative sign which appears to be counterintuitive. Although a linear functional relationship is not expected between telecommunication infrastructure and location of R&D it being a necessary and not a sufficient condition, its negative sign is quite surprising. *PHONES* appears to be picking up other influences. In any case, given the high and quite comparable levels of telecommunication infrastructure in the industrialised countries, it may be a relevant factor only in the case of developing countries. Hence, a comment on its performance is reserved till its performance in subsamples has been observed.

Among the policy factors, *IPP* comes up with a positive and significant coefficient consistently. It would appear to suggest that a strong intellectual property regime is an important condition for attracting R&D activity of MNEs. The role of *IPP* is subject to further tests in the following subsections and hence is reserved for a comment later.

TRBARR is with a positive coefficient and achieves statistical significant in some combinations such as equation 3. It tends to suggest that protection of intermediate and capital goods industries may attract more R&D investments than others keeping other things same. The possible explanation for this outcome is that barriers on imports of capital and intermediate goods encourage MNE affiliates to undertake product and process adaptations locally by making imported alternatives more expensive.

TTREQ has a positive sign but is not statistically significant. The performance requirements for transfer of technology do not, therefore, appear to be important in influencing the pattern of R&D location. The time dummies are generally insignificant; 1977 with a positive sign and 1989 with a negative sign. It tends to signify a decline in internationalization of R&D by US MNEs since 1977 as was noted in section 2 above.

5.2. Level of Development and Overseas R&D

In the second stage of analysis, subsamples of industrialised and developing countries were separated and same model was estimated for subsamples. The results for industrialised countries subsample summarised in Table 4 echo the full sample findings. Hence, we do not repeat their explanations. The relationships for the developing country subsample reported in Table 5 look quite different from those of full or industrialised country samples in a number of respects and hence warrant comment.

The scale of US FDI in developing countries represented by *USSALES* has a positive coefficient as earlier but manages to cross the threshold of t-value for a 10 per cent level of statistical significance. Therefore, developing countries with a higher extent of US FDI have a slightly better chance of receiving R&D investments in affiliates, other things remaining the same. *MSIZE* retains its positive and highly significant coefficient indicating the importance of market size for R&D activity presumably because of economies of scale involved in R&D irrespective of level of development. *LOCASAL* imparts a strong positive influence on affiliate R&D for this sample unlike the previous two. Affiliate exports intensity whether or not to US has a converse relationship (not reported in the Table). It appears that affiliate R&D in developing countries whenever undertaken is geared towards adaptations for the local markets. Developing countries are unlikely to be used as location for technology development for global markets.

RDGNP is positive and significant as earlier, suggesting that other things being same, developing countries with higher scale of technological activity have a greater chance of being chosen as bases for R&D activity by MNEs. *RESPAT* which was never significantly different from zero in earlier samples, turns up with a strong positive coefficient. The share of residents in total patent granted in a country that this variable represents is a measure of national technological capability. Therefore, this relationship suggests that developing countries with higher technological capability are more likely to be chosen as bases for R&D of MNEs. This finding tends to reinforce the expectation that a potential motive of internationalization of R&D of MNEs is to internalize the spillovers of national R&D systems in the host countries. *PHONES* comes up with a predicted positive sign unlike the previous samples. The statistical significance is marred by its high collinearity with *IPP*. Though it has poor t-values in the equations reported in the table, it does achieve a 10 per cent level of statistical significance in some combinations not reported here. Unlike their industrialised counterparts, developing countries differ greatly among themselves in terms of the availability of telecommunication infrastructure. Other things being same, countries equipped with reasonable levels of such infrastructure appear more likely choices for R&D investments by MNEs.

