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Globalisation of Innovation: The Role of Multinational Enterprises

by

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Abstract
This paper undertakes a brief evaluation of the trends in the internationalization of innovative activities. We provide a taxonomy of R&D internationalization strategies, and discuss the main relevant theoretical and empirical issues, before discussing the centripetal and centrifugal forces underlying the nature and evolution of cross border innovation. We address the issue of international technology partnering as a key strategy that is complementary to the internationalisation of innovative activities through internal means, before raising important policy dimensions and directions for future research that derive from these debates.

Key words: R&D internationalization, globalisation, multinationals, alliances, technology policy

JEL Codes: F23, O32

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1. Introduction

Economic globalisation is generally accepted to imply the growing interdependence of locations and economic units across countries and regions. Technological change and the increasing significance of multinational enterprises (MNEs) are often cited as the primary driving forces of this process. In this chapter we attempt to evaluate – albeit tentatively – the changing extent and importance of MNEs as conduits for cross-border knowledge flows.

It is important to note that MNEs use a variety of options through which innovation develops and diffuses across national borders, among which FDI (through which MNEs acquire existing assets abroad or set up new wholly or majority owned activities in foreign markets) is only one option. Other modalities by which international knowledge flows occur include trade, licensing, cross-patenting activities, and international technological and scientific collaborations. These other modalities involve a wide variety of economic actors as we shall briefly outline below. However, to a great extent, the MNE also plays a pivotal role among these actors. This chapter will highlight the MNE's multi-faceted role in the more general process of globalisation of innovation.

The chapter is structured as follows. Section two undertakes a brief evaluation of the trends in the internationalization of innovative activities. Section 3 provides a taxonomy of R&D internationalization strategies, and discusses the main theoretical and empirical issues. Section 4 presents a discussion on the geographical concentration and dispersion of R&D activities, and the forces underlying the nature and evolution of cross border innovation. Section 5 will address the issue of international strategic technology partnering (STP) as a key strategy that is complementary to the internationalisation of innovative activities through internal means. Section 6 concludes this chapter and raises important policy dimensions that derive from these debates.

2. Trends in the internationalization of innovative activities.

The growth of international innovative activities involves different actors - firms and institutions – and processes. A useful taxonomy proposed by Archibugi and Michie (1995) identifies three main categories of the globalization of innovation. Table 1 provides an outline of these categories. Although there are a variety of economic actors that undertake innovation and are engaged in its internationalization, MNEs are the only institution which by definition can carry out and control the global generation of innovation within its boundaries. We briefly discuss each of the three categories, and some of the associated trends.

Table 1 about here

2.1 The cross-border commercialization of national technology

The first category involves (both national and multinational) firms as well as individuals engaged in the international commercialization of technology developed at 'home'. Key indicators of these activities are international trade flows and cross border patenting, both of which are responsible for growing levels of global transfer and utilization of technology.

As far as trade is concerned, the share of high-tech products (including electrical and electronic equipment, aerospace products, precision instruments, fine chemicals and pharmaceuticals) in world exports has risen from 8% in 1976 to 23% in 2000, with exports of information and communications technology products showing the highest annual growth rate in 1985-2000 (UNCTAD 2002 pp.146-147).

While all commodities and services embody some knowledge, this is greater in sectors with the highest technological content. Hence an increase in the share of world trade represented by R&D intensive sectors can roughly signal that this pattern of globalization of innovation is increasing.

The correlation between the R&D intensity and the export intensity for most industrialized countries has increased rapidly over the last three decades, confirming that the link between international trade and innovation diffusion has considerably strengthened over time (Archibugi and Iammarino 2002). This trend characterizes most science-based sectors more markedly than the average of industries[1].

As table 2 illustrates, there has also been a steady growth in the international aspect of patenting, which is reflected by the dynamics of non-resident patenting (i.e. patent applications of foreign inventors in the country, showing the extent of incoming inventions) and external patenting (i.e. patent applications of national inventors abroad). To the extent that (temporary) protection of innovation is necessary to commercialise new products in a given market – a need that is made more compelling due to shortening product life cycles – offshore patenting represents a key strategy to extend markets and to gain access to static and dynamic scale economies.

Table 2 about here

2.2 Technological and scientific collaborations

Actors involved in technical and scientific collaborations are both private and public institutions, including (national and multinational) firms, universities and research centers. The academic world has a long tradition in the cooperative generation and diffusion of knowledge. Private firms have also significantly increased the use of non-internal options that involve cooperation between competitors, suppliers and customers, variously referred to as networks or strategic technology partnering (STP). Studies in international STP suffer a number of drawbacks due to the quality of data available. For instance, press releases are often used to construct data-sets, and these are not always factual, sometimes reflecting the public relations objectives of the firms; the coverage of large firms is higher than for smaller firms; STP failures are not reported as accurately (or as often) as STP formation; large databases are hard to update and are frequently subject to changes in the methodology of data collection over time. In spite of these drawbacks, there is a general agreement in the literature that global inter-firm alliances have become increasingly popular over the past two decades (Hagedoorn 2002; See also Grodal and Powell, this volume)[2]. There has also been a gradual shift in the types of agreements favoured by firms over time: according to the MERIT-CATI database, in the mid 1970s, the share of equity agreements was about 70%, and by the end of the 1990s the percentage of equity agreements in the total had declined to less than 10%. As we shall argue more extensively below (section 5), the increasing share of non equity alliances is consistent with the emerging view in the literature that, in an age of rapid technical change and globalisation of markets, MNEs increasingly need to resort to technology partnering as a relatively low cost means to gain timely and extensive access to knowledge sources across borders. Within this context, international STP has grown considerably in absolute terms, although as a percentage of all STP it has been rather steady in the 1970's and 1980's, oscillating around 60% of all agreements, while the share has declined in the 1990s to about 50% (Hagedoorn 2002). Given this general trend, one can observe a considerable variation by sector and by geographic area. Sector-wise, technological agreements appear to be most likely in the domain of new materials, biotechnology and information technology. From a geographical perspective, STP, even more than R&D activities in general, largely involve Triad economies rather than developing economies. Developed country firms participate in 99% of STP agreements as recorded by the MERIT-CATI dataset (Hagedoorn 2002). While there has been a growth in R&D and manufacturing outsourcing agreements with developing country firms over the last two decades, the share of these firms in STP has remained around 5-6% since the 1990's (Narula and Sadowski 2002). Seventy per cent of all STP since the 1960s have had at least one US partner, with collaborations between European and North American firms increasing from 18.5% to 25.2% of overall technological alliances between the 1970's and the 1990's (Hagedoorn 2002). The geographical concentration of STP in highly industrialized areas, together with an increasing role of alliances involving US firms might have to do with the fact that these areas are also the largest investors in R&D: firms which are most active in technological collaborations tend to be based in countries wherein technological accumulation is the highest. We shall return to this when discussing the issue of complementarity between internal and non-internal innovation strategies of MNEs (see section 5 below).

2.3 The role of MNEs in the cross-border generation of innovation

The globalization of innovation goes hand in hand with the growth and spread of the MNE and the importance of FDI since the Second World War. FDI stocks as a percentage of GDP[3] stood at 21.46% in 2001, up from just 6.79% in 1982 (Table 3). Furthermore, MNEs engage in considerable intra- and inter-firm trade (Table 3). The primary source of outbound FDI – almost 90% of the total in 2001 - continues to be the industrialised countries. The EU as a block accounted for the largest share of outward FDI, with Netherlands, UK, France and Germany accounting for fully 41.3% of all outward FDI stock from the developed world. Around 68% of inward FDI is also directed towards Triad countries. Although there has been an increase in the share of inward FDI to developing countries, this increase is almost entirely due to a small group of developing countries which primarily includes the Asian NICs and China.

