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ISSN: 1468-4322 (Print), ISSN: 1741-5292 (Online)

R&D and knowledge: a theoretical assessment of the internationalisation strategies

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Abstract: We make a literature review on the process of internationalisation, and the process of Research and Development (R&D). Firm is considered as a repository of specific knowledge. Knowledge is a key resource that plays a vital role in long-term performance of the firm. In this context, the geographical dispersion of the firm brings important consequences:

- The firm extends its structure to protect or replicate knowledge-based assets effectively.
- The renewal of knowledge-based assets is a process conditioned by the optimisation procedure that takes into consideration the new structure of the firm.
- The power hierarchy of the firm will be affected by the exercise of control over the knowledge.

We conducted an intensive survey of the literature. Research and Development is a process by which firms might reconvert themselves and create richness, by cutting and leaving behind old techniques and products.

Keywords: multinationals; Research and Development (R&D); knowledge transfer; strategic behaviour of firms.

Reference to this paper should be made as follows: Dias, R.P. and Bresciani, S. (2006) 'R&D and knowledge: a theoretical assessment of the internationalisation strategies', *Int. J. Technology, Policy and Management*, Vol. 6, No. 1, pp.1–32.

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"Innovation is taken as being a synonym for the successful production, assimilation and exploitation of novelty in economic and social spheres. It offers new solutions to problems and this makes it possible to meet the needs of the individual and society." (European Union, 1995)

"Home market rivalry and firm's possession of intangible assets such as brands labels, product innovations drive the international competitiveness of a country's industries." (Kogut, 1991)

1 Introduction

1.1 Research and Development

The worldwide scenario nowadays is characterised by phenomena of enhanced frequency of innovations, the shortening of technoeconomic life cycles, the rapid generation and commercialisation of new technologies and by the outbreak of strategic alliances between large firms. In the green book for innovation, the European Commission defined innovation as the renewal of products and services, and the establishment of new methods of production, supply and distribution. It included as well the introduction of changes in management, work organisation, and the changing of working conditions and the skills of the workforce.

Innovation can be divided into the following categories: Product Innovation (Incremental, Technical, Application and Radical Innovations), Technology Innovation, Human Innovation, Organisational Innovation, Market Innovation, Business Innovation and Global Innovation (Bhat, 2001). The 'Frascati Manual' (OECD, 2002) proposed a distinction of Research and Development (R&D) into different categories such as Basic Research, Applied Research and Experimental Development. The first relates to the work of acquiring new knowledge through the observation of phenomena and facts without any particular application or use in view. The second relates to the exploration to acquire

knowledge directed to a precise and practical purpose and the third relates to extending developed knowledge gained from research and practical experience to produce new products, materials and processes or to improve the existing ones.

The process of research on the production and the distribution of industrial knowledge has three phases:

1 invention

2 innovation

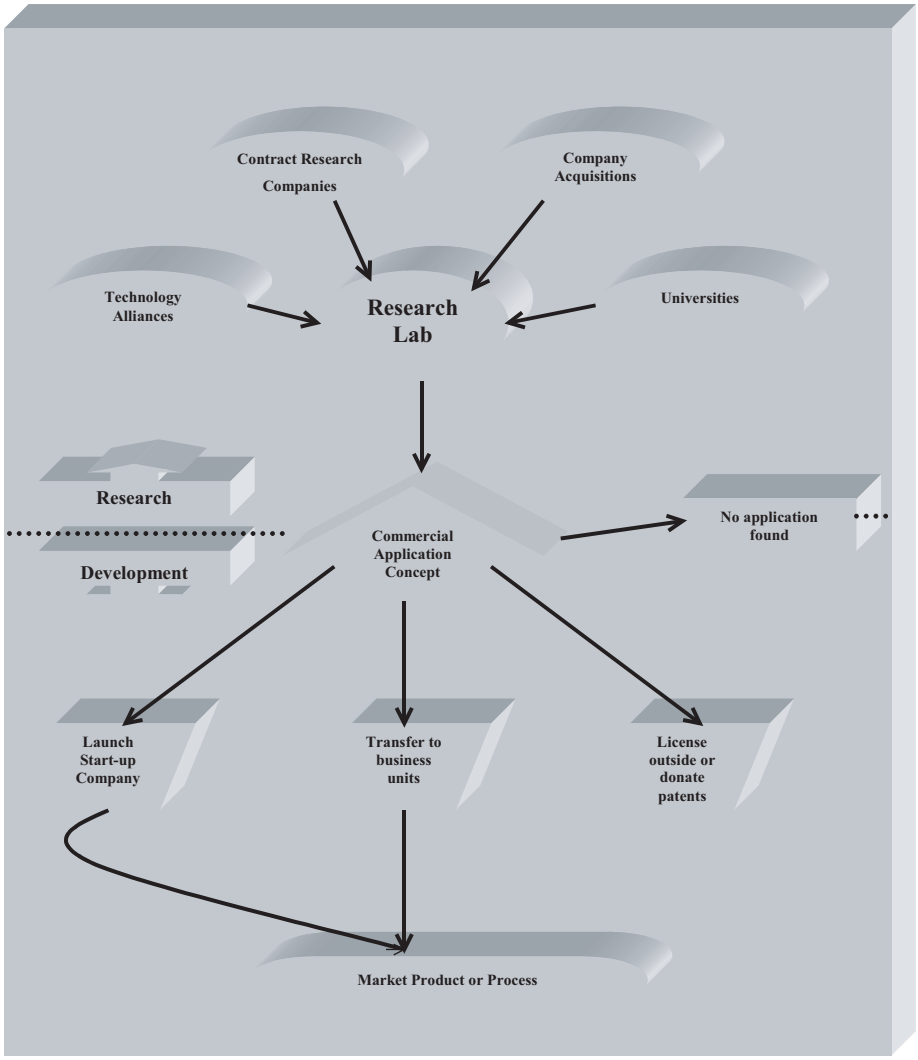
3 diffusion (Caves, 1981).

The first covers the generation of the new idea and its development to the point that the invention showed it worked; the second took the invention to the point of being placed in the market, including building production facilities, and testing and refining the innovation itself; and the third commenced when the potential users of innovation came to make efficient decisions by adopting it. Ghoshal and Bartlett (1988) decomposed the innovation into three distinct processes: creation, adoption and diffusion. In the first case there would be the development and adoption of new products, processes and administrative systems locally using technical and managerial resources to respond to the local state of affairs. The second would be characterised by the adoption of innovations developed by the parent or central R&D facility, and the third process would include the dissemination of local innovations to parent companies or other subsidiaries. Dougherty *et al.* (2003) stressed the difference between research and development. To them, both processes had attached different uncertainties, different time horizons, labour and capital inputs, and different within-firm organisation. Figure 1 gives us a graphical understanding of the differences between research and development. The process of research is depicted in the upper part and the process of development is described in the lower part of the same diagram.

