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## **Global Location Patterns of R&D Investments<sup>1</sup>**

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# Global Location Patterns of R&D Investments

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## ABSTRACT

This paper concerns offshore R&D investments, focusing mainly on large multinational companies within the industrialized world. What do we know about offshore R&D activities regarding trends, scope and destinations, driving forces and constraints? What do we know about consequences for the R&D investing company, as well as for national systems of innovation, regional R&D externalities, agglomeration and urban economies of home and host countries as well?

**Keywords:** foreign direct investment, R&D, innovation, externalities

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*The main idea is that the foundations of competitive advantage no longer reside in any country, but in many. New ideas and products may come up in many different countries and later be exploited in a global scale (Hedlund 1986).*

## **1. INTRODUCTION**

This chapter concerns offshore R&D investments, focusing mainly on large multinational companies within the industrialized world. What do we know about offshore R&D activities regarding trends, scope and destinations, driving forces and constraints? What do we know about consequences for the R&D investing company, as well as for national systems of innovation, regional R&D externalities, agglomeration and urban economies of home and host countries as well? Although there is a considerable literature on foreign direct investments and outsourcing, much of it has focused on the production perspective. The effects of a growing globalization of R&D have been less scrutinized.

The chapter draws on recent literature on internationalization of R&D, bearing in mind the difficulties to generalize without systematic empirical studies and representative samples. In general, the data sources are aggregate statistics provided by UNCTAD or national statistical agencies, on the one hand side and selected sample studies or case studies on the other. Studies based on extensive company level data are still rare.

Section 2 provides a short introduction to the large area of theoretical and empirical studies on the importance of overseas engagement in R&D activities. Section 3 presents some key determinants of offshore R&D investment and discusses motives such as adjustment to local demand conditions. Section 4 reveals empirical evidences on the relative importance on different global R&D strategies. Section 5 analyses possible consequences for the national economy. Section 6 concludes

## **2. GLOBALIZATION OF INNOVATION**

The scope of international R&D investment and technology flow differs considerable among the industrialized countries as well as between industries, branches and company sizes. However, the time-trend is unambiguously, which can be illustrated by Kuemmerle (1999). Studying 32 multinationals with headquarter in the U.S., Japan, Germany, France and

Netherlands, he reports that the share of R&D carried out outside their home country's boundaries was 6.2 percent in 1965. In 1995, the corresponding figure was nearly 26 percent.

Historically, one can identify a period when FDI flows were directed to exploit natural resources. However, the share of FDI into the primary *sector* started to decline, whereas foreign direct investments in the manufacturing industry became the dominating target. Currently it is possible to observe a rapidly increasing importance of service production as an investment target. This latter change also includes investments in R&D activities abroad.

The subdivision of FDI investments into the primary (associated with natural resources), secondary (manufacturing industry) and tertiary (services) sectors of the host country economy is illustrated in Table 1. We can see that both primary and secondary sector declined for a set of European countries and the U.S. between 1990 and 2001. However, the remarkable change between 1990 and 2001 is a clear shift to FDI in the tertiary sector that includes sales offices, after-sales services and research laboratories. Information about Sweden is only available for 1990 and 1995, showing a reduction of tertiary inward FDI stock between 1990 and 1995.

Table 1 Composition of inward FDI stocks into sectoral shares, percent.

	Primary 1990	Primary 2001	Secondary 1990	Secondary 2001	Tertiary 1990	Tertiary 2001
France	6.4	0.2	37.5	19.7	56.1	80.2
Germany	0.1	0.2	36.4	11.5	63.4	88.4
Italy	3.5	2.9	38.2	39.8	58.3	57.2
Netherlands	0.2	1.3	55.5	33.2	44.3	65.5
Norway	49.0	29.1	10.6	20.3	40.4	50.6
United Kingdom	23.1	11.6	36.1	25.1	57.6	63.3
United States	13.5	2.2	39.0	35.7	40.8	62.1

Source: Johnson (2006) based on OECD data.