IPP unlike in the previous samples has a negative sign in the present sample and just misses a 10 per cent level of significance. It is an interesting result and suggests that among developing countries, level of intellectual property protection does not appear to be a prerequisite for R&D investments by MNEs. If at all, a strong regime may discourage MNEs to do R&D in the country! One possible explanation of this result could be that MNEs do some local R&D in countries with weak patent regimes to safeguard their intellectual property by registration of adaptations as local innovations. The developing countries with weak patent regimes are generally those with significant imitative capabilities. While intellectual property protection is generally weak, local innovations which may often be marginal adaptations of foreign innovations, are better protected than the foreign innovations as a part of the national policies to encourage local technological capability. In the countries with strong patent regimes such response on the part of MNEs would not be necessary.

An alternative and perhaps more plausible explanation could be provided by the divergence in the performance of *IPP* in developing and industrialised country subsamples. A strong positive influence in the case of industrialised countries and an insignificant negative influence for developing countries may in fact be reflecting the different nature of R&D activity performed by MNE affiliates in the two groups of countries. It is possible that overseas R&D located in industrially and technologically advanced countries is of more creative type or product or process development oriented and may be more responsive to availability of adequate intellectual property protection. The examples of this type could include the development of Ford Mondeo in Europe for production and sales worldwide by Ford's Belgian subsidiary, or biotechnology research by German chemical and pharmaceutical MNEs in the US to benefit from spillovers from other R&D in the field in the country (Wortman, 1990). On the other hand R&D based in developing countries may be geared more to adaptations for the local or regional markets. These adaptations may not be affected much by the availability or otherwise of patent protection. Note in this context that *LOCASAL* as a determinant of overseas R&D is significant only for the developing country subsample and not for industrialised countries. That may indicate that R&D performed in developing countries is more local production oriented than that conducted in industrialised countries and hence is not sensitive to the level of intellectual property protection. However, one may not read too much from these results in view of the limitations of measurement.

TRBARR, like earlier, comes up with a positive and significant influence on affiliate R&D intensity. It is consistent with the explanation of *LOCASAL*. In developing countries the bulk of the R&D activity is geared towards adaptations for the local market. The requirement for such adaptations may be particularly higher in economies with high trade barriers because of imported alternatives being more expensive. The year dummies are with positive sign but are not significantly different from zero.

5.3. Product Patents and Overseas R&D in Food and Chemical Industries

A further test of the role of the intellectual property regime in influencing the location of overseas R&D activity of MNEs is conducted for chemical and food products industries. The Benchmark Surveys do not provide the break up of affiliate R&D expenditure in different host countries by the industries of affiliate. However, the R&D employment in the affiliates is given for 7 broad manufacturing groups. Thus it is possible to construct the share of R&D employment as a proportion of total employment of affiliates in respective industries in different host countries. Processed foods and chemical (covering pharmaceutical) industries are picked up from the broad industries available. The level of patent protection varies across countries for food and chemical industries as a number of countries with soft intellectual property regimes do no provide product patents in these industries. The observations are pooled across the two industries for the 1989 Benchmark Survey. It is not possible to extend this analysis to cover earlier years because of unavailability of certain variables. The exact model estimated is as follows:

$$AFRDEMP_{ij} = AFRDEMP_{ij}\,(MSIZE_j, RDGNP_j, AFFSAL_{ij}, DPRODPAT_{ij}, DCHEM_{ij}, DLDC_j\,, u_{ij})$$

where $AFRDEMP_{ij}$ is share of R&D employees in total employment of affiliate in *i*th industry and *j*th country;

$AFFSAL_{ij}$ is share of total affiliate sales in *j*th country accounted for by *i*th industry;

$DPRODPAT_{ij}$ is dummy for availability of product patents for products of *i*th industry in *j*th country;

$DCHEM_{ij}$ is a dummy variable for chemical industry observations;

$DLDC_j$ is a dummy variable for developing country.

u_{ij} represents unspecified and random influences.

i = chemical or food industry.

j = 1......n host countries.