MNCs, like any other firm, allocate significant resources to R&D. R&D is expected to be a process that allows MNCs to increase productivity and performance. This enables them to accumulate resources that are used in their structure either in home markets or foreign markets' operations. Firms expecting higher revenues and competitiveness enhancement in worldwide activities stimulate R&D. Therefore the growth of MNCs depends on the new knowledge generated by R&D and the extension of applicability of that knowledge to achieve high levels of performance. The process needs to be directly in touch with the manufacturing process. To this respect, Kotabe and Murray (1990) refer that US firms have ignored manufacturing as a strategic weapon by placing emphasis on product innovations. This kind of innovation by itself, according to the authors, did not sustain long-term competitive advantage, eroding therefore the US MNCs leading advantages. Their empirical study confirmed that product innovations or process innovations alone may not be used as direct causal evidence of firms' market performance, but their interaction with the manufacturing process could be.

The foreign share of technological activity has been gradually expanded by multinationals. This expansion involved the emergence of increasingly advanced technological capabilities outside the country of origin. The internationalisation of advanced technological capabilities has been associated with benefits raised in value flexibility and with multiple idiosyncratic innovation processes.

Figure 1 Organisation of R&D within the firm



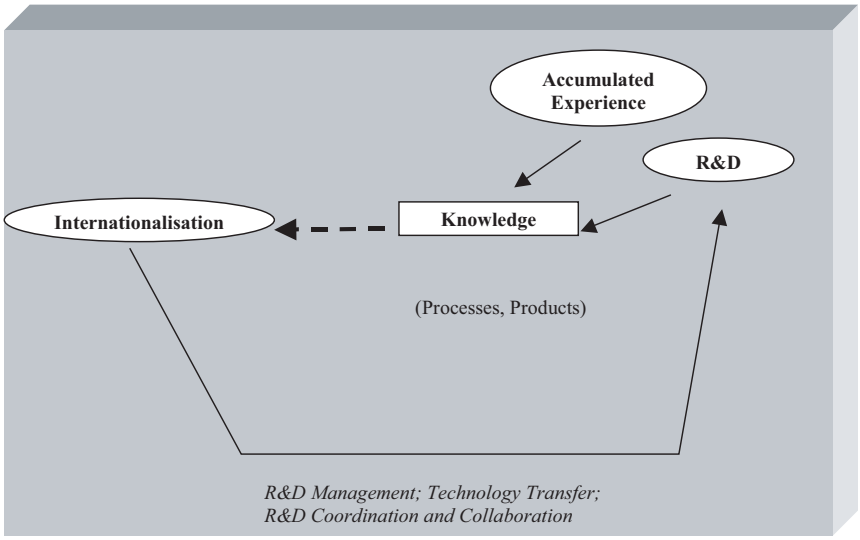
Source: Dougherty *et al.* (2003)

What are the particular R&D strategies associated with firms that possess 'added-value' activities spread around different countries? And what is the role that knowledge plays in the internationalisation process? Maybe Figure 2 can help us with this question. These are some of the topics that we will discuss in the following sections. The paper proceeds as follows. Section 1 addresses the role of knowledge in multinationals; Section 2 describes the implications of R&D in for internationalisation; Section 3 discusses the R&D strategies within and outside the boundaries of the firm. The last section concludes.

Example – R&D and the Volkswagen Group

The objective of the Volkswagen Group's R&D activities is to set new standards in automotive engineering in terms of individuality, appeal, safety and environmental compatibility by means of innovative concepts and new models. Moreover, being a Group with seven different brands provides the company with economies of scope in its R&D activities; high-grade components and state-of-the-art innovations from luxury-class automobiles can be applied in very high volumes when incorporated in the volume models, thereby making them economically viable. The central R&D centre of the VW Group is in Wolfsburg, Germany. In 2002, the centre employed over 9500 people. The R&D centre consists of a design centre, two wind tunnels, an acoustics centre, a crash test site and two large halls where the effect of electromagnetic fields on the electronic systems in the cars is being tested. Besides this large R&D centre, the VW Group possesses other, smaller R&D centres in Ingolstadt (Germany), the Czech Republic, Spain, Brazil, Mexico and China. The developmental engineers working at the Wolfsburg R&D centre work on projects from the early beginning, the preliminary design, till the moment the prototype has been tested so well it can go to the production phase. VW Group stimulates product diversity, so it is important that the product creation processes are as short as possible. The use of virtual technologies helps the design engineers and production planners in reaching this goal. They use the virtual technology to design, simulate and optimise many of the functions and processes of both individual components and the complete cars. The total innovative power of Volkswagen was reflected in the fact that Group employees were registering 852 patent applications – 159 of them abroad.

Figure 2 Firm as an integrated result of internationalisation, knowledge and R&D



1.2 Internationalisation and the role of Knowledge

What is the role knowledge plays in the process of internationalisation of the firms? To begin with, knowledge in internationalised firms is geographically separated, which requires global knowledge management. Buckley and Carter (2004) outline a model of process organisation for the combination of different types of knowledge from spatially separated sources in the multinational enterprise. They identify regularities in the types of knowledge combination within the firm that provide additional value to it. They found the following barriers to the combination of knowledge: knowledge losses, decision losses and imperfection in the process. According to the authors, the strategies of combination of knowledge might be of three types: additive, sequential and complex.

These are important competencies in knowledge management. Yeniyurt *et al.* (2005) identify global knowledge management competencies as consisting of global customer evaluation, competitor and supplier knowledge development, interfunctional coordination and value chain coordination. The relationship between global market knowledge competencies and global market advantage is partially mediated by the company's responsiveness to the environment. But what is the role of the diffusion of knowledge in the internationalisation process?

To answer this question we recall three seminal works: the first, the Product Cycle Theory of Vernon (1966), second, the Knowledge Development Model of Johanson and Vahlne (1977) and third, the Evolutionary Theory of the Multinational Corporation by Kogut and Zander (1993). They all seem to be an interesting starting point to discuss knowledge in internationalisation. All the three contributions describe the importance of knowledge in firms' activities and make a dynamic description of the use of knowledge in the process of internationalisation.

The first author explicitly clarifies that his objective is to explain international trade and investment. He gives emphasis to the timing of the innovation, the effects of economy and the roles of ignorance and uncertainty in the internationalisation process. The knowledge of a scientific principle and its use in a production of a good or its sale were not immediate. The knowledge in this theory is a factor that conditions the decision to trade or to invest. Another important point in the process of internationalisation is that the conscience and responsiveness of opportunities is a function of communication, and this is a function of geographic proximity. Furthermore, knowledge is a fundamental part of the decision-making process and with important consequences towards the outcome, and that is why the product innovation is expected to be better understood by local agents.