Table 2 reveals the control of R&D investments in selected OECD *countries* by foreign companies. In Canada 34 percent of all R&D investments was carried out within foreign owned multinational companies. Other countries with a very high proportion of R&D expenditures of foreign affiliates are Spain (33 percent) and UK (31 percent). In contrast, only 15 percent of the R&D expenditures in Finland and the U.S. were associated with foreign

owned companies. The corresponding figure for Sweden was 20 percent in year 1995 and 40 percent 2001.

Table 2. R&D expenditure of foreign affiliates in a host country as a percentage of total R&D expenditures by all companies in selected economies

Country	Percentage of R&D
Canada (1998)	34.2
Spain (1999)	32.8
United Kingdom (1999)	31.2
Netherlands (1998)	21.8
France (1998)	16.4
United States (1998)	14.9
Finland (1999)	14.9
Japan(1998)	1.7

Source: UNCTAD 2002.

The association between *industry* and globalization of R&D has two extreme cases; mature technologies and emerging technologies. When the technology is mature, to a great extent codifiable, and widely disseminated constant and close interaction with customers is not important. In this case R&D and production may be separated and the production is more globalized than research and development. However, rapid technology change in emerging technologies often requires a close interaction between R&D and production.

The company *size* aspect of the global location patterns of R&D investments is strongly related to financial resources and to absorptive capacity. Both contribute to the dominance of large companies. A dispersion of R&D across the border(s) requires extensive resources for the collection coordination and dissemination of information, and the absorptive capacity of companies is correlated to a critical mass of accumulated R&D. Some minimum threshold size of R&D activities exists in every specific location.

The literature shows that multinational companies have pursued different strategies for global expansion of R&D-activities reflecting an adjustment to geographical patterns of national innovation systems, geographical proximity, industrial clusters and global networks. See for example Jaffe et al. (1993), Audretsch & Feldman (1996) and Cantwell & Janne (1999). Criscuolo et al. (2005) suggest that R&D can be said to internationalize for broadly the same motives as other elements of the value chain.

The main explanation for the close association globalization of production and R&D is that many of the largest companies engaged in FDI are key actors in also the generation and diffusion of innovation. More than one-third of the top 100 multinational companies are active in the most R&D intensive industries, such as electronics and electrical equipment, pharmaceuticals and chemicals (Narula & Zanfei 2004). Similar to the production activities, most offshore R&D investments as well as technology trade are still largely limited to the OECD-countries. Well over 90 percent of the R&D expenditures of a majority of multinational companies are located within the OECD (UNCTAD 2002).

For the typical OECD-country various forms of globalization of innovation activities are a two-way phenomenon: A growing share of the host country's R&D (and production) is controlled by foreign owned multinational companies and a growing share of the R&D activities (and production) within domestically owned multinationals are conducted in other OECD-countries.

Between 1995 and 2001, the manufacturing production in foreign affiliates of Swedish-owned multinational companies increased from 65 to 75 percent of total production (approximated by number of employees). During the same period, the corresponding R&D engagement conducted abroad increased from 34 to 48 percent. See Table 3.

Table 3. Outward FDI from Sweden: Production and R&D in foreign affiliates as a share of total production and research of the Swedish owned multinational companies.

	<b>1995</b>	<b>2001</b>
Production	64.9%	75.0%
R&D	34.4%	47.7%

Source: ITPS 2005a

The two-way process of globalization is reflected by inward FDI to Sweden for the same period. In 1995 about 21 percent of the manufacturing production (approximated by employees) was conducted in affiliates owned by foreign multinational companies. Six years later the proportion had increased to 34 percent. This development was accompanied by an even stronger trend towards increased foreign control of the R&D investments in Sweden. Figure 3-4 shows that the share increased from 20 to 40 percent.

Table 4. Inward FDI to Sweden: Production and R&D in Sweden conducted by foreign-owned multinational companies as a proportion of total production and R&D in Sweden.

	1995	2001
Production	20.7%	33.9%
R&D	20.1%	40.3%

Source: ITPS 2005a.