The estimated version of the above equation is presented in Table 6. The technological resources and infrastructure variable *RDGNP* continues to be significant with positive sign. *MSIZE* representing market size in terms of overall national income is not significantly different from zero. Perhaps the national income does not capture the size of the market for the respective industries as the composition of industrial value added indeed varies widely across nations. The importance of the industry for US operations in the country captured by $AFSAL_{ij}$ has a positive sign but does not achieve statistical significance. It suggests that the importance of the *i*th industry for operations of US affiliates in a particular country is not related to its importance as R&D location. This observation corroborates the inference drawn earlier about MNEs being more selective about R&D locations than for production locations.

$DPRODPAT_{ij}$ turns up with a negative coefficient which is not significantly different from zero. This outcome in a sample comprising both industrialised and developing countries for intellectual property protection sensitive chemical and food industries is interesting. It suggest that the level of patent protection has no significant influence on decision making of MNEs regarding location of their overseas R&D in chemical and food industries. This finding considerably weakens the argument that a strong patent regime is a prerequisite for innovation and thus for attracting R&D activity of MNEs. It appears that the other factors such as availability of R&D infrastructure and environment are more important in influencing the decision making of MNEs with respect of R&D location than the intellectual property regime. The lack of product patents does not seem to be a particularly significant constraint for MNEs to set up an R&D laboratory in a particular country. In any case MNEs may register patents in their home countries or elsewhere as they would do in any case. There are examples of R&D facilities set up by affiliates of chemical, pharmaceutical and food MNEs such as Ciba, Hoechst, ICI, Unilever, Cadbury, and Astra in India which does not provide product patents in their branches of manufacture. Furthermore, findings reported in earlier sections suggested that the bulk of the overseas R&D especially in developing countries is directed to support local production and is presumably of adaptive type. If that is the case, the availability of product patents may not matter much for influencing the location of overseas R&D.

The strong positive coefficient of *DCHEM* signifies that chemical industry affiliates are more R&D intensive than their food industry counterparts. In general chemical industry is more research intensive than the food industry. This result suggests that chemical industry MNEs also undertake more overseas R&D than their food industry counterparts. Mansfield et al. (1979) had noted a higher propensity of drug firms to locate R&D abroad to avoid FDA regulations. *DLDC* has a significant negative coefficient indicating that a much less proportion of overseas R&D is performed in developing countries even after holding other factors constant.

6. CONCLUDING REMARKS

This paper has examined the determinants of location of overseas R&D activity by US MNEs in an analytical framework developed to take into account the influences of the nature and extent of FDI and host country resources and policy regimes. The major empirical findings of the analysis are recapitulated here. A larger penetration of FDI in a country, in general, does not appear to improve its attractiveness as a potential host for R&D investment by MNEs. Among the developing countries, however, FDI penetration appears to improve their chances to attract R&D investments, other things held constant. The countries hosting high technology productive investments of MNEs are also not necessarily important hosts of their R&D investments. The countries with larger domestic markets are more likely to receive R&D investments from MNEs holding other things constant. The affiliates producing for export markets, whether to the home country or to other countries, appear to produce according to given designs and drawings and are unlikely to undertake local R&D. Affiliates producing for the local markets, especially in developing countries, on the other hand, are more likely to have a R&D laboratory supporting them. The need for adaptations for specific local markets appears to be a major motivation for overseas R&D, especially in developing countries.

The technological resources and infrastructure available in the country exercise a strong influence on the probability of attracting R&D investments from MNEs. In addition, in developing countries the local technological capability also plays an important role in attracting MNE investments in R&D. It would appear from this finding that another major motivation of overseas R&D investments is to utilize technological resources available in different countries and to internalize the spillovers from R&D done by national firms. The barriers on import of capital and intermediate goods especially in developing countries creates greater demand for technological inputs by subsidiaries by making imported alternatives relatively more expensive and hence increases probability of undertaking local R&D for adaptations.