A practical example was given in which the US market gathered the most advantageous conditions for product development: the existence of intensive communication between the high-income market, the suppliers and the firms. The hypothesis is twofold: the local agents are those with the most probability of finding an opportunity for high-income or labour-saving new products, and secondly the first production plants will be located in the country of the market with the best characteristics to produce those goods.

The unstandardised nature of the design in this case would possess locational implications. The reason is that while the product is not completely defined, it forces the firm to have greater flexibility relative to its inputs suppliers and productive structures. A second reason would be related to the fact that the demand elasticity is low (which means that firms would not be very preoccupied in reducing costs), so firms would need to interact intensively with the market (customers, suppliers) in order to accomplish, through adjustments, the qualities that the final product would have to accomplish. As the author stresses, the uncertainty would remain regarding the dimensions of the market, the efforts of rivals and the specifications of the inputs needed for production.

The second phase, the so-called 'the maturing product' phase, appears afterwards. Demand would require standardisation. The product innovation process would not end since the firm would pass from the quest of product differentiation to a growing acceptance for standardised products. The need for flexibility at this stage would decline. The consequence would be the increase in economies of scale and long-term commitment of the firms. Product development concerns would change its focus from product characteristics to product costs. The reduction of uncertainties would allow the costs

evaluations to be made more accurately. Up to this stage, demand could be expected to grow beyond national markets. Moreover, the projection of costs is of the utmost importance for the firm in the sense that it is presumed that the foreign market investment would take place only if the marginal cost added to transportation cost was superior to the projected investment cost. MNCs would possess foreign-owned affiliates and it would be predictable that they would start their production there (in low-input countries). The decision where to produce would be the result of a comparison between scale benefits and low-input benefits. The foreign-located affiliates would serve the home-country market. In this context the uncertainty would be something that would be reduced by imitation (follow-up innovating strategies would be able to gather rents, reducing the risk of unexpected results).

According to the author, the complete standardisation of the product would come in the third phase. Uncertainty would be at its lowest point (the stock of knowledge at its highest) and the long-run commitment would be made without a lot of risk. The author assumes that it would be in this third phase that less-developed countries might offer competitive advantages as a production location for high-capital intensive products. The value of knowledge and information of those projects would be such that not all firms would be ready to pay the cost of obtaining it. The price of investigating overseas markets of unknown dimensions and unknown promises might be too high for firms. One of the main conclusions/extensions is that information would be one of the main inputs of the R&D process and it would be important to be able to gather it.

The second perspective is the one from Johanson and Valhne (1977), which stated that the internationalisation process of the firm is focused on the gradual acquisition and integration of gradual knowledge of the foreign market and its operations. The 'psychic distance' could be characterised as the sum of the factors preventing the flow of information from and to the market. One of the internationalisation phases, the exporting phase, was expected to help the firm to determine the nature and size of the market. The authors stated that internationalisation might not be a mechanism of optimum allocation of resources (where alternative ways of exploiting foreign markets were compared and evaluated), but instead a process of incremental adjustment to changing conditions of the firm and its environment. Changes in the firm and its environment would expose firms to new problems and opportunities. Lacking routines for the solution of sporadic problems would force management to search, within this new context, for solutions to the new problems. As a response the firm might increase commitment to these new markets.

The knowledge within this problem-solving framework would determine commitment decisions. Knowledge in this perspective was considered fundamental to the firm because with it, the firm would evaluate correctly the different solutions. The authors divided the specificity of knowledge into four types: objective knowledge, experimental knowledge, general knowledge and market-specific knowledge. According to the authors, establishment and performance of an operation abroad would require both general and market-specific knowledge. The latter might be gathered through experience with the market interaction. The diffusion of the general knowledge would facilitate lateral growth, defined as the establishment of technically similar activities in dissimilar business environments. Firms' uncertainty regarding the market would be reduced through higher interaction and integration with the market environment. The lack of internationalisation knowledge of the firm might come not only from the lack of business knowledge but also from the lack of institutional knowledge (Ericksson *et al*., 1997).

In the third perspective, multinationals arise not out of the failure of markets for the buying and selling of knowledge, but out of their superior efficiency as an organisational vehicle by which firms transfer this knowledge across borders. For Kogut and Zander (1993), the firms specialise in the internal transfer of tacit knowledge. The successful firm producing a differentiated product controls knowledge about serving the market that can be transferred to other national markets for this product at little or no cost (Caves, 1971). Knight and Cavusgil (2004) highlight the role of innovative culture and knowledge/capabilities in born-global firms as early adopters of internationalisation. They expand into foreign markets and exhibit international business prowess and superior performance, from or near to their founding. In this respect, Jensen and Szulanski (2004) state that the reuse of organisational practices in multiple locations is a fundamental way by which MNCs leverage knowledge to seek competitive advantage. They suggest that some degree of adaptation is a very important factor in this process. The adaptation is expected to increase as the institutional distance between source and recipient location increases. In their empirical study they find that the process of adaptation significantly increases, rather than decreases, the stickiness of cross-border knowledge transfer. Eriksson and Chetty (2003) state that learning about foreign markets often occurs as a result of collaboration with other firms which already have that knowledge. They consider 'absorptive capacity' as being the firm's ability to use its prior related knowledge to identify the value of new information and to develop this into something creative. They conclude that the lack of foreign market knowledge in the ongoing business is determined both by the firm's absorptive capacity generated with foreign customers and the customer's network.

Kogut and Zander (1993) state that firms differ in their codes by which information is transferred, so it is reasonable to admit that they should differ in their capabilities to understand and apply knowledge. The costs of technology transfer are viewed as stemming from the degree of tacitness of the knowledge. The transfer of the technology is expected to be carried more economically within the firm. Firms use joint ventures or subsidiaries to internationalise because the transfer of knowledge needs an organisational vehicle. One of the most relevant factors in the process of technology transfer comes from the ability to codify that knowledge. The greater the experience of the firm in codifying the knowledge, the greater the probability of completing successfully a process of technology transfer.

According to Kogut and Zander (1993), the initial entry serves as a platform that recombines the firm's knowledge acquired in the home market with the gradual accumulation of learning in the foreign market. In a subsequent phase, the learning from the foreign market is transferred internationally, influencing accumulation and recombination of knowledge throughout the network of subsidiaries, including the home market. That is why they consider that knowledge management and knowledge transfer is a relevant determinant of the competitive advantage of the firm.

The notion of competitiveness based on knowledge causes great impact on the traditional notion of a multinational firm. Chen (2005) extends the traditional internationalisation theory by positioning the technology transfer transaction in the broader context of the entire value chain, including manufacturing/marketing linkages with the market of final products. The choice of an optimal governance structure is determined by the complementarity of strategic assets controlled by the economic actors involved, and by the linkages among the technology-manufacture interaction in two

intermediate input markets, and the subsequent sales function in the final products market. The general idea is that both transaction cost considerations and learning effects influence strategy selection (Verbeke, 2003).