Table 3 about here

The figures for R&D activity broadly reflect these same patterns, since some of the largest firms engaged in FDI are also key actors in the generation and diffusion of innovation. To illustrate, over a third of the top 100 MNEs are active in the most R&D-intensive industries, such as electronics and electrical equipment, pharmaceuticals, chemicals (UNCTAD 2002). Furthermore, large MNEs play a dominant role in the innovative activities of their home countries and control or own a large part of the world's stock of advanced technologies. For instance, Siemens, Bayer and Hoechst performed 18 per cent of the total manufacturing R&D expenditures in Germany in 1994 (Kumar, 1998). In 1997 three MNEs accounted for more than the 30 per cent of the overall UK R&D investment in manufacturing. These same MNEs also undertake a growing share of their total R&D activities in host locations.

Table 4 about here

More generally, significant differences emerge when considering the relevance of international R&D across both host and home countries. As far as recipient countries are concerned, R&D expenditures represent varying shares of total R&D expenditures by all firms in industrialized and in developing areas (see table 4 for some details).

By country of origin, the internationalization of innovative activities reflects different national propensities to organize R&D across borders. Cantwell (1995) suggests that countries such as Switzerland, UK and the Netherlands which have historically been home to large MNEs (and thus have always had a high level of international technological activity) have seen remarkable increases in international R&D especially after the Second World War. Another group includes countries (such as France and Germany) which have few large MNEs, and have seen a gradual increase in their international innovative activity over the last 80 years. A third group is characterised by countries whose technological activity is as much internationalised today as it was in the early decades of the 20th century (having actually experienced a dip, only returning to their pre-war levels relatively recently). This group includes the large US MNEs which have a relatively low proportion of their R&D and patenting activity abroad; and Swedish MNEs, which have historically tended to seek technology internationally, and show much higher shares. Table 5 gives a historical perspective of internationalisation of innovative activities between 1920 and 1990.

***Table 5 about here ***

On average, firms from EU countries have shown a higher tendency to adopt international research strategies relative to companies from US and Japan, as shown in Table 6. In the period 1969-95, the share of total patents of EU firms attributable to foreign affiliates grew from an already high 26.3% to 32.5% (with an acceleration in recent years). European firms tend to concentrate a considerable share of their international R&D activities in the US (over 50% on average, with German, British and Swiss firms showing the highest concentration of their foreign activities in the US). The foreign patenting activity of US firms also increased over the same period but remained below 10%[4]. It is worth highlighting that although US foreign R&D activities are relatively low compared to EU firms, they are much larger than Japanese companies, who undertake approximately 1% of their patenting activity abroad (having declined from 2.1% at the beginning of the period).

Table 6 about here

Overall, MNEs have increasingly internationalized their innovative activities, with a few relevant exceptions (most notably, Japanese MNEs). The importance of R&D activities of foreign affiliates has been generally growing in most host economies over the 1990's, although with significant diversities across countries: it is especially high in the case of some countries (UK, Ireland, Spain, Hungary and Canada), and lowest in Japan, with other countries (including the US, France and Sweden) in intermediate position.

Nevertheless, most R&D and patenting activities are still largely concentrated in the MNEs' home countries, and in a few host countries. Indeed, well over 90% of the R&D expenditures of most MNEs tends to be located within the Triad[5]. While there are significant differences in the international dispersion of innovative activity across industries, firms have generally not internationalised their innovative activity at the same rate as their production activities. Exceptions to this rule are MNEs originating from small economies, such as Belgium, the Netherlands and Switzerland. It is still very much the case that a large proportion of even the most internationalised MNEs tend to concentrate their more 'strategic' activities, such as R&D and headquarters functions, that tend to stay at home (Benito *et al* 2003).

This relatively low – but increasing - degree of internationalisation is associated *inter alia* with the complex nature of systems of innovation, and the embeddedness of the MNE's activities in the home environment (see e.g., Narula 2002a), the need for internal cohesion within the MNE (Blanc and Sierra 1999, Zanfei 2000), the high quality of local infrastructures and appropriability regimes that R&D activities tend to require. These factors, together with the difficulties of managing complex technological portfolios, tend to introduce some "inertia" in the globalisation of innovation. 'Inertia' implies that the international generation of innovation occurs at a slower pace than the internationalization of production. The is due mainly to the fact that the globalisation of innovation tends to be path dependent, i.e., it follows patterns which are largely shaped by the historical sequence of events and decisions taken by MNEs, governments and other economics actors involved in innovative activities in different countries. The next section delves into nature and determinants of these patterns in greater detail.

3. Overseas innovative activities of MNEs: theoretical and empirical issues

R&D tends to internationalise for broadly the same motives as traditional elements of the value added chain, although not at the same rate, nor to the same extent. Two primary types of R&D activity have been identified in the economic literature.

First, firms internationalise their R&D because of the need to improve the way in which existing assets are utilised. That is, firms may seek to promote the use of their technological assets in conjunction with, or in response to, specific foreign locational conditions. This has been dubbed as asset-exploiting R&D (Dunning and Narula 1995) or home-base exploiting (HBE) activity[6] (Kuemmerle 1996). Locational conditions may require some level of modification to the product or processes in order to make them more appropriate to local conditions, or in some cases, to create peripheral products. In such activities, the technological advantages of the firm primarily reflect those of the home country. Such activities lead to a duplication of the MNE's home base activities, since the host location is acting as a substitute for activities it may have wished, *ceteris paribus*, to undertake at home (Zander 1999), but find that it can undertake these more efficiently elsewhere.

Asset-exploiting strategies by and large correspond to the traditional view of the organization of innovative activities. Referring mainly to the US based multinationals, Vernon (1966), Kindleberger (1969), Stopford and Wells (1972) theorised a quasi-colonial relationship between the parent company and foreign subsidiaries, wherein the latter replicated the former's activities abroad, with strategic decisions - including R&D and innovation strategies - being rigidly centralised in the home country. In particular, Vernon emphasised that co-ordinating international innovative activities would be too costly, due to the difficulties of collecting and controlling relevant information across national borders. Host countries and foreign subsidiaries would then play a role almost exclusively in the adoption and diffusion of centrally-created technology.

The second broad classification is that of strategic asset-seeking, or asset-augmenting activity (Dunning and Narula 1995) or home-base augmenting (HBA) activity (Kuemmerle 1996). In such kinds of investments, firms aim to improve their existing assets, or to acquire (and internalise) or create completely new technological assets through foreign-located R&D

facilities. The assumption in such cases is that the foreign location provides access to complementary location-specific advantages that are not as easily available in its primary or 'home' base. In many cases the location advantages sought are associated with the presence of other firms. A location which is home to a major competitor may attract asset-augmenting investments by other firms in the same or in other related industries (see Cantwell in this volume on the implications of these patterns of FDI on the competitiveness of host countries). The investing firm may seek to acquire access to the technological assets of other firms, either through spillovers (in which case the firm seeks benefits that derive from economies of agglomeration), by direct acquisition (through M&A), through R&D alliances, or by arms-length acquisition. Asset-augmenting motives and technology sourcing have been partially incorporated in formal models of the FDI decision[7].