The overall strength of intellectual property regime of the country favourably affects the probability of attracting R&D investments of MNEs only in full and industrialised country samples. For developing countries, strength of intellectual property protection does not appear to be a condition for R&D investments. It appears that the type of R&D that is undertaken in developing countries is not sensitive to the relative strength of patent protection offered by them. The R&D based in industrialised countries may be more creative or new development oriented, hence demanding stronger intellectual property regimes. These inferences should, however, be read with caution and treated as tentative in view of limitations of measurement. A more direct test for food and chemical industries covering both industrialised and developing countries did not bring out a significant role of intellectual property protection in influencing the location of R&D by MNEs. Apparently, there are types of R&D operations which may be quite sensitive to the strength of property rights. But there are others which are not so much affected by the availability of product patents or strong patent regimes. MNEs, in any case, are better placed than national firms to obviate constraints placed by weak intellectual property regimes of their host governments on their technological activities by registering the patents in their home countries. How else could one explain the setting up of biotechnology research centres by pharmaceutical MNEs such as Astra in such countries having no product patents for pharmaceutical products as India?

MNEs from different home countries have revealed different propensities to internationalize their R&D activity as seen in Section 2. US MNEs have a lower tendency to internationalize their R&D than European MNEs and higher tendency than Japanese MNEs, for instance. While there are no *a priori* reasons to expect a different performance of the above variables in explaining the location of overseas R&D by MNEs from other countries, there may be a few additional factors operating in specific cases.

Let us now conclude the paper with a few remarks on the policy implications for developing countries aspiring to host R&D investments of MNEs. The R&D investments of MNEs are highly dependent upon the country's ability to provide necessary technological resources and local technological capability. These conditions have to be created before R&D investments from MNEs can take place. Seen this way, MNEs tend to widen the gap between technologically richer and technologically poorer nations by concentrating their R&D investments in the countries already ahead in this respect. The intellectual property protection regime as such may not affect the flow of investments in R&D significantly but may affect the nature or direction of R&D activity conducted. The liberalization of either FDI or trade regime may not be of much consequence as far as inflows of R&D investments from MNEs are concerned. Finally, in so far as market size is an important determinant of location of R&D, membership in a regional trading block may increase a country's attractiveness as a host to R&D investments by extending the effective market size beyond national territories.

Table 1: Overseas Research and Development by United States Corporations
(millions of dollars)

	1966	1977	1982	1989
Group R&D Expenditure	**8976**	**21028**	**60171**	**90149**
R&D Expenditure Parents	**8386**	**18953**	**56320**	**82227**
R&D Expenditure Majority owned non-bank affiliates	**590** (6.57)[1]	**2075** (9.87)[1]	**3851** (6.40)[1]	**7922** (8.79)[1]
Major Destinations of Affiliate R&D				
Canada	**163** (27.63)[2]	**255** (12.29)	**505** (13.11)	**975** (12.31)
Belgium	**17** (2.88)	**92** (4.43)	**223** (5.79)	**313** (3.95)
France	**52** (8.81)	**291** (14.02)	**332** (8.62)	**521** (6.58)
Germany	**123** (20.85)	**462** (22.27)	**1079** (28.02)	**1726** (21.79)
Italy	**14** (2.37)	**85** (4.10)	**150** (3.90)	**393** (4.96)
Netherlands	**9** (1.53)	**55** (2.65)	**65** (1.69)	**367** (4.63)
United Kingdom	**133** (22.54)	**393** (18.94)	**824** (21.40)	**1718** (21.69)
EC	**215** (36.44)	**1395** (67.23)	**2729** (70.86)	**5346** (67.48)
Japan	**3** (0.51)	**36** (1.73)	**112** (2.91)	**1000** (12.62)
Australia	**21** (3.56)	**93** (4.48)	**114** (2.96)	**190** (2.40)
Industrialised countries	**560** (94.92)	**1916** (92.34)	**3650** (94.78)	**7516** (94.88)
Argentina	**6** (1.02)	**16** (0.77)	**20** (0.52)	**10** (0.13)
Brazil	**4** (0.68)	**55** (2.65)	**97** (2.52)	**92** (1.16)
Mexico	**5** (0.85)	**19** (0.92)	**30** (0.78)	**37** (0.47)
Hong Kong	**NA**	**D**	**D**	**12** (0.15)
Singapore	**NA**	**D**	**D**	**24** (0.30)
Taiwan	**NA**	**1** (0.05)	**5** (0.13)	**24** (0.30)
Israel	**NA**	**4** (0.19)	**11** (0.29)	**29** (0.37)
Developing countries	**29** (4.92)[3]	**159** (7.66)	**202** (5.25)	**406** (5.12)