From all these theories we realise that knowledge is a relevant element in explaining the process of firm internationalisation. R&D is a knowledge-intensive process. The possibility of managing its implications and its efficiency depends on the ability of the firm to integrate the process into the specificity of the structure of the firm. In the following sections, we try to give a perspective on how internationalisation and R&D are related and how they influence each other. For example, Hohenthal *et al.* (2003) study the antecedents and consequences of discoveries during international expansion. To them market discovery is the result of both exploration and exploitation activities, but in order to exploit market discovery, the firm must learn how to handle the discovered opportunity. Usually a discovery is made while a firm is conducting daily activities, occurring in connection with search, planning, routine and improvisation. The resulting learning can lead to changes in pace, orientation and extension of the international expansion of the firm.

2 Internationalisation of R&D

We have been discussing the central role of knowledge in explaining MNCs' existence. Once international, the firm equates the structure of their operations on terms of efficiency, rentability of resources and maximisation of results (Dias and Tardivo, 2005). It is comprehensible that in such a scenario, firms develop several strategies that take into consideration the firms' overall performance, firm structure and optimisation of the process of R&D.

Mansfield *et al.* (1979) stated that the R&D process gains centrality owing to the fact that it requires interaction, communication and cooperation with marketing, production and top management. According to them, the reason that MNCs spend resources in foreign countries for this kind of sensible activity is that they search for synchrony with foreign environmental conditions, such as customer's special design needs, and they try to lower the cost of skills and talents of the R&D process. According to them, the factors that influence the percentage of overseas R&D expenditures is the weight that foreign markets possess in total sales. The higher the affiliates' sales, the higher will be the propensity for MNCs to spend in foreign R&D. Another factor is firm size. The explanation for the relevance of size is that there has to be a minimum scale for the project to be efficient. They found that this problematic is sector specific, in the sense that some sectors have tight regulatory frameworks, which can be minimised only with local R&D investment that will allow market access to those firms. Fors and Svensson (2002), investigating the relationship between R&D and foreign sales in the specific case of Swedish firms, came to the conclusion that the relationship of R&D influencing foreign sales and foreign sales influencing R&D (the experience of foreign market stimulated additional research) was more accentuated in the case of MNCs whose home country was smaller in size.

Example – R&D in Canon Inc.

Canon Inc. developed R&D in electronics, applied physics, precision mechanics and organic chemistry. In 2002, 7.9% of Canon's revenue was invested in R&D, *i.e.*, an investment in R&D of 233,669 millions of yen. The company employed over 8000 scientists and R&D engineers in Japan. R&D headquarters in Japan focused their research on advanced technologies such as next-generation displays and electronic devices. Canon's R&D overseas bases were specialised in specific technological structure. R&D centres in Japan tried to strengthen links with all of these R&D bases. Patent acquisition strategy seems to be a driving force of Canon's R&D activities.

Europe:

♦*UK* – Canon Research Centre Europe Ltd. (CRE) is the first overseas Canon R&D laboratory, established in 1988 in the UK, near London, opened in 1989. This operational lab provides work for approximately 65 employees. CRE is specialised in software R&D activities and focuses on multimodal dialogue, information searching (retrieval), digital interactive and 3D technologies.

♦*France* – Canon Research Centre France, S.A. CRF was founded in 1990. The centre is located in Rennes-Atalante in France. Canon Inc. owns 40% of CRF, 30% belonging to Canon Europe and 20% to Canon France. It has over 90 employees. The main activity of this centre concerns the transmission of numerical data through networks. They are also developing next-generation wireless broadband communications and home multimedia network technologies.

USA:

Canon Development Americas, Inc. (CDA) is based in California's Silicon Valley (University of California) and suburban Los Angeles. CDA focuses on the themes of digital home, digital office and digital industry, performing R&D for advanced networking, imaging, printing and medical research. With over 133 employees, the main strategy of CDA is to pursue research and development with strategic mergers and acquisitions in mind.

Asia:

♦*Philippines* – Founded in 1991, Canon Information Technologies Philippines, Inc. (ci-tech) develops electronic equipment and software, core technologies in imaging and networking systems. With 148 employees, it also elaborates products and software applications for home, office and industry sectors.

♦*China* – In 1998, Beijing PeCan Information System Co., Ltd. (BPIS), a joint venture with Peking University, was established to develop software. More precisely, a staff of 65 employees works on Chinese-language processing and image-processing technologies, as well as internet-related applications.

♦*India* – Canon India Software Development Center (ISDC) was founded in 1998 in New Delhi to develop software and image-processing systems for business machines.

Oceania:

Specialised in intelligent imaging solutions, Canon Information Systems Research Australia (CISRA) was established in 1990. Located in the technology hub of North Ryde, near Sydney, CISRA is jointly owned by Canon Inc. (51%) and Canon Australia (49%). One of Canon's largest R&D centres outside Japan, CISRA employs over 180 staff engineers and scientists in activities including research (image processing, graphics, user interfaces and patents), chip design (state-of-the-art digital integrated circuits), and hardware and software designs.

MNCs' develop R&D according to a strategy that has three phases:

1 establishment of a centralised hub of laboratories, existing as a central unit producing all the major innovations and a network for technical assistance for adaptation and transfer

2 a polycentric stage of a decentralised federation of laboratories with a group of R&D units performing different tasks

3 a global approach, with communication and coordination organised by the parent company's lab, with more autonomy in overseas R&D establishments (Hakanson, 1990).

Florida (1997) justified R&D investment by MNCs in the USA (see Table 1) using technology-oriented or supply-side factors. The statistical results on the relationship between R&D spending and R&D activities indicated that two technology-oriented factors – gaining access to science and technology, and developing links to the scientific and technical community (human capital) – were the only factors associated with the development of R&D laboratories. She also found evidence that R&D was a heterogeneous process in the sense that the sources of innovation changed from sector to sector. She concluded that laboratories tended to emulate and learn from US approaches to R&D organisation and management.