Indeed, the increasing attention to asset-augmenting strategies goes hand in hand with the emergence of a wide literature on the advantages stemming from multinational expansion, which tend to complement the *ex ante* proprietary advantages characterizing MNEs (see Ietto-Gillies 2001 for a review). This implies a new perspective on the role played by local contexts in the cross-border generation and diffusion of innovation. Considering local contexts more as sources of competencies and of technological opportunities, and less as constraints to the action of MNEs marks a fundamental departure from the conventional wisdom. In a seminal contribution, Hedlund (1986: 20-21) caught the essence of this new way of theorising the role of local contexts: "The main idea is that the foundations of competitive advantage no longer reside in any one country, but in many. New ideas and products may come up in many different countries and later be exploited on a global scale". Later, Kogut (1989: 388) expressed a similar, complementary view: "What is distinctive in the international context, besides larger market size, is the variance in country environments and the ability to profit through the system-wide management of this variance".

There are several reasons why such asset-augmenting R&D activities would be hard to achieve through arms-length means. Some of these reasons are associated with the nature of technology. When the knowledge relevant for innovative activities is located in a certain geographical area and it is "sticky", foreign affiliates engage in asset-augmenting activities in these areas in order to benefit from the external economies and knowledge spillovers generated by the concentration of production and innovation activities in specific regional or national clusters. The tacit nature of technology implies that even where knowledge is available through markets (as technology markets generally tend to be under-developed or non-existent), it still needs to be modified to be efficiently integrated within the acquiring firm's portfolio of technologies. In addition, the tacit nature of knowledge associated with production and innovation activity in these sectors implies that "physical" or geographical proximity is important for transmitting it (Blanc and Sierra, 1999). While the marginal cost of transmitting codified knowledge across geographic space does not depend on distance, the marginal cost of transmitting tacit knowledge increases with distance. This leads to the clustering of innovation activities, in particular at the early stage of an industry life cycle where tacit knowledge plays an important role (Audretsch and Feldman, 1996).

The discussion on asset-exploiting vs. asset-augmenting activities thus bears important similarities to the debate on the local nature of technological spillovers in the economics literature (e.g., Jaffe *et al*., 1993, Jaffe and Trajtenberg, 1996, 1998, Jaffe *et al*., 1998). The issue here is whether or not knowledge spillovers between firms, or from (semi-) public knowledge institutes to firms, depend on geographical distance (see Asheim, this volume). If knowledge spillovers are indeed localized, one may expect that local knowledge bases tend to differ with regard to focus and quality. The only efficient way for a firm to tap into a local knowledge base would then be to be physically present in such a local environment, which is indeed what we have defined as asset-augmenting activities.

In general, asset-exploiting activities are primarily associated with demand- driven innovative activities, with the internalisation of technological spillovers as a secondary issue. Asset-augmenting activities, on the other hand, while often reported as a much smaller phenomenon in terms of international R&D expenditure (Patel and Vega 1999, Gerybadze and Reger 1999, Niosi 1999), are primarily undertaken with the intention to acquire and internalise technological spillovers that are host location-specific. Asset-exploiting activity, broadly speaking, represents an extension of R&D work undertaken at home, while asset-augmenting activity represents a diversification into new scientific problems, issues or areas.

A rather extensive literature has recently suggested that asset augmenting internationalisation of R&D has significantly gained momentum over the past two decades as a result of several factors ranging from: a) 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 bits of knowledge; b) the higher pace of innovative activities in a number of industries, spurring firms to search for application abilities which are mainly location specific; (c) the growing pressures from host governments on MNEs which have led them to an increase in the access to, and use of, local resources as a key condition to gain access to foreign markets.

While the conceptual differences are clear, in reality it is quite hard to find appropriate indicators of the motivations underlying investment decisions. Until recently, empirical studies had largely reflected the widely accepted view that the role played by foreign R&D units be predominantly determined by market or demand-side factors. Pioneering studies by Mansfield et al (1979), Lall (1979), and Warrant (1991) tended to make the assumption that the internationalization of R&D is by and large demand driven, i.e. it is considered to be highly correlated to foreign sales[8]. More recent works have focused their attention on technology sourcing motives for R&D investments. A number of contributions have used case studies and interviews to managers of foreign R&D units to identify the orientation of their activity. Detailed analyses carried out by Miller (1994), Odagiri and Yasuda (1996), and Florida (1997) have highlighted that technology sourcing strategies play an important role in a number of manufacturing industries in North America, Europe and Asia[9]. In some cases market oriented R&D units are found to evolve into technology oriented ones, as shown by Rondstadt (1978) in his seminal investigation of R&D investment abroad. In other circumstances, foreign R&D units experienced no major shift in their characters, as observed by Kuemmerle (1999).

Several studies using different multivariate techniques attempt to identify the relative importance of asset-augmenting vs. asset-exploiting orientation. Using patent citations Almeida (1996) found that foreign firms in the semiconductor industry not only learnt more from local sources, but they did so to a greater extent than their domestic counterparts. This study also found that, with the significant exception of subsidiaries of Japanese MNEs, foreign firms locate their technological activities overseas in areas where these firms exhibited a home country disadvantage (measured in terms of revealed technological advantages [RTA]). Using a similar methodology, Cantwell and Noonan (2002) described technology-sourcing activities of foreign firms located in Germany between 1975 and 1995, and found that MNE subsidiaries source a relatively high proportion of knowledge (especially new, edge-cutting technology) from this host country, and that few citations lead back to patents of the parent firms. This altogether would give support to the idea that foreign owned technological activities undertaken in Germany are largely asset-augmenting. A more comprehensive assessment of the relative importance of asset-augmenting vs. asset-exploiting motives was carried out by Patel and Vega (1999) through their study of US patenting activities in high technology fields. By comparing the RTA of the MNE at home and the host location, they showed that in a majority of cases firms tend to locate their technology abroad in the core areas where they are strong at home. They interpreted this as evidence of the fact that adapting products and processes and materials to suit foreign markets and providing technical support to off-shore manufacturing plants remain major factors underlying the internationalization of technology. This result is by and large confirmed by an extensive interview-based survey carried out by Pearce (1999). Expanding on Patel and Vega's methodology, Le Bas and Sierra (2002) find that while European firms rarely internationalise their R&D to compensate for their technological weaknesses, there is nevertheless a high recourse to asset-augmenting strategies. These would in fact occur when both the foreign and the domestic firms are endowed with technological advantages, paving the way to what the authors describe as dynamic learning through the interaction with local contexts (see Box 1 for details on the methodology used to measure alternative international R&D strategies).

Box 1 about here

4. The contrary forces for concentration versus dispersion

The literature on the location of R&D activities has tended to view the MNE's innovative activities as being affected by centrifugal and centripetal forces which determine whether the MNE centralizes (in the home location) or internationalises to create additional centers abroad. This classical terminology – while substantially correct – has an important limitation in that it presumes the MNE has a single center in the first place. In order to allow for the increasingly likely possibility that the MNE may have multiple home bases or several locations of R&D concentration rather than a single 'hub', this section uses the terminologies, 'concentration' and 'dispersion'.