### 3. GLOBALIZATION VERSUS LOCALIZATION

Archibugi & Michie (1995), separated this process of globalization of R&D into three different categories: (1) international exploitation of technology produced on a national basis; (2) global generation of innovations, i.e. the company carries out R&D and innovative activities both in home and the host countries (3) the global technological collaborations in term of joint scientific projects. Each of the three categories might have different impact on the economic and innovation performance not only on the individual company but clusters of companies, regions and countries. In addition, they might have different implications for national policies.

Vernon (1966) suggests that the main reason for foreign R&D activities is to exploit technological activities created within the home country. More recent analysis (see Dunning & Narula 1995, among others) suggests that two other factors have become increasingly important; the need to monitor new technological developments, and the ability to generate entirely new technologies and products from foreign locations. Both of these have been attributed to increasing technological complexity and the resulting rise in R&D cost.

In the terminology of the modern FDI literature, the internationalization of multinational companies R&D can be described as a dichotomous set of motives. First, asset-exploiting R&D (Dunning & Narula 1995) or home-base exploiting activity (Kuemmerle 1996), which is associated with a company's need to invest in R&D affiliates abroad in order to exploit their knowledge base in the home country. Secondly, asset-seeking (Dunning & Narula 1995) or home-base augmenting (Kuemmerle 1996) R&D-investments. The latter is related to the growing significance of augmenting existing assets by absorbing and acquiring technological spillovers from agglomerative effects in specific sectors, specific companies, public infrastructure or others in the host countries (see for example Criscuolo et al. (2005), Kuemmerle (1999), Cantwell & Janne (1999), Patel & Vega (1999)).

For many companies the globalization of R&D starts with a move of R&D operations that are related to developing products for the local market, and then may later move higher end research to selected centers as their home company grows and can take advantage of the economies of scale. However, how do findings on the increasing globalization of R&D square with the widely held agreement in the modern literature that any given R&D facility's capacity to exploit and augment its technological competences is a function, not just of its own resources, but also of the efficiency with which it can utilize complementary resources, in terms of formal and informal linkages, plus complex interdependencies between various factors in small local geographical areas?

The literature on proximity identifies several reasons for locating R&D activities in economic environments outside the home country. First, in line with Dunning & Narula (1995), companies may locate in the proximity of places with specialized excellence, from which novelties can be developed and transferred through the internal networks of the multinational organization. This corresponds to a strategy where knowledge from several attractive local R&D environment is combined into an asset for the entire organization.

Second, a company that relies on its home-base knowledge assets – the technology embedded in the company's internal network - may still need to carry out R&D that requires proximity to customers in a foreign country, and thereby adjust the attributes of its products (including services) to local preferences and requirements. Hence, we have two major proximity factors that influence the offshoring of R&D. The first is accessibility to specialized knowledge and R&D environment, and the second is accessibility to customers

Foreign knowledge can be obtained in two major forms. The company can establish an R&D-unit abroad. An alternative is to find a partner abroad and collaborate in a strategic partnership. Much of such R&D cooperation was recognized as strategic alliances in 1970s and 1980s. A more recent label used by Hagedoorn (2002) is “strategic technology partnering” (STP), and this type of innovation interaction has continued to grow. Information about such innovation networks is fragmented and uncertain, and as a consequence, available indicators of international STP have clear quality drawbacks. In spite of this, recent literature reveals a general agreement that international inter-firm alliances have become more frequent over the past two decades (Hagedoorn 2002).

There are clear reasons to believe that more systematic technology cooperation has started to become an institutionalized form of strategic R&D among multinational companies. In the 1970s the European Union decided to both promote and register R&D alliances. These



collaborative activities started to grow rapidly during the 1980s, especially with regard to information and communication technology (ICT), followed by biotechnology and composite materials. In the beginning of the 1990s more than half of all alliances in Europe were based on explicit and contractual agreements, in the form of joint ventures (R&D companies), contract-based cooperation projects, and collaboration based on FDI investments, with ownership as a control instrument.