Table 1 Firms patents ranking in the USA, 2001

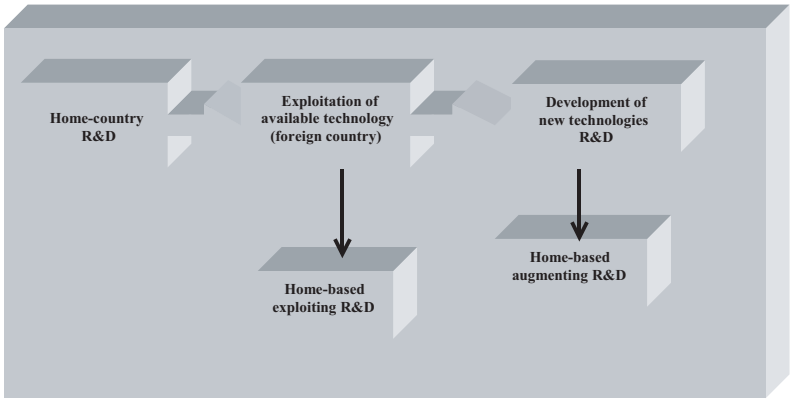
Top 10 Private Sector Patent Recipients in the USA, 2001				
Preliminary Rank in 2001	*Preliminary Patents in 2001*	*Firm*	*2000*	*Number of patents in 2000*
1	3411	IBM	1	2886
2	1953	NEC Corporation	2	2021
3	1877	Canon Kabushiki Kaisha	3	1890
4	1643	Micron Technology, Inc.	7	1304
5	1450	Samsung Electronics Co., Ltd.	4	1441
6	1440	Matsushita Electrical Industrial Co., Ltd.	11	1137
7	1363	Sony Corporation	6	1385
8	1271	Hitachi, Ltd.	13	1036
9	1184	Mitsbushi, Denki Kabushiki Kaisha	14	1010
10	1166	Fujitsu Limited	10	1147

R&D can be classified into (i) the Home-Base Exploiting R&D (HBE) and (ii) Home-Base Augmenting R&D (HBA), according to the objectives of the different strategies (Kuemmerle, 1999a). In the first case, affiliates are established in the host country in order to use the specific advantages of that environment, and in the second affiliates' activities are used to gather new abilities in knowledge and capacities. The latter kind of R&D activity is usually developed near universities and the former is generally developed near firms or significative markets. Two examples of the importance of the home environment impact on the ability of Multinationals to structure their internationalisation strategies are the existing industrial organisation of that environment or the magnitude of the potential of interchange between innovative agents such as Home-Based Research Institutes and firms (Tardivo and Dias, 2004). Home-based exploiting facilities usually have a closer proximity to their objective than home-based augmenting affiliates. The reason for this is that HBE activities need to interact actively with clients and other firms. But this attempt to locate nearer HBA activities makes its activity more costly and more difficult than HBE activities. The reason is the specificity of the attraction point in question. The difficulty comes from the fact that HBA requires specific know-how usually located beyond the firms' frontiers. On the contrary, HBE

activities concentrate on specific knowledge that exists inside firms. The accumulated experience from establishing an HBE makes the HBA implementation strategy easier. The author defined the 'R&D creation cycle' that can be seen in Figure 3.

The firm's propensity to invest in HBA's R&D activities rise with the relative commitment to R&D of private and public entities in the target country, with the quality of human resource pool and with the level of scientific achievement in relevant sciences (Kuemmerle, 1999b). The propensity to invest in HBE activities increases with the relative attractiveness of the target country's market, since when investing abroad, firms seek different kinds of spillovers from the national and local environment in which they invest. Firms also create spillovers because their activity provides work and learning opportunities for local researchers. This happens more in HBA than in HBE. MNCs have three ways to accomplish the foreign R&D investment: Green-field Investments, Acquisition of Assets and Joint Ventures (Kuemmerle, 1999b). The author concludes that the Green-field Investment was the most preferred type owing to the different levels of risks, such as difficulties of protection of brevets, licences and confidentiality problems.

Figure 3 MNCs' R&D creation cycle



Source: Kuemmerle (1999a)

Niosi (1999) tracked the internationalisation of R&D and divided his analyses into three main periods:

1 Until the 1980s, R&D activity was characterised by the principles of the product life cycle model.

2 From the mid-1980s to the beginning of the 1990s, centralised structures emerged – the polycentrique structures.

3 In the 1990s, things like management and coordination became important.

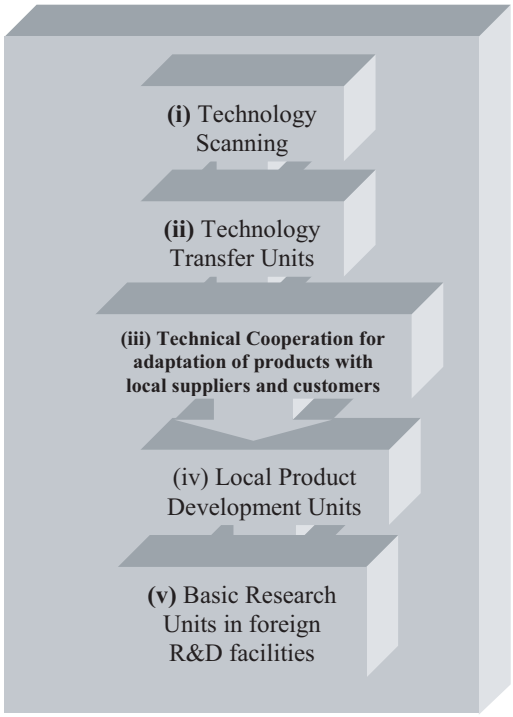
Several models of internalisation were proposed. The author based the analysis on a typology proposed by Bartlett and Ghoshal (1990):

- central for global
- local for local
- locally linked
- globally linked.

In the first case there is the development of new products or production processes in the domestic market to global markets, in the second there is the development of products and processes independently by the R&D centres to a local exploitation, in the affiliate's market, in the third there is local development to a global exploitation, and in the fourth development is accomplished through the collaboration of R&D units localised in different countries for a global exploitation.

Niosi and Godin (1999) found out that Canadian R&D activities served to support manufacturing subsidiaries and to get closer to customers and markets, to hire skilled personnel, to monitor foreign technological development and to increase the inflow of new ideas into the corporation and to choose sociopolitical environments (from a regulatory point of view). They found that R&D was mainly decentralised and autonomous and this Canadian MNCs' R&D decentralisation was mainly made through the acquisition of foreign laboratories and expatriate R&D. MNCs' R&D activity abroad had five stages, as can be seen in Figure 4.