We can single out at least four broad sets of factors underlying the tensions towards concentration *and* dispersion of innovative activities. As we shall see, these forces are active at both the macro-level of countries, regions and systems of firms involved in the globalisation of innovation; and the micro-level of individual firms and of their internal networks of innovative activities across national borders. Let us discuss them in some detail:

a) The costs of integrating activities in local contexts. When firms engage in R&D in a foreign location to avail themselves of complementary assets that are location specific (and include those that are firm-specific or institution-specific, which the laboratory in question seeks to use through collaboration), they are essentially aiming to explicitly internalise several aspects of the systems of innovation of the host location. However, developing and maintaining strong linkages with external networks of local counterparts is expensive and time consuming, and is tempered by a high level of integration with the innovation system in the home location. Such linkages are both formal and informal, and will probably have taken years – if not decades – to create and sustain. Frequently, the most significant issues are the 'know-who'. Government funding institutions, suppliers, university professors, private research teams, informal networks of like-minded researchers take considerable effort to create, and once developed, have a low marginal cost of maintaining. Even where the host location is potentially superior to the home location - and where previous experience exists in terms of other value adding activities - the high costs of becoming familiar with, and integrating into a new location may be prohibitive. Firms are constrained by resource limitations, and that some minimum threshold size of R&D activities exists in every distinct location. As such, to maintain more than one facility with a threshold level of researchers must mean that the new (host) location must offer significantly superior spillover opportunities, or provide access to complementary resources that are simply not available anywhere else, and which cannot be acquired by less risky means more efficiently[10].

b) Local technological opportunities and constraints. As we have noted, the high costs associated with integrating into the host location's systems of innovation – in contrast to the low marginal cost of maintaining its embeddedness in its home location's innovation system – may increase the fixed costs firms have to overcome in order to expand internationally (Narula 2002a). However, these costs must be tempered by other supply-side considerations: the development of these technologies benefits from diversity and heterogeneity in the knowledge base, which might come from competitors, from interaction with customers and from other complementary technologies. A single national innovation system is often unable to offer the full range of interrelated technological assets required for this diversification strategy (see Box 2 on the interactions between innovation systems and R&D internationalization strategies). The point we are trying to raise is that the complex centripetal and centrifugal forces underlay the kinds of R&D activities a firm undertakes, and where these are located. It is rare that firms undertake either asset exploiting or asset seeking overseas in exclusion of the other.

****Box 2 about here***

Where local technological opportunities are high enough to enable firms to overcome the inertial factors illustrated earlier, asset augmenting activities are most likely to take place. Capturing foreign opportunities is likely to imply seeking proximity to local 'technology leaders' (see Cantwell, this volume), and given that firms tend to concentrate their more strategic R&D activities in their home location, this high level of competence is often reflected in the associated system of innovation. It is worth noting that technology leaders are not always synonymous with industry leaders: firms - particularly in technology intensive sectors – increasingly need to have multiple technological competences (see e.g., Granstrand 1998, Granstrand *et al* 1997).

Whenever products are multi-technology based, one firm may be marginally ahead in one technology, and its competitor in another; but on a macro-level, both may be associated with 'powerful' innovation systems (Criscuolo et al 2004). Even within any given technology (and in particular for highly dynamic sectors), there are several technological paradigms at play: all firms base products on the current dominant design, yet they pursue the long-term intention of replacing it with their own new dominant design. Thus, technology leadership can change rather rapidly. This is another reason why firms often engage in both asset-augmenting and asset-exploiting activities simultaneously[11] From another perspective, this implies that internationalization of R&D does not always imply that firms 'exit' in order to internationalise.

c) Firm size and market structure. An important structural trait that determines efficient internalisation is the size of the firm. Smaller firms are constrained by their limited resources: the expansion of R&D activities- both at home and in overseas locations - requires considerable resources both in terms of capital investment, and managerial resources which these firms simply do not have. *Ceteris paribus*, large firms have more money and resources to use in overseas activity. As they have higher R&D budgets at home, they are also more likely to have the absorptive capacity to set up linkages with both foreign and domestic science bases. On the other hand, large firms tend to have a well-developed network of supplier firms at home. Small firms are generally in the role of supplier firm, and as such form part of the network of some larger firm, and are thus also bound to their home location (or the location of their main customers) (Narula 2002b). Internationalisation of supplier firms often occurs in tandem with the internationalisation of their primary customer, especially where the customer is large and dominant in terms of their market, as has been observed with regards to Japanese auto manufacturers and their network of supplier firms, which relocated part of their production facilities to the US and Europe in the 1980's and early 1990's (Florida 1997). However, even when such strong customer - supplier links are not the case, small firms are constrained by limited resources. R&D is a costly and slow affair, and the long-term horizon that such investments need makes overseas R&D facilities an expensive and risky option that is hard to justify for SMEs. Indeed, Belderbos (2000) finds that there is a non-linear relationship between firm size and overseas R&D, with medium-sized Japanese firms showing a higher propensity (in relative terms) to internationalise R&D than small or large sized firms.

There are also considerable industry-specific differences which encourage or discourage concentration in as few locations as possible. It is axiomatic that the industrial structure of countries is path dependent, and technological specialisation changes only very gradually over time (Cantwell 1989, Zander 1995). As Teece (1986) has argued, the maturity of the technology, and its characteristics, determines the extent to which the innovation process can be internalised. At one extreme, mature technologies evolve slowly and demonstrate minor but consistent innovations over time. The technology is to a great extent codifiable, widely disseminated, and the property rights well-defined. Under these circumstances, constant and close interaction with customers is not an important determinant of R&D: profits of firms are highly dependent on the costs of inputs, and proximity to the source of these inputs is often more significant than that of customers. On the other extreme, rapidity of technological change in 'newer' technologies or engineering industries, require a closer interaction between production and R&D (Lall 1979). A closer coordination between users and producers of technology is also required in these industries. In fact, in some circumstances both new technology and applications environments have a high tacit, uncodified element, thus requiring extensive trial and error practices. To illustrate, this seems to justify the set up of both manufacturing and R&D plants close to applications abilities in foreign telecommunications markets (Ernst 1997). In other circumstances the scientific and generic content of knowledge is so high that a large variety of international linkages are required to exploit its possible applications, as appears to be particularly the case of biotechnology (Arora and Gambardella 1990).

d) Organisational issues. Another micro-level determinant is associated with the difficulties of managing cross-border R&D activities. It is not sufficient for the foreign affiliate to internalise spillovers if it cannot make these available to the rest of the MNE – there needs to be <u>internal</u> proximity between overseas R&D and the rest of the MNE (Blanc and Sierra 1999). Allowing for differences in the motivation to conduct overseas R&D (which may themselves derive from firm- and industry-specific differences), geographical proximity to host locations is important in determining the location of R&D, in both the case of supply and demand-driven R&D activity. A dispersion of R&D activities across the globe requires extensive coordination between them – and particularly with headquarters- if they are to function in an efficient manner with regards to the collection and dissemination of information. This acts as a centripetal force on R&D, and accounts for a tendency of firms to locate R&D (or at least the most strategically significant elements) closer to headquarters.

Complex linkages, both within the firm, and between external networks and internal networks, require complex coordination if they are to provide optimal benefits (Zanfei 2000). Such networks are not only difficult to manage, but also require considerable resources (both managerial and financial). It is no surprise, therefore, that external technology development is primarily the domain of larger firms with greater resources, and more experience in trans-national activity (Castellani and Zanfei 2004).