There is a mix of motives behind strategic technology partnering. The literature list a variety of reasons such as (1) Companies in so-called high-tech industry sectors are forced into strategic R&D collaboration by high R&D costs in combination with the increasing uncertainties associated with strategic projects. (2) By joining forces with others, each individual company loses the opportunity to capture monopoly profits that may follow from a successful innovation. On the other hand, the cooperation brings about reduced risk. An alliance can guarantee that the individual company receives a flow of knowledge about technical solutions and markets – partly as a by-product, irrespective of whether particular R&D efforts are successful or not. (3) Cooperation between companies, each party will keep itself informed about technological opportunities that develop over time among its collaborators, (4) Partnering with regard to R&D cooperation between several companies. It can shorten the development time, and hence speed up the market introduction of novel products and services.

#### **4. EMPIRICAL EVIDENCES**

The literature provides somewhat conflicting evidence on the relative importance of (1) asset-exploiting and (2) asset-seeking R&D activities in other countries than the company's home country and (3) strategic partnering, respectively.

Some survey information indicates that the second aspect may be growing in importance, see for example Pearce (1999), von Zedtwitz & Gassmann (2002) and ITPS (2005b). In a survey by the Swedish Institute for Growth Policy Studies (ITPS), 42 percent of the Swedish-owned multinational companies reported that an important motivation for offshore R&D investments was an ambition to carry out demand-related adjustments of existing products and processes. See Table 5

This type of adaptive innovations can also be interpreted as a customization process (Kuemmerle 1999). The corresponding figure for R&D related to production in foreign

affiliates was 40 percent. Both motives coincide with the international exploitation of technology produced on a national basis in the taxonomy discussed above. About 20 percent of the companies regarded access to global research and proximity to other innovative companies as critical for their decision to engage in R&D overseas (innovative R&D).

Table 5. Main objectives for Swedish multinational companies R&D investments abroad.

Main Objective	Proportion
Adaptation of products and processes to customer demands	42%
Production related R&D	40%
Access to global research	23%
Proximity to other innovative enterprises	16%

Source: ITPS 2005b.

The main explanation to offshore R&D expenditures by Swedish multinational companies is organic growth (55 percent), according to the ITPS survey. Acquisition accounts for 32 percent, and only 13 percent of the R&D expenditures are related to greenfield investments. See Table 6.

Table 6. Determinants to offshore R&D investments by Swedish multinational companies

Main factor	Proportion
Organic growth	55%
Acquisition	32%
Greenfield investment	13%

Source: ITPS 2005b.

In their study, based on the analysis of the patenting activities of 220 of the most internationalized companies in terms of their technological activities in the 1990s, Patel & Vega (1999) find that companies are active outside their home countries in those expanding technology areas, where they have formed strategic alliances.

The Patel & Vega (1999) study shows that the vast majority of companies (75 percent) tend to locate their technology abroad in their core areas where they are strong at home. In a small minority of cases (10 percent), companies go abroad in their areas of weakness at home to exploit the technological advantage of the host country. The largest increases (especially for chemical and pharmaceutical companies) have occurred in technical fields where there are complementary strengths between domestic activity of a company and their host country. The

results suggest that adapting products and processes to suit foreign markets and providing technical support to offshore manufacturing plants remains a major factor. They are consistent with the observation that companies are increasingly engaging in small scale activities to monitor and scan new technological developments in centers of excellence in foreign countries within their areas on existing strength. Moreover, Patel and Vega find very little evidence to suggest that companies routinely go abroad to compensate for their weakness at home.

Kuemmerle (1999) reports results from a survey of FDI in five different home countries. The survey identified 238 R&D sites, 156 of which were established abroad. His conclusion is that a majority of the offshore R&D investments, 62 percent of the R&D laboratories in the sample, invest abroad in order to access unique resources and in order to capture externalities created by local institutions and companies.

Using patent citation data from the European Patent Office to quantify the relative importance of offshore R&D activity Criscuolo et al. (2005), found that both foreign affiliates of European multinational companies in the U.S., and U.S. foreign affiliates in Europe rely extensively on home region knowledge sources. But, interestingly, they appear to exploit the host country knowledge base as well.

However, due to the fact that dynamics in the economy, manifested by the continuous changing of technological leadership over time, and also because products and processes require multiple technological competences, Criscuolo et al. (2005), also suggests that most multinational companies tend to undertake both adaptive and innovative R&D activities simultaneously.