Figure 4 International R&D



Source: Niosi and Godin (1999)

Pearce and Papanastassiou (1999) argued that MNCs move from tactical short-term 'adaptation operations' to strategic medium-term 'product development', and in a third phase they reach longer-term 'knowledge creation'. According to them, overseas R&D in MNCs emerges dependent on the current state of the group's technological trajectory, being thereon after interdependent with the key processes of reformulation and regeneration of core knowledge and commercial scope. According to them, the main

stimulus inducing overseas R&D is the need to adapt products or processes to subsidiaries' local-market conditions. The extent and nature of overseas R&D would depend on the stage of evolution of the firm's globalisation strategy and on their basic approach to competitiveness. MNCs adopt new strategic approaches to the pursuit of global competitiveness, which involve restructuring the roles of individual subsidiaries and a reformulation of their intra-group interdependencies in order to support this new positioning. This represents substantial changes in the strategic positioning of overseas R&D in MNCs: when labs operate within production subsidiaries, they are more likely to play a role in the development of substantially original new products, rather than merely supporting the effective localisation of well-established products; and overseas R&D labs move from a clearly dependent position in the technology programmes of their MNCs to play significantly interdependent roles:

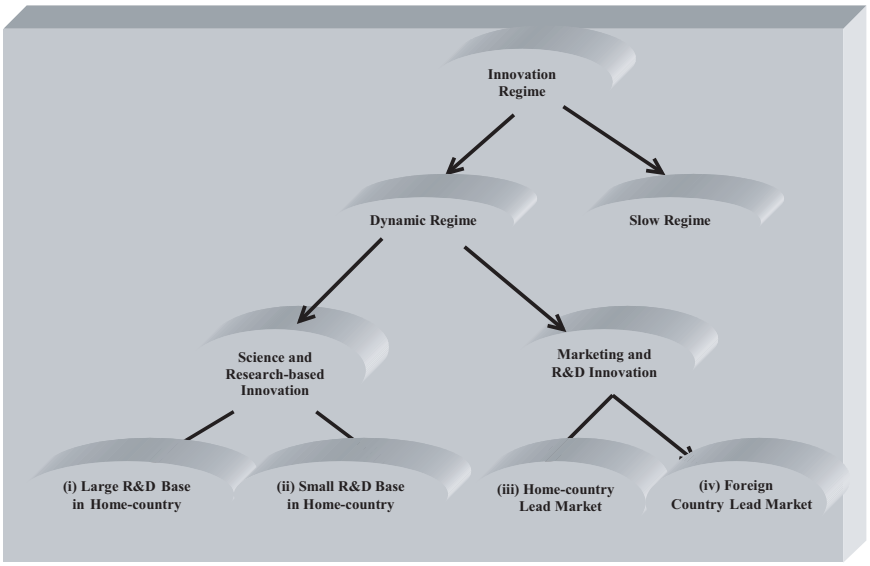
- Labs can help their subsidiaries to develop a new product from emergent group-level knowledge.
- The overseas R&D labs can make available knowledge, advice and research assistance to other parts of the MNC.
- Those labs can take positions in globally integrated networks of labs that focus predominantly on precompetitive (basic and applied) research.

Zander (1999) stated that the internationalisation of technological capabilities in various forms was the result of ambitions to exploit existing technology in foreign markets (centrifugal forces). The evolution of foreign technological capabilities depended on (i) market conditions and (ii) firm-specific events (ex: unexpected merger), as well as on (iii) management attitudes towards the internationalisation of resources. There are two generic types of transnational innovations: the dynamic fast innovation and the slow innovation regime (Gerybadze and Reger, 1999). The dynamic fast innovation regime is characterised by fast innovation cycles, and slow, less dynamic innovation is characterised by low R&D intensities and incremental innovations (see Figure 5). This scheme:

- means the MNC is located in a highly developed country with strong R&D capabilities
- means the MNC is dependent on high technological levels but it is located in a small country
- means the MNC will try to benefit from the high potentialities in which the firm is located
- means the MNC is dependent on a great foreign country's market.

They also state that MNCs internationalise R&D activities in a process that has two stages: firstly, they define the basic decision-making unit that will define the strategy and attribute responsibilities. Secondly, they define a centre of gravity at a global scale for this unit, according to the required knowledge, key resources and where the highest value might be obtained.

Figure 5 Transnational innovations' regimes



Source: Gerybadze and Reger (1999)

The size of the parent firm, the R&D intensity of the firm, the export intensity of the firm, the foreign manufacturing intensity of the firm, the accumulated experience in operating the overseas manufacturing plants and the degree of the control by the core firm, all these were factors directly related to overseas innovative activity (Belderbos, 2001). This author found that firms that went through a relatively late but rapid expansion of overseas manufacturing activities were found to operate less internationalised R&D operations. The author also found that firms increased the scale of overseas innovative activity as they got bigger, but this effect would be smaller for the bigger firms.

Asakawa and Lehrer (2003) mapped the regionally driven knowledge mobilisation. In doing so they distinguished two kinds of innovation: the local-for-regional innovation and regional-for-global innovation. In the first case, the products are developed and manufactured locally with the objective of pacing with local and regional markets' needs. This strategy embodies some distance from normal (home) reality of the MNC. In the second case, the firm will mobilise development and knowledge within the regions towards the worldwide scenario. Affiliates will possess different contributions for mobilising the local knowledge across networks. In the next graphic, the grey-shaded area represents the affiliate's relevance in the innovation process (Table 2).

Table 2 Innovation management cycle

	Local	*Regional*	*Global*
Identification	■	■	
Extraction		■	
Diffusion		■	■

Source: Asakawa and Lehrer (2003)

3 Managing R&D: inside and outside the boundaries of MNCs

Multinationals are firms whose activities are spread worldwide. R&D is an important function as it encompasses the creation, management and development of important tangible and intangible assets. It is also an activity with great impact on the development, production and commercialisation of several products. By innovating, MNCs are able to supply the market with higher quality as they stimulate demand by differentiating from competitors. Consequently, it is a function with strategic importance to the long-term performance of MNCs. It is a function characterised by the necessity of devoting a great amount of resources (capital, specialised human resources and specialised support technology). To achieve the objectives of the R&D strategies, firms need to allocate resources. This process will influence the structure of the organisation, the power hierarchy, the flows of knowledge and the management dynamics of the firm. By having a dispersed R&D structure, firms need to be able to transfer the new knowledge they are able to create. Considering knowledge an important resource to competitiveness gives power to whoever holds it. These points will be addressed in Points 3.1 and 3.2. The last subsection will address a complementary way firms have to develop R&D: interfirm cooperation. So we will describe:

- the technology transfer process
- the headquarters-subsidiaries relationship
- the technological cooperation strategies.

3.1 The process of technology transfer

The process of technology transfer or technology diffusion is a function of information, knowledge and competencies (capacity to apply know-how and the capacity to use knowledge efficiently) (Coccia and Rolfo, 2002). Teece (1980) stated that diffusion of technology was the process by which an innovation is disseminated amongst potential users. The profitability opportunity is assumed to be easily appropriated by early adopters, since followers are penalised with inferior rents. Technology could be transferred by physical items or by information transference such as methods of organisation and operation, production techniques and quality control (Teece, 1977a). At the operational level transfer costs fell into four categories:

1 pre-engineering costs related to technology exchanges

2 engineering costs

3 R&D personnel costs

4 pre-start-up training costs.

The author concluded that the differences from domestic and international technology transfer were distance, communication, language differences (communications costs), international differences in units of measurement and engineering standards, cultural and attitudinal differences between nations, differences in the level of economic development and differences in the socioeconomic structure (Teece, 1977a).