Sources: Computed from U.S. Department of Commerce, 1975, 1981, 1985, 1992.
"D" indicates that the data in the cell have been suppressed because of confidentiality requirements.
1 Numbers in parentheses are percentages of group R&D expenditure.
2 Following numbers in parentheses are percentages of R&D expenditure by majority-owned, non-bank affiliates
3 Percentages of developing and developed countries in 1966 don't add up to 100 because of round off errors.

Table 2: Overseas Research and Development Expenditure by Japanese Corporations
(millions of yen)

	4th survey 1989-1990	5th survey 1992-1993
R&D Expenditure by parents	**4430036**	**54444000**
R&D Expenditure by affiliates	**64646** (1.44)[1]	**139900** (2.51)
Regional Distribution of Affiliate R&D		
North America	**42527** (65.78)[2]	**62340** (44.56)
Europe	**13750** (21.27)	**68900** (49.25)
Asia	**5844** (9.04)	**6880** (4.92)
Latin America	**436** (0.67)	**400** (0.28)
Oceania	**2037** (3.15)	**1350** (0.96)

Sources: Computed from Japan, MITI (1991, 1994)
1 Numbers in parentheses are percentages of group R&D expenditures.
2 Numbers in parentheses are percentages of R&D expenditures by affiliates.

Table 3: Determinants of R&D intensity of affiliates of US MNEs - Full sample

Explanatory variables	Equation 1	Equation 2	Equation 3
Intercept	-0.306E-1*** (-6.134)	-0.234E-1*** (-2.682)	-0.316E-1*** (-4.184)
USSALES	0.358E-2 (1.562)	0.280E-2 (1.603)	0.149E-3 (0.763)
LOG *MSIZE*	0.117E-2*** (5.693)	0.796E-3** (2.102)	0.121*** (3.988)
TECHINT		-0.352E-1 (-0.384)	
LOCASAL	0.652E-4 (0.057)	0.315E-2 (1.604)	
NUSEXP			-0.135E-3 (-0.063)
RDGNP	0.223E-2*** (3.143)	0.320E-2*** (3.092)	0.198E-2** (2.310)
RESPAT	-0.839E-3 (-0.516)		
HED			0.198E-2 (0.516)
RDEXEMP		0.149E-4*** (2.586)	0.334E-4** (2.011)
PHONES	-0.968E-4*** (-3.816)	-0.107E-3*** (-3.622)	-0.959E-4*** (-3.537)
IPP	0.129E-2*** (4.654)	0.115E-2*** (3.305)	0.109E-2*** (3.751)
TRBARR	0.728E-3 (1.168)		0.111E-2*** (3.043)
TTREQ		0.128E-2 (0.292)	
D1977	0.809E-3 (1.512)	0.492E-3 (0.778)	0.877E-3 (1.300)
D1989	0.593E-3 (0.891)	-0.307E-3 (-0.417)	-0.762E-3 (-0.827)
Adj R^2	0.54	0.54	0.56
F-statistic N	10.73 84	8.62 71	8.08 61

Note: Figures in parentheses are t-values. Levels of significance: *** 1 %, ** 5%, and *10%.