Large firms tend to engage in both asset-augmenting and asset-exploiting activities, because large MNEs may have several semi-autonomous sister affiliates in the same location, which may operate in similar technological areas. In addition, any given subsidiary has a need for a variety of technologies, and any given host location may possess a relative technological advantage in one area, but be relatively disadvantaged in another. Lastly, MNEs tend to also engage in production activities (whether in the same or another physical facility) in the host location, and this prompts a certain level of asset-exploiting activity. Thus, an MNE in a given location may not only be seeking to internalise spillovers from non-related firms, but may also be engaging in intra-firm knowledge transfers within the same multinational group (Criscuolo et al 2004). However, this line of research is as yet preliminary, and more detailed and disaggregated data is required before this conclusion can be strongly asserted.

5. Innovation through international strategic technology partnering

The previous sections have discussed the growing international dimension of R&D, concentrating on the intra-MNE aspect of this development. However, it is important to note that not all innovatory activity is undertaken within hierarchies. As discussed earlier (section 2), over the last 2 decades there has been a concurrent rapid growth in non-internal R&D activities through cooperative agreements. There certainly are circumstances under which international STP substitute for internal innovatory activities. One such circumstance is that of R&D alliances aiming to enter foreign markets protected by non-tariff barriers, as it is the case of environmental regulations in the chemical industry, or of safety standards in the automobile industry. However, it is worth noting that there are limits to how much a firm can substitute STP for in-house R&D, and by extension, international STP for overseas R&D facilities[12]. STP tends to develop in areas in which partner companies share some complementary capabilities, and these alliances create a greater degree of interaction between the partners' respective paths of learning and innovation (Mowery *et al* 1998, Cantwell and Colombo, 2000, Santangelo 2000).

Fully examining the role of (international) networks in the generation and diffusion of innovation is beyond the scope of this chapter (see Grodal and Powell, this volume, for a more comprehensive discussion). A key issue that is relevant to the analysis being developed here is whether and to what extent there is substitution or complementarity between internal innovative activities and technological collaborations on a global scale.

One way to look at this issue is to tackle the problem of *firm size, technological capabilities and collaborations*. Do MNEs need to be large, and well equipped with innovative capabilities in order to successfully participate to collaborations? STP tends to be highly correlated with large firms with ample resources in technology intensive sectors. Thus, it appears that these alliances have little to do with technological catching-up or with the transfer of mature technology. Co-operation is most frequently the way to keep up with the technological frontier: by associating complementary resources and competencies, it makes it possible to explore and exploit new technological opportunities.

Even smaller technology-based MNEs are involved in a web of such agreements, and their growing significance raises numerous conundrums (Narula 2002b, see also the chapters by Lam, and by Grodal and Powell, this volume). Firms – regardless of size – must maintain the appropriate breadth of technological competences, and to do this they must maintain complex international internal and external networks. Such networks are not only difficult to manage, but also require considerable resources (both managerial and financial). SMEs strongly need to rely on non-internal sources, as they often experience wider gaps in terms of competencies and development abilities than their larger counterparts (Zanfei 1994) but must be more skilful at managing their portfolio of technological assets, because they have limited resources (Narula 2002b). Managing a web of different types of agreements across borders is not without its price, and highlights the role of transaction-type ownership advantages in the success of the MNE. A dispersion of activities across the globe also requires extensive coordination between them – and particularly with headquarters- if they are to function in an efficient manner with regards to the collection and dissemination of information. Indeed, the management of intangible assets is a key advantage of the MNE. This complementarity between firm size, technological capabilities and the development of innovation networks is consistent with some of the trends highlighted in section 2.2. In particular, the geographical concentration of STP activity within the Triad reflects *inter alia* the fact that firms from these areas tend to be larger and account for a major share of R&D activity.

The issue of complementarity/substitution between internal and non-internal innovative activities of MNEs can also be examined by looking at the *interdependencies between multinational expansion and international STP.* Two streams of literature have addressed this issue with diverging outcomes. First, drawing from transaction cost literature, several works on international market entry strategies have highlighted that multinational experience, obtained through an extensive and long lasting presence in foreign markets, is a fundamental means to reduce the *uncertainty* MNEs have to deal with when carrying out their operations abroad. In the absence of multinational experience, cooperative ventures would be considered to be more effective market entry tools than hierarchical control strategies, being more flexible and less commitment intensive means to gather information on host economies. As MNEs accumulate greater experience in foreign markets, the information gathering advantages of collaboration will be gradually reduced, and the risks of commitment intensive strategies will be perceived to be lower. As a result, it will be more likely that the organisational costs of cooperation, in terms of shirking and conflicts of interest between partners, will exceed the benefits deriving from this strategy. (e.g. Gomez-Casseres 1989, Hennart and Larimo, 1998). In summary, multinational experience is supposed to impact negatively on collaborative ventures and positively on equity based, commitment intensive linkages. This view is largely - but not exclusively- consistent with the argument that multinational experience helps facilitate the exploitation of MNEs' assets in foreign markets. That is, MNEs respond to uncertainty in host economies by utilising their own assets as a means to penetrate these markets. Such a view regards STP as a second-best option.

By contrast, a second stream of literature, focusing mainly on the evolution of high technology industries, has highlighted an important motive for entering inter-firm linkages, i.e. the need to explore and rapidly exploit new opportunities, either new businesses or new technological developments. The idea is that strategic alliances can be thought of as "an attractive organisational form for an environment characterised by rapid innovation and geographical dispersion in the sources of know how" (Teece, 1992: 20). In other words, the need for a timely and effective knowledge access may well overcome short term, static (transaction and organisational) cost minimisation. As the relevant knowledge sources are dispersed on a global scale in a number of industries, this way of theorizing helps to better explain the formation of international STP agreements. From this perspective, the role of multinational experience can also be re-considered. In fact, consistently with a more general view of complementarity between internal and external competence accumulation, multinational experience – which is associated to the establishment and activity of foreign subsidiaries over time - can be identified as a fundamental asset increasing a firm's capacity to *search for and absorb external knowledge* (Cantwell 1995, Castellani and Zanfei 2004). This view is consistent with a number of studies on high technology industries which highlight the mutually reinforcing nature of intra-firm and inter-firm networks. The relevant implication here is that multinational experience can be expected to expand the *exploration potential* and hence lead to a greater recourse to international STP [13]. Some of the trends in the development of STP highlighted in section 2.2 seem to be consistent with the view that firms with multinational experience are more likely to use alliances as an exploratory strategy. However, the growing spread and intensity of foreign activities of MNEs is not necessarily correlated with the growing use of international STP. As we have shown, the fraction of *non equity* STPs is also growing, particularly in high technology industries. One could interpret this as evidence of the fact that low commitment intensive agreements are more effective as a mechanism to gain timely and extensive access to rapidly evolving technology across borders. From this perspective, STP may represent a "first-best" option to MNEs (Narula 2003), especially where innovatory activities are concerned. In other words, firms do not necessarily resort to these strategies because they cannot have access to more effective and more profitable channels of technology transfer (as uncertainty is too high or institutional barriers constrain "internal" strategies); on the contrary, STPs, especially non equity agreements, can be preferred as a tool that is both more flexible and more apt for knowledge development and learning.

6. Conclusions and policy issues

This chapter has discussed the internationalisation of innovative activities, and highlighted that it has been driven by a myriad of factors. The most recurrent of these factors are the need to respond to different demand and market conditions across locations, and the need for the firms to respond effectively to these by adapting their existing product and process technologies through foreign-located R&D.