Firms invest in R&D in order to develop product or process innovations, assuming that the marginal cost of transferring innovation to other projects is small compared with the average cost of research development and application. The cost of technology transfer can be divided into two kinds: the transmission cost and the absorption cost. The first is related to the nature of the transferor and the second is related to the transferee. We present hereinafter a table of the characteristics that according to Teece (1977b) influenced the magnitude of the transference cost (Table 3).

Table 3 Influence of the transference cost

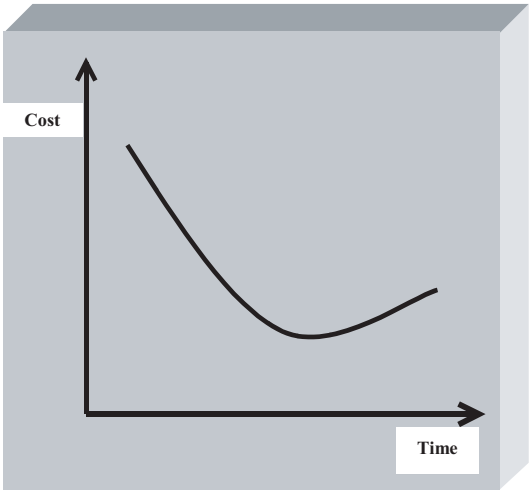
Transferor characteristics	*Transferee and host-country characteristics*
• Perceptibility of the technology	• Years of manufacturing experience
	• Size
• Age of technology	• R&D of the transferee
• Number of firms utilising the technology	• Level of development of the host country infrastructure

Source: Teece (1977a)

The underlying logic is that the higher perceptibility of the technology (measured by number of the applications), the greater age of the technology and the greater number of firms using the technology would be inversely related with the technology transfer cost. As far as the transferee is concerned, the greater the number of years of manufacturing experience, the greater the size of the firm, the higher the level of the R&D and the higher the level of the development of the host country infrastructure, the lower is the cost of technology transfer. Teece (1977a) identified a time-cost trade-off by MNCs by scheduling the design, construction and start-up of manufacturing project abroad. This effect is described in the graph of Figure 6.

The transfer of technological know-how requires adjustment of basic design parameters and scale adaptations, producing uncertain responses in the quality and the cost of the final product. We can see from Figure 6 that measures that reduce project implementation time are expected to increase the costs of that project. According to the author this elasticity would be related, in some way, to the structure of the network of the tasks involved in the technology transfer project. To such a project resources are to be allocated in such a way that their utilisation costs equal their marginal costs. The author suggested that this elasticity would be lower, the longer the duration of the preliminary planning stage and if the technology to be embodied in the new project had been applied previously. He suggested that the elasticity would also be influenced by the size of the primary transfer agent, by the projects' total costs and by the possibility of serving foreign markets with exports. It was also expected that the higher the size of the transfer agent, the higher the projects' total costs and the higher the possibility to serve foreign markets with exports, the lower the time-cost elasticity.

Figure 6 The time cost trade-off



Source: Teece (1977b)

Firms should be considered social communities that specialised in the creation and internal transfer of knowledge (Kogut and Zander, 1993). The authors stated that MNCs arose for their superior efficiency as an organisational vehicle by which to transfer this knowledge across borders. The problem with knowledge is that it has the property of being a public good, being able to be transferred at zero marginal cost. So the firm responsible for its creation has the difficulty of appropriating exclusively the return to its use. It is hard to protect knowledge from non-discriminated dissemination, for example by imitation. Kogut (1991) stated that knowledge imitation times and costs are some things specific to each industry and each country. The number of the competitors and their resources were additional factors that would determine the imitation rate. Imitation depends also on the conditions of access to the technology, on the accessibility to resources devoted to that process, and on the legal and institutional factors that determine the profitability from the innovation that can be recovered by the imitator from the innovator. The degree of the uncertainty of imitation depends on the nature of the technology (how is it codifiable and how can it be part of a system) and on the previous experience, educational level or cultural background of individuals who imitate. Gupta and Govindarajan (2000) conceptualised knowledge flows to be the consequence of five factors:

1 value of the source unit's knowledge stock – the greater the value of a subsidiary's knowledge stock for the rest of the MNC

2 motivational disposition of the source unit – the greater would be its attractiveness and affiliates are stimulated to gear knowledge management by its propensity to defend power within the MNC structure

3 existence and richness of transmission channels – captured by informality, openness and density of communications

4 existence and richness of transmission channels – due to ego-defence mechanisms and power struggles within an organisation

5 absorptive capacity of the target unit – ability to recognise the value of new information, to assimilate it and apply it to commercial ends. For this, are important the extent of prior related knowledge and the extent of the acceptance of inter-unit collaboration.

In the previous section we assumed that MNCs internalise the R&D function, mainly for preventing knowledge dissemination. Empirical evidence suggests, however, that several times MNCs get together in common projects to develop technological projects. The next section searches for the causes of MNC cooperation and tries to analyse how projects are structured and exploited.

3.2 Strategies for coordinating R&D within the firm

With experience, MNCs spread their innovative objectives (in terms of output, scale and scope). The enlargement of the objectives takes place because innovation spreads itself across a greater number of related technological fields (Phene and Almeida, 2003). Building successful overseas R&D operations and integrating overseas R&D into the firm's existing R&D network is a major challenge for MNCs. The development of the coordination and control systems necessary to manage geographically dispersed networks of R&D operations is a time-and resource-consuming process subject to strong learning effects (Belderbos, 2001).

Wang and Tong (Wang *et al*., 2004) developed a two-stage model describing knowledge transfer from MNCs to their Chinese subsidiaries. In the first stage is analysed factors affecting the extent of knowledge contributed by the MNC to its affiliate. In the second stage the model analyses the factors affecting the extent of knowledge acquired from the subsidiary by the MNCs. They conclude that knowledge contributed by the parent to the subsidiary is determined by parents' capacity and willingness to transfer knowledge. They also conclude that the knowledge acquired by the subsidiary from its parent is determined by the subsidiary's capacity and intent to acquire knowledge.

Cantwell and Santangelo (1999) concluded that effectively, there was an increasing geographical dispersion of corporate R&D. In trying to find out the reason for such a spreading of core technologies, the authors came to the conclusion that global technological networks increased owing to Information and Communication Technologies (ICT) specialisation that ended up by increasing the interaction between affiliates and the local innovation systems. Such an international integrated approach enabled MNCs to tap local tacit knowledge. Bresman *et al.* (1999) stated that the more tacit knowledge is (technological know-how), the greater the necessity for intensive communication in its transference. Trust and shared vision are also important factors in the case of tacit knowledge (Li, 2005). Therefore, the existence of social links between firms was associated with higher probability of existing knowledge flow. This probability would decrease with greater social distance. This explains geographic localisation of knowledge spillovers (Singh, 2003). Tie strength, trust and shared values and systems are important factors in the transfer of tacit knowledge. The influence of transferred tacit knowledge on an international joint venture's performance stems principally from its indirect effect on the learning of explicit knowledge (Dhanaraj *et al.*, 2004).