Table 4: Determinants of R&D intensity of affiliates of US MNEs in industrialized countries subsample

Explanatory variables	Equation 4	Equation 5
Intercept	-0.414E-1*** (-4.410)	-0.455E-1*** (-5.053)
USSALES	0.226E-2 (0.673)	-0.606E-3 (-0.192)
LOG *MSIZE*	0.142E-2*** (2.879)	0.174E-2*** (3.946)
LOCASAL	0.161E-2 (0.650)	0.615E-3 (0.322)
RDGNP	0.187E-2** (2.491)	0.210E-2*** (3.085)
RESPAT		-0.365E-2 (-1.331)
RDEXEMP	0.204E-4*** (3.040)	0.153E-4*** (2.841)
PHONES	-0.113E-3*** (-4.344)	-0.108E-3*** (-4.309)
IPP	0.219E-2** (2.229)	0.168E-2*** (3.618)
TRBARR	0.249E-2 (0.693)	
D1977	-0.863E-5 (-0.010)	0.586E-3 (0.790)
D1989	-0.609E-3 (-0.591)	-0.104E-3 (-0.954)
Adj R^2	0.55	0.55
F-statistic N	6.51 46	6.87 49

Note: Figures in parentheses are t-values. Levels of significance: *** 1 %, ** 5%, and *10%.

Table 5: Determinants of R&D intensity of affiliates of US MNEs in developing countries subsample

Explanatory variables	Equation 6	Equation 7
Intercept	-0.120E-1*** (-3.896)	-0.107E-1*** (-3.414)
USSALES	0.376E-2* (1.673)	0.373E-2 (1.632)
LOG *MSIZE*	0.408E-3*** (3.487)	0.358E-3*** (3.028)
LOCASAL	0.346E-2*** (4.371)	0.341E-2*** (4.481)
RDGNP	0.689E-3** (2.376)	0.819E-3*** (2.726)
RESPAT	0.229E-2*** (2.792)	
PHONES	0.264E-3 (0.896)	0.218E-4 (0.664)
IPP	-0.258E-3 (-1.624)	-0.251E-3 (-1.523)
TRBARR	0.538E-3 (1.256)	0.906E-3** (2.503)
D1977	0.626E-3 (1.564)	0.712E-3 (1.600)
D1989	0.146E-3 (0.314)	0.424E-3 (0.966)
Adj R^2	0.58	0.51
F-statistic N	4.84 29	4.26 29

Note: Figures in parentheses are t-values. Levels of significance: *** 1 %, ** 5%, and *10%.

Table 6: Determinants of Affiliate R&D activity in the Chemical and Food Products Industries

Explanatory variables	Equation 8
Intercept	0.662E-2 (0.145)
Log *MSIZE*	-0.496E-3 (-0.275)
RDGNP	0.165E-1*** (4.588)
AFFSAL	0.777E-1 (1.157)
DPRODPAT	-0.685E-2 (-1.386)
DCHEM	0.239E-1*** (4.333)
DLDC	-0.158E-1* (-1.829)
Adj R^2	0.602
F-statistic N	9.33 34

Note: Figures in parentheses are t-values. Levels of significance: *** 1%, ** 5%, * 10%.

Annex 1

The Data Set

The data set for this study draws upon the **Global Technology and Economic Development (GLOB-TED) data base** created from different sources at the United Nations University Institute for New Technologies as a part of the research project on Foreign Direct Investment, Technology Transfer and Export-Orientation in Developing Countries.

The Benchmark Surveys on Direct Investments Abroad of US Companies for the years 1977, 1982 and 1989 brought out by the US Department of Commerce (Bureau of Economic Analysis) provided data on the dependent variable. The coverage of sample was thus determined by the coverage of these surveys.

The Sample: The countries included in the sample are Canada, Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, Argentina, Brazil, Chile, Colombia, Venezuela, Costa Rica, Mexico, Barbados, Dominican Republic, Jamaica, Trinidad, UK Islands Caribbean, South Africa, Israel, Saudi Arabia, UAE, Australia, Japan, Hong Kong, India, Indonesia, Malaysia, New Zealand, Philippines, Singapore, Taiwan, Thailand. Not all these countries, however, are included in individual equations estimated depending upon the missing values of some independent variables.