However, supply factors and the need to gain access to local competencies have become an increasingly important motivation to engage in asset-augmenting R&D abroad. This is due, *inter alia*, to the growing tendency for multi-technology products, and to the fact that patterns of technological specialisation are distinct across countries, despite the economic and technological convergence associated with economic globalisation.

As a result, there is a growing mismatch between what home locations can provide and what firms require. In general, innovation systems and industrial and technological specialisation of countries changes only very gradually, and – especially in newer, rapidly evolving sectors - much more slowly than the technological needs of firms. Firms must seek either to import and acquire the technology they need from abroad, or venture abroad and seek to internalise aspects of other countries' innovation systems. There is a third option – that of firms seeking to modify the home-country innovation system – which is expensive, and difficult to sustain in the long run (Narula 2002a). Thus, in addition to proximity to markets and production units, firms also venture abroad to seek new sources of knowledge, which are associated with the innovation system of the host region. The interdependence of markets and the cross-fertilisation of technologies – whether through arms-length means, cooperative agreements or equity based affiliates - means that that few countries have truly 'national' systems. Of course, some innovation systems are more 'national' than others, and the term is indicative rather than definitive (see also chapters by Edquist and by Malerba in this volume for a discussion). Furthermore, firms need a broader portfolio of technological competences than they have in the past.

The internationalisation of R&D raises crucial welfare issues, since it provides opportunities for spillovers between the MNE and its host economy, and in certain circumstances between the MNE affiliate and its home country. From this perspective, there has been some concern in the US with the potential loss of competitiveness of domestic firms and with the impoverishment of the 'national knowledge base' which would be associated with the increasing local R&D presence of foreign-owned MNEs (e.g., Dalton et al, 1999). In other countries and areas of the world, the perception is quite opposite, as local presence of foreign R&D and value added activities is expected to contribute to the upgrading of national technology systems. A few empirical studies seem to provide sound evidence on the existence of positive spillovers of multinational presence in the case of some emerging economies such as Korea, Taiwan and Singapore (Hobday 2000, Lim 1999), and of some of the EU member states (Barry and Strobl 2002, Castellani and Zanfei 2003). However the evidence in the case of most developing countries does not point to significant spillovers (see Harrison 1999). Indeed, according to a recent survey on econometric studies of productivity spillovers from FDI, the number of studies in which negative or non-significant results are obtained is approximately as high as cases where positive spillovers were observed (Gorg and Strobl 2001). This suggests a cautious approach to this issue, and calls for a refinement of analytical tools. There is a need to develop more appropriate measures of technological spillovers, which are not properly captured by performance indicators like productivity. The channels through which spillovers occur also need to be examined more carefully, if FDI-related spillovers are to be explicitly used as means for technological upgrading.

****Box 3 about here****

The flipside of the policy debate is that the internationalisation of R&D may lead to a 'hollowing out' of the home country's innovatory capacity when the domestic innovation system does not meet the needs of firms in certain industries. It has been argued that when systems suffer from sub-optimal lock-in, firms seek alternative innovation systems in which to embed themselves, despite the cost and efforts associated with both 'exit' and 'entry' (see Box 2 in section 4 for a discussion on this issue). Although there is currently little evidence to support or refute the hollowing out hypothesis, this has been raised by policy makers in several countries, and represents an important area for future research. The consequences of a potential hollowing out are particularly important to small open economies especially where the innovation system is specialised around a few products, and/or concentrated around a few large firms. Another related and potentially important area for future research is the need to distinguish between hollowing-out as a symptom of sub-optimal lock-in and the internationalisation of innovation to supplement domestic supply limitations (Narula 2003). After all, no country can possibly expect to provide world-class competences in all technological fields. Even the largest, most technologically advanced countries cannot provide strong innovation systems to all their industries, and world-class competences in all technological fields. Some countries have regarded imported technologies as a sign of national weakness, and have sought to maintain and develop in-country competences, often regardless of the cost (Narula 2002a). Relying largely on in-country competences may however lead to a sub-optimal strategy, especially in this age of multi-technology products. In fact, the cross-border flow of ideas is fundamental to firms, and this imperative has increased with growing cross-border competition, and international production.

Table 1 A taxonomy of the globalization of innovation

Categories	Actors	Forms
International Exploitation of Nationally Produced Innovations	Profit-seeking (national and multinational) firms and individuals	Exports of innovative goods. Cession of licenses and patents. Foreign production of innovative goods internally designed and developed.
Global Generation of Innovations	MNEs	R&D and innovative activities both in the home and the host countries. Acquisitions of existing R&D laboratories or green-field R&D investment in host countries.
Global Techno-Scientific Collaborations	Universities and Public Research Centres	Joint scientific projects. Scientific exchanges, sabbatical years. International flows of students.
	National and Multinational Firms	Joint-ventures for specific innovative projects. Productive agreements with exchange of technical information and/or equipment.

Source*:* elaboration on Archibugi and Michie, 1995.

Table 2 - Rates of growth of industrial R&D and patenting in the OECD countries

COUNTRIES	Average annual rates of change (per cent)							
	Industrial R&D (1)		Resident patents (2)		Non resident patents (3)		External patents (4)	
	1970-80	1985-95	1970-80	1984-94	1970-80	1984-94	1970-80	1985-95
United States	2.0	1.3	-2.0	5.7	5.0	6.6	-0.6	15.6
Japan	6.1	5.4[e]	5.1	2.2	-0.8	5.1	5.5	8.3
Germany	4.9[a]	1.1	-0.7	1.4	0.8	4.6	1.7	8.0
France	3.7	3.2	-2.4	1.0	0.2	5.3	3.0	8.4
United Kingdom	3.0[b]	0.3[e]	-2.4	-0.4	0.8	4.8	-1.7	16.2
Italy	3.6	-0.5	n.a.	2.5[l]	n.a.	3.8	1.8	10.3
Netherlands	1.4	3.3[e]	-2.1	-1.5	1.5	6.8	0.1	14.1
Belgium	6.7[c]	1.7[f]	-3.0	-1.6	-0.1	7.7	0.5	13.4
Denmark	3.8	7.4[g]	1.7	3.0	-0.3	19.9	1.0	22.5
Spain	12.7	1.8[e]	-4.5	2.0	0.2	19.2	1.3	16.0
Ireland	5.2[c]	15.4	6.8	2.3	4.9	31.1	6.7	24.3
Portugal	4.6[d]	2.2[h]	-6.4	0.9	-0.5	37.2	-24.2	52.4
Greece	n.a.	-1.4[i]	-0.8	-13.4[m]	2.4	37.0	n.a.	21.5
Sweden	5.9[c]	0.2[g]	-0.5	0.0	2.5	7.1	3.0	14.2
Austria	9.8[a]	5.1[g]	0.3	-1.6	3.4	9.0	1.4	10.1
Finland	6.8[c]	5.1	4.7	2.7	0.7	13.4	5.7	23.1
Switzerland	0.8[a]	-0.5[l]	-3.1	-1.5	2.2	7.8	-1.3	5.5
Norway	7.3	1.3[g]	-2.7	0.9	-0.1	11.1	0.8	21.1
Australia	n.a.	8.9[e]	5.2	1.5	-2.0	7.5	6.7	21.7
Canada	5.5	4.9	-1.1	2.2	-2.1	4.5	-0.5	21.5
OECD weighted average	n.a.	n.a.	1.3	2.7	0.9	9.3	0.9	13.3