## **5. CONSEQUENCES FOR THE NATIONAL ECONOMY**

### **5.1 National Systems of Innovation**

A vast body of the theoretical and empirical literature has convincingly shown that companies are more reluctant to expand or relocate their R&D operations abroad as opposed to other value-adding activities such as manufacturing, sales and marketing.

Investigating the reasons for this phenomenon, Freeman (1992), Ehrnberg & Jacobsson (1997), Narula (2002) and others suggest that the companies are embedded in various systems of innovation in their home countries, built on relationships of trust and interaction within

formal and informal networks between customers, suppliers, competitors, consultancies, universities and research institutes, government agencies, funding organizations etc. Most likely the high cost of becoming familiar with, and integrating into a new location may be prohibitive even in the cases when the host location is superior to the home.

Table 7 reveals considerable differences in the embeddedness within various systems of innovation in Sweden. Based on data from the Community Innovation Survey, conducted in 2001, Johansson & Lööf (2005) found that foreign-owned multinational companies in Sweden collaborate more intensively than non-affiliate (independent companies) and uni-national companies (belonging to a group with only domestic affiliates) with the scientific, vertical and the horizontal system innovation. More than 70 percent of the Swedish multinationals collaborate on innovation with the national scientific system of innovation (universities and research institutes). The corresponding figure for foreign owned multinational companies in Sweden is about 30 percent. Among pure national companies engaged in innovation, only one in five companies collaborated with universities or research institute. Considering vertical systems of innovation (customers and suppliers) and horizontal systems of innovation as well, the study shows a similar pattern as for the scientific system of innovation

Table 7. Collaboration on Innovation in Sweden. Companies conducting R&D and export. Share of the companies.

	<b>Foreign-owned companies</b>	<b>Swedish-owned companies</b>	<b>Uni-national companies</b>	<b>Non-affiliate companies</b>
Scientific system of innovation: Universities and research institutes	32.4%	72.5%	19.2%	19.4%
Vertical system of innovation: Customers and suppliers	36.1%	82.3%	23.2%	25.7%
Horizontal system of innovation: Competitors and consultancies	26.3%	52.9%	17.3%	18.7%

Source: Johansson and Lööf (2005).

## 5.2 Regional R&D Externalities

Global generation of innovation activities will, naturally, be where opportunities for exploiting spillovers are highest (Coe & Helpman 1995). This implies seeking proximity to 'technology leaders', and given that companies tend to concentrate their strategic R&D

activities in their home location, this high level of competence is often reflected in the associated systems of innovation. Thus, asset seeking activities are often assumed to be associated with locations that exhibit a technological or comparative advantage, relative to other locations. (See Patel & Vega 1999, Le Bas & Sierra 2002).

It is worth noting that technology leaders are not always synonymous with industry leaders. It is important to realize that companies – particularly in technology intensive sectors – increasingly need to have multiple competences (e.g. Granstrand 1998). Even where products are mono-technology-based, the processes used to manufacture them often utilize several technologies. Furthermore, even within any given technology (and in particular for technology intensive sectors), technology leadership changes rather rapidly. Criscuolo et al. (2005) suggest that this is another reason that companies may engage in both asset exploiting and asset augmenting activities simultaneously.

### 5.3 Agglomeration and Urbanization Economies

From a bird's eye view the role of metropolitan regions in the world economy are focal points for FDI-oriented FDI. When multinational companies decide about innovation activities abroad, the pertinent investments are almost generically located in metropolitan regions. The conventional explanation of this pattern is that metropolitan regions provide diversity in a spectrum of dimensions – variety of knowledge providers, diversity of customers and of input suppliers.

In addition, the opportunities to sustain face-to-face interaction between dispersed R&D facilities are much greater if the different R&D-nodes are placed in metropolitan regions, with their superior infrastructure and interaction facilities.