Variable Measurements and sources:

$AFRDS_{jt}$: expenditure on R&D performed by majority owned affiliates of US corporations in *j*th country in respective years as a proportion of their total sales. Source: Benchmark Surveys (henceforth Benchmark).

$USSALES_{jt}$: sales of nonbank US affiliates in *j*th country in *t*th year (source: Benchmark) as a proportion of GDP in US $ at market prices (source: World Bank, *World Tables*, 1993).

$MSIZE_{jt}$: GNP of *j*th country in *t*th year in market prices in US$. Source: World Bank, *World Tables*.

$TECHINT_{jt}$: direct investment royalties and technical fees received by US parents from their affiliates in *j*th country and *t*th year divided by affiliate sales (all non-bank affiliates). Source: Benchmark.

$LOCASAL_{jt}$: host country sales of majority owned affiliates in *j*th country in *t*th year as a proportion of their total sales. Source: Benchmark.

$NUSEXP_{jt}$: exports by majority owned affiliates to countries other than the United States in *j*th country in *t*th year as a proportion of their total sales. Source: Benchmark.

$USEXP_{jt}$: exports by majority owned affiliates to the United States in *j*th country in *t*th year as a proportion of their total sales. Source: Benchmark.

$RDGNP_{jt}$: total national expenditure on R&D in *j*th country as a proportion of GNP in *t*th year. Source: UNESCO, *Statistical Yearbook*, various years.

$RESPAT_{jt}$: number of patents granted in *j*th country to the residents as a proportion of total patent grants in *t*th year. Source: WIPO, *Industrial Property Statistics,* various years.

HED_{jt}: total gross enrolment ratio for higher education in *j*th country in respective years[1]. Source: Barro and Lee (1994) on the basis of UNESCO.

$WAGE_{jt}$: average wage in US$ in *j*th country in respective years. Source: UNIDO, *Industry and Development: Global Reports*, different years.

$RDEXEMP_{jt}$: expenditure on R&D performed by majority owned affiliates in *j*th country divided by R&D employment in respective years. Source: Benchmark.

PHONES$_{jt}$: number of telephones per thousands of inhabitants in *j*th country in respective years. Source: United Nations, *Statistical Yearbook*, various years.

IPP$_{jt}$: a six point index of the relative strength of patent protection where

0 - no intellectual property laws;
1 - inadequate protection laws, no law prohibiting piracy;
2 - seriously flawed laws;
3 - flaws in law, some enforcement laws;
4 - generally good laws;
5 - protection and enforcement laws fully consistent with minimum standards proposed by the US Chamber of Commerce. Source: Rapp and Rozek (1990).

TRBARR$_{jt}$: addition of two variables viz. 'own-import weighted tariff rates on intermediate inputs and capital goods' and 'own-import weighted non-tariff frequency on intermediate inputs and capital goods' of *j*th country. Source: Barro and Lee (1994) on the basis of UNCTAD data.

TTREQ$_{jt}$: number of affiliates that were required by foreign governments to transfer technology to the host country in *j*th country as a proportion of total number of affiliates. Source: unpublished data for 1989 made available by the US Department of Commerce; for other years, respective Benchmarks.

AFFRDEMP$_{ij}$: R&D employees of majority owned affiliates in *i*th industry and *j*th country as a proportion of total employment. Source: Benchmark 1989.

AFFSAL$_{ij}$: share of industry *i* in total sales of majority owned affiliates in *j*th country. Source: Benchmark 1989.

DPRODPAT$_{ij}$: dummy variable for availability of patent protection on products of *i*th industry in respective countries as of 1988. Source: Siebeck ed. (1990), Appendix 1.

DCHEM$_{ij}$: dummy for chemical industry observations.

DLDC$_{ij}$: dummy for developing countries.

D1977: dummy for 1977.

D1989: dummy for 1989.

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