Notes:

n.a. = not available [a] 1970-81 [b] 1972-81 [c] 1971-81 [d] 1971-80 [e] 1985-94 [f] 1985-91 [g] 1985-93 [h] 1986-92 [i] 1986-93 [l] 1992-94 [m] 1984-93

(1): Million US$ at 1995 PPP
(2): Resident Patents: inventors in their home country
(3): Non Resident Patents: foreign inventors in the country
(4): External Patents: national inventors patenting abroad

Source: Archibugi and Iammarino (2002) based on OECD, MSTI, various years

Table 3. Selected indicators of FDI and international production, 1982-2001 (US $Billion at current prices and percentage values)

	1982	**2001**
FDI inflows	59	735
FDI outflows	28	621
FDI inward stock	734	6846
FDI outward stock	552	6582
Sales of foreign affiliates	2541	18517
Gross product of foreign affiliates	594	3495
Total assets of foreign affiliates	1959	24952
Exports of foreign affiliates	670	2600
Employment of foreign affiliates (thousands)	17987	53581
Inward FDI stocks to GDP ratio	6,79%	21,46%
Foreign affiliates' export to total exports	32,20%	34,99%

Source: UNCTAD, based on its FDI/TNC database and UNCTAD estimates.

Table 4. R&D Expenditure of foreign affiliates as a percentage of total R&D expenditures by all firms in selected host economies, 1998 or latest year

Canada	34.2
Finland (1999)	14.9
France	16.4
Japan	1.7
Netherlands	21.8
Spain (1999)	32.8
UK (1999)	31.2
US	14.9
Czech Republic (1999)	6.4
Hungary	78.5
India (1994)	1.6
Turkey	10.1

Source: UNCTAD (2002), table I.10

Table 5. Shares of US patenting of largest nationally owned industrial firms due to research located abroad, 1920-1990

	1920-1939	1940-1968	1969-1990
US	6.81	3.57	6.82
Europe	12.03	26.65	27.13
UK	27.71	41.95	43.17
Germany	4.03	8.68	13.72
Italy	29.03	24.76	14.24
France	3.35	8.19	9.55
Sweden	31.04	13.18	25.51
Netherlands	15.57	29.51	52.97

Source: Cantwell (1995)

Table 6. Share of US patents of the world's largest firms attributable to research in foreign locations by main area of origin of parent firms 1969-1995

Nationality of parent firm	**1969-1977**	**1978-1986**	**1987-1995**
US	5.4	6.9	8.3
Japan	2.1	1.2	1.0
European countries *	26.3	25.6	32.5
Total all countries**	10.3	10.7	11.3
Total all countries excluding Japan	11.1	13.0	16.2

* Germany, UK, Italy, France, Netherlands, Belgium, Luxembourg, Switzerland, Sweden, Denmark, Ireland, Spain, Portugal, Greece, Austria, Norway, Finland
** Total includes all the 784 world's largest firms recorded by the University of Reading database, base year 1984

Source: Cantwell and Janne (2000)

Box 1 – Disentangling international R&D strategies

Le Bas and Sierra (2002) selected the 345 MNEs with the greatest patenting activity in Europe in 1988-1990 and in 1994-1996. Altogether these firms account for 47.1 and 45.6% of all patents registered by the European Patent Office (EPO) in the two periods. US firms amounted to 37.1% of the total, Japanese firms to 22.6% and European firms (German, French, British and Swiss MNEs in particular) to 38%. Less than 3% originate from other countries, mainly Canada and Korea. The authors classify the sample MNEs according to the RTAs based on their European patenting activities and compare these with the host country's RTAs in the same technological fields. Denoting as *Pij* the number of patents granted in technological field *j* to firm (or country) *i*, the RTA index is calculated as follows:

$RTA_{ij} = (P_{ij}/\sum_i P_{ij})/(\sum_j P_{ij}/\sum_{ij} P_{ij})$

Drawing on Patel and Vega (1999, p. 152), Le Bas and Sierra (2002) construct two types of RTA index. First, homeRTA, is an indicator of a firm's relative strength or weakness in a particular technological field in its home country, i.e. in the country of the headquarters. For each particular technological field, homeRTA is defined as the firm's share in that field of European patents due to inventions in its home country, relative to its overall share of all European patents due to inventions in the same country. Second, *hostRTA*, is an indicator of the host country's relative strength or weakness in a particular technological field. For each particular technological field, hostRTA is defined as the host country's share of all European patenting in that field, divided by its share of all European patents in all fields. In all cases an RTA> 1 signals a relative advantage of the country (firm). Based on these definitions four R&D strategies are identified:

Corporate technological activities in the home country	Technological activities in the host country	
	Weak	Strong
Weak	**Type 1: market-seeking** HomeRTA < 1 HostRTA < 1 (Technology is not a driver of FDI)	**Type 2: technology-seeking** HomeRTA < 1 HostRTA > 1
Strong	**Type 3: asset-exploiting** HomeRTA > 1 HostRTA < 1 (Efficiency-oriented FDI in R&D)	**Type 4: asset-augmenting** HomeRTA > 1 HostRTA > 1 (Learning-oriented FDI in R&D)

Source: adapted from Patel and Vega (1999, p. 152).

Le Bas and Sierra find that a great majority of MNEs located their activities abroad in technological areas or fields where they were strong at home (strategies 3 and 4), while purely technology seeking activities (corresponding to strategy 2, i.e. a technological disadvantage at home and a technological advantage in the host location) as well as pure market seeking strategies (not technology related) were the least likely to occur. While these results are conditioned by the fact that MNEs included in the sample are the most innovative ones (hence the particularly low weight of strategy 1), it is apparent that the most frequent is strategy 4, wherein not only foreign R&D activities concern technologies in which the company has a relative advantage at home (Home RTA〉1), but also the location is relatively strong, i.e. the host country has a revealed technological advantage as well (Host RTA〉1). This case would correspond to the essence of asset-augmenting orientation of R&D FDI, and reflects what the authors identify as dynamic learning, because the interaction with local contexts is most likely to produce knowledge improvements over time.

Evolution of multinationals' strategies (percentage share): comparisons between 1994–1996 and 1988–1990

	1994–1996	**1988–1990**

Strategy 1 (market seeking)	9.5	10.8
Strategy 2 (technology seeking)	13.1	12.8
Strategy 3 (home base exploiting)	30.1	31.0
Strategy 4 (home base augmenting)	47.4	45.4
Total	100	100
Source : Le Bas and Sierra (2002 p.606)		

Box 2 - How innovation systems affect the internationalisation of R&D

Innovation systems are built upon a relationship of trust, iteration and interaction between firms and the knowledge infrastructure, within the framework of institutions based on experience and familiarity of each other over relatively long periods of time. In engaging in foreign operations in new locations, firms which already face opportunities and constraints created by their home innovations systems gradually become embedded in the host environment. The self-reinforcing interaction between firms and infrastructure perpetuates the use of a specific technology or technologies, or production of specific products, and/or through specific processes. Increased specialisation often results in a systemic lock-in. Institutions develop that support and reinforce the interwoven relationship between firms and the knowledge infrastructure through positive feedback, resulting in positive lock-in. When SI cannot respond to a technological discontinuity, or a radical innovation that has occurred elsewhere, there is a mismatch between what home locations can provide and what firms require, this is known as sub-optimal lock-in (Narula 2002a).