MNCs are expected to locate their international operations in locations with specialised fields complementary to major strengths, to enjoy localised spillovers. In this way MNCs contributed to the competitiveness enhancement of their innovation system through their affiliates' actions (Cantwell and Santangelo, 1999). The authors found evidence that this dispersion was sector specific since in some sectors, tacit and uncodifiable knowledge would require closer face-to-face interaction. They also concluded that mature and noncore technologies appeared less context dependent, and that they would flow easier across borders. The less codifiable the technology, the higher the probability that the technology transference is made within the firm (Kogut and Zander, 1993). According to these authors, a firm was a repository of knowledge that consisted of how coordination was coded and action coordinated. Like what we have already seen, firms are expected to be different in coding knowledge, in transferring that knowledge and in the ability to understand and to apply it. Hedlund (1994) stated that the problem of large firms was the flexibility of tightly specified and articulated systems of knowledge. Firms have difficulty engaging in projects not perceived to fit in the pre-established objectives of the firm (Hedlund, 1994). The source of these knowledge rigidities depends on the structure of the firm. Essentially the firm is designed like an instrument to exploit resources and knowledge efficiently. The structure and control of the firm influences the knowledge management (creation, input, output and application of knowledge). A central feature of international R&D structure involved balancing the need for overall corporate coordination and creativity (Florida, 1997). R&D subsidiaries require linkages to other corporate units to coordinate their activities (reporting requirements), but the perception of external control can have negative impacts, both on innovative performance and on the ability to recruit and attract high-quality human resources. In fact, within a structured unit such as a firm, knowledge is power (Mudambi and Navarra, 2004). As MNC subsidiaries have become more closely linked to international networks, their knowledge intensity has risen, and some of their R&D has gained a more creative role. These also concluded that as many subsidiaries acquire strategic independence, they get considerable intrafirm bargaining power to influence the distribution of the firms' resources. Intra-MNC knowledge flows are therefore a key determinant of the subsidiary bargaining power. Subsidiaries use this power to pursue their own ends (Mudambi and Navarra, 2004). The subsidiary's strategic independence, designed to enhance the competitiveness of outputs (market knowledge) and inputs (asset seeking and learning), can be corroded when the pursuit of subsidiary objectives encourages rent seeking. In this case they are expected to manage knowledge strategically.

Ghoshal and Bartlett (1988) analysed the attributes of the affiliates in the innovation process: the extent of local resources, the local autonomy in decision making, the normative integration of the subsidiary with goals and values of the parent company, the densities of internal communication among managers within the subsidiary and the densities of the communication. Their model predicted that the existence of high levels of local resources would facilitate creation and diffusion but would impede adoption of innovations by subsidiaries; it predicted that a high level of local autonomy would facilitate creation and diffusion but would impede adoption of innovations; it predicted that high levels of normative integration between headquarters and subsidiaries would facilitate creation, adoption and diffusion of innovations by the subsidiaries; and it predicted that the creation of innovations by a subsidiary would be facilitated by high levels of intrasubsidiary communication, and that adoption and diffusion

would be facilitated by high levels of headquarters-subsidiary and inter-subsidiary communication. The determinants of centralisation and decentralisation of R&D are the levels of Home-Country R&D, the amount of the reduction of costs of communication and control economies of scale of R&D, the possibility of having better coordination between central productive facilities and R&D units, the possibility of having better protection of strategic technical knowledge, the possibility of having easier access to governments, and the possibility of having more experience in launching new products (Niosi and Godin, 1999). The authors considered two types of degrees of technological autonomy of subsidiaries:

1 strategy of diversification (highest autonomy)

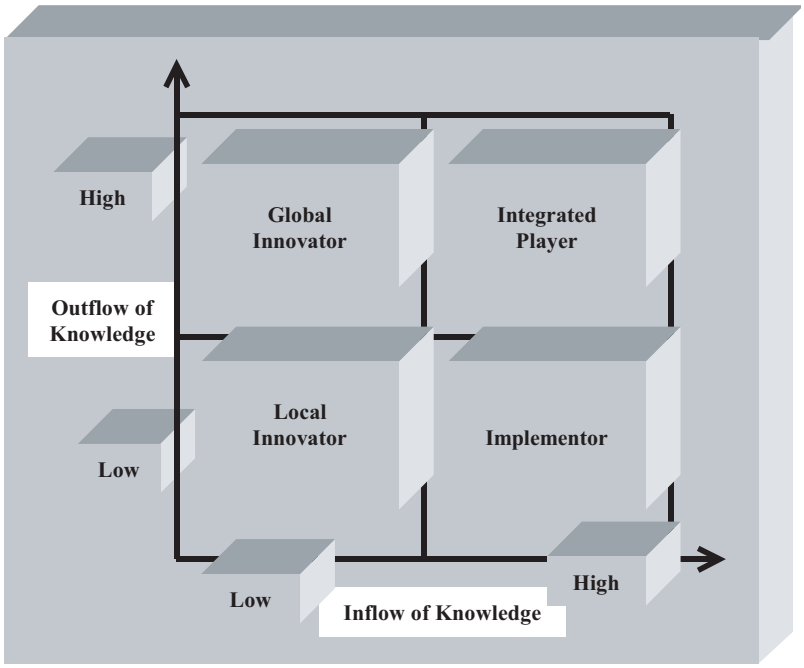
2 strategy of vertical integration.

The autonomy of the R&D process would depend on the technology transference capability, on the global structure of the MNC and on the foreign-market designing possibility. In the technology transfer process the coordination and support that the expatriate laboratory gets from the parent company are important (Niosi and Godin, 1999). The preference of MNCs for centralisation is a reflex of the quest for economies of scale, economies of agglomeration (benefit from the synergistic position in a community of research institutions) and the quest for a solution to the problem of security of technology (unwanted external diffusion of knowledge) (Pearce and Papanastassiou, 1999).

MNCs are characterised by their geographical dispersion. The headquarters' function is to coordinate and control information, inputs and output throughout all the firm's structure or network. This centrality is used to organise all the activity within the organisation between all affiliates. Gupta and Govindarajan (1991) devised taxonomy for the role of creation/reception of knowledge for subsidiaries within the network of an MNC. According to this taxonomy, affiliates are expected to be one of the following four types: *Global Innovator, Local Innovator, Integrated Player* and *Implementor*. The criteria to enclose firms within this taxonomy were the amount of knowledge outflow (inflow) to (from) the rest of the MNC (see Figure 7).

A *Global Innovator* subsidiary has high outflow of knowledge and