This means that large urban regions across the globe increase their importance as places where multinational companies can benefit from intense interaction with specialized knowledge providers and research centers. The same places will also function as meeting places where multinational companies can exercise interface activities with important customers. In essence this means that the world map evolves into a set of "islands" where subsidiaries of multinational companies reside, while at the same time being combined into the internal networks of each multinational company.

## 6. CONCLUSIONS

The evidence regarding the trends, scope and strategies behind offshore R&D-investments is varied, heterogeneous - and still limited. Some characteristics are fairly well documented: (1) Large multinational companies play a dominant role in the innovation systems of their home countries. (2) The same enterprises own a large stock of advanced technologies in their home countries. (3) These companies have not internationalized their innovative activities in the same way as with their production activities. (4) The relatively lower degree of internationalization is explained by the complex nature of innovation and innovation systems as well as the embeddedness of R&D activities in the home environment. (5) Offshore R&D is mostly production supportive and associated with international exploitation of technology produced on national basis (adaptive R&D).

There are an increasing number of studies, however, that suggest that the process of innovation has become more globalized during the past two decades. Competitive advantage, especially in advanced technologies, no longer resides in any cluster, region or country, but in many. This is the results of several overlapping factors:

- The increasing costs and complexity of technological development, leading to a growing need to expand technology sourcing and interaction with different and geographically dispersed actors endowed with complementary knowledge.
- The faster pace of innovation activities in a number of industries, spurring companies to search for application opportunities and these are mainly location-specific.
- Existing innovation systems often have systematic and self-reinforcing lock-in characteristics, which change only very gradually and constitute their technological specialization. In new and rapidly evolving industry sectors or areas, national innovation systems in general, evolve more slowly than the technological needs of companies. As a result, companies may seek to acquire the technology they need from abroad through offshore R&D investments in terms of acquisitions, greenfield investments or strategic collaboration.

The general agreement in the literature is that conditions in the home country is still important in the creation of global technological advantage even for the most internationalized companies; often their technological advantages primarily reflect those of innovation systems of the home country. Therefore it becomes important to improve our understanding of reasons

why companies producing for a world market are continuing to keep a proportionally larger part of their R&D activities close to its home base.

New findings indicate that offshore R&D has risen considerably over the last decades, and companies invest in R&D – mainly in the industrialized world – in order to exploit their existing knowledge base, or in order to augment it. The former motive leads to R&D engagements close to existing production facilities and markets, while the other motive is more associated with establishments close to companies, clusters and universities that have a global technology leadership. It is important to keep in mind that this is a two-way phenomenon for the individual country. In parallel with increasing offshore R&D-investments by the home-based multinational companies, the presence of R&D-intense foreign multinational companies in the home-country increases rapidly, mainly through mergers and acquisitions.

From a policy perspective it is important to increase the understanding of to what extent and in what ways the ongoing globalization can provide positive stimuli to the national innovation systems, and generate harmful impacts on the innovation system. An impact on the innovation system is considered to be positive if it supports or improves the conditions for industrial renewal, creates new areas of specialization and contributes to economic growth in the country. A harmful impact is identified when the innovation system becomes less effective in stimulating renewal and growth.

The strategic R&D is a basic component of a company's long-term development. When the strategic parts of innovation activities remain in the home country (and home region) this also means that the orchestration of the company's future and its future assets stays domestic. If such parts of the development activities tend to drift abroad, a likely outcome is that the company as such gradually leaves its initial country of residence. On the other hand, R&D spending abroad that aims at adjusting products and services to match customer demands and preferences in a foreign market does not imply that the control of knowledge assets are moving away from the home region of the company.

It is also necessary to identify and investigate those factors that have a strong influence on how "national" multinational companies allocate their R&D investments between the home county and abroad. Which are the factors that influence foreign multinational companies to locate their R&D activities to establishments in their home-country?

In a similar way as for “national” multinational companies offshore R&D, we need to identify factors that are important and for foreign multinationals to engage in R&D in the host-country, and why they are. In this context it is important to understand which types of innovation activities that foreign multinational companies carry out inside in their home country instead of abroad.

Another important issue to investigate the effects of R&D globalization with regard to the frequency of spin-offs and spin-outs from national-owned and foreign-owned multinational companies.



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