In general, national innovation systems and industrial and technological specialisation of countries change only very gradually, and – especially in newer, rapidly evolving sectors - much more slowly than the technological needs of firms. In other words, there may be *systemic* inertia. Firms have three options open to them (Narula 2002a). Firms may seek either to import and acquire the technology they need from abroad, or venture abroad and seek to internalise aspects of other countries' innovation systems, thereby utilising a 'exit' strategy. Of course, firms rarely exit completely, preferring often to maintain both domestic and foreign presence simultaneously. There are costs associated with an exit strategy. For instance, it must suffer the costs of entry in another location (in terms of effort, capital and time), and firms may minimise this through a cooperative strategy with a local firm. Developing alternative linkages and becoming embedded in a non-domestic innovation system takes considerable time and effort.

They can also use a 'voice' strategy which is to seek to modify the home-country innovation system. For instance, establishing a collective R&D facility, or by political lobbying. Firms are inclined towards voice strategies, because it may have lower costs, especially where demand forces are not powerful, or where the weakness of the innovation system is only a small part of their overall portfolio. But voice strategies have costs, and are not necessarily realistic for SMEs, which have limited resources and political clout. Such firms cannot afford an 'exit' strategy either, and end up utilising a 'loyalty' strategy, relying instead on institutions to evolve, or seeking to free-ride on the voice strategy of industry collectives, or larger firms.

Box 3: Host country effects: technology gaps, technological upgrading and absorptive capacity

One of the strongest and most popular arguments in favour of inward investment as a vehicle for local technological upgrading is that foreign firms usually outperform domestic ones (see Bellak 2002 for a review on empirical evidence on this aspect). The underlying policy issue is whether or not foreign presence can generate technological opportunities for the local economy. There is a clear connection here to the literature on technology gaps and catching up (Fagerberg and Godinho, this volume). On the one hand, some works suggest that the larger the *productivity gap* between host country firms and foreign-owned firms, the larger the potential for technology transfer and for productivity spillovers to the former. This assumption, can be derived from the original idea put forward by Findlay (1978), who formalised technological progress in relatively "backward" regions as an increasing function of the distance between their own level of technology and that of the "advanced regions", and of the degree to which they are open to direct foreign investment.

On the other hand, scholars have argued that the lower the technological gap between domestic and foreign firms, the higher the *absorptive capacity* of the former, and thus the higher the expected benefits in terms of technology transfer to domestic firms. It is worth noting that the role of absorptive capacity is also implicitly recognised in the catching up tradition, when it is acknowledged that a sort of lower bound of local technological capabilities exists, below which foreign investment cannot be expected to have any positive effects on host economies[14]. The "technological accumulation hypothesis" goes beyond this simplistic view of absorptive capacity and places a new emphasis on the ability to absorb and utilise foreign technology as a necessary condition for spillovers to take place.

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[1] Of course, both changes in the composition of world trade, and sectoral correlations between R&D intensity and internationalization should be considered with caution since definitions of industries change over time (See Acha and Von Tunzelman, this volume).

[2] STP refers to inter-firm cooperative agreements where R&D is at least part of the collaborative effort, and which are intended to affect the long-term product-market positioning of at least one partner.

[3] Strictly speaking, the two numbers are not comparable, because GDP is a flow figure. Nonetheless, it is generally accepted that FDI stock is a monotonic function of value added, so the change in this ratio gives a general idea of how the significance of FDI activities has changed.

[4] Although the degree of R&D internationalisation of US firms is below average, it more than doubled between the mid 1960's and the end of the 1980's (Creamer 1976, Pearce 1990).

[5] Even where MNEs do engage in R&D in developing countries (e.g., industries where demand considerations and regional variations are especially significant, such as food products and consumer goods), these tend to agglomerate in just a few locations such as China, India, Malaysia, Brazil, South Africa and the Asian NICs.

[6] Although the HBE-HBA terminology clearly dominates in the literature, it is worth observing that this classification scheme is less accurate, and holds to a very traditional view of the MNE as centred in a dominant home-base. In fact, by emphasising the role of home bases, the HBA-HBE jargon cannot be easily made consistent with the possibility that firms are evolving towards network structures, hence reducing the importance of a single home and, by the same token, expanding the number of countries wherein the firm ends up being based. This chapter takes the view that being accurate is more important than being fashionable, and avoids using the HBE-HBA terminology except where necessary for historic accuracy.

[7] Fosfuri and Motta (1999) and Siotis (1999) show that a technological laggard may choose to enter a foreign market by FDI because there are positive spillover effects associated with locational proximity to a technological leader in the foreign country. Where the beneficial knowledge spillover effect is sufficiently strong, Fosfuri and Motta show that it may even pay the laggard firm to run its foreign subsidiary at a loss to incorporate the benefits of advanced technology in all the markets in which it operates.

[8] The study carried out by Mansfield et. al (1979) found that a firm’s percentage of sales from foreign subsidiaries has a highly significant effect on its percentage of R&D expenditures carried out overseas.

[9] Miller (1994 p.37) studied the factors affecting the location of R&D facilities of 20 automobile firms in North America, Europe and Asia, and found that an important motivation is to establish “surveillance outposts” to follow competitors’ engineering and styling activities. In their study of 254 Japanese manufacturing firms, Odagiri and Yasuda (1996 p.1074) note that R&D units are often set up in Europe and in the US to be kept informed of the latest technological developments. Similar results are obtained by Florida (1997 p.90) analyzing 186 foreign affiliated laboratories in the US.

[10] With few exceptions (e.g., Narula 2002a), this is an area which has not as yet been properly explored and represents an important area for further research.

[11] This is another area which has not as yet been fully studied (for an exception, see Zander1999) and represents an important area for further research.

[12] The attempt to understand the reasons behind a firm's choice between non-internal and internal technological development is not new. The work of Teece (1986) presents a pioneering analysis of this issue, which builds on Abernathy and Utterback (1978), Dosi (1982) among others. See also further developments by Pisano (1990), Henderson and Clark (1990), Nagarajan and Mitchell (1998), Veugelers and Cassiman (1998), Gambardella and Torrisi (1998), Nooteboom (1999), Narula (2001) and Brusoni *et al* (2001).

[13] Castellani and Zanfei (2004) have tried to provide some empirical basis to this view with reference to the electronics industry. They measure what they call “specific experience” in terms of the number of subsidiaries a MNE has established in a given country, which in their view would reduce uncertainty about the foreign market. Controlling for a number of sources of heterogeneity, they show that this factor is positively

correlated with the creation of new subsidiaries and of equity agreements. By contrast, what they call "variety experience", reflecting the heterogeneity and geographical dispersion of markets where a MNE is active, should increase the firm's exploratory capacity. They find that, in the examined industry, variety experience has a positive and significant impact on non equity technical alliances.

[14] As Findlay (1978 p.2-3) notes: "Stone age communities suddenly confronted with modern industrial civilisation can only disintegrate or produce irrational responses … Where the difference is less than some critical minimum, admittedly difficult to define operationally, the hypothesis does seem attractive and worth consideration". Findlay also observes that the educational level of the domestic labour force, which is a good proxy for what is currently named country's "absorptive capacity", might also affect, *inter alia,* the rate at which the backward region improves its technological efficiency. (Findlay 1978 pp.5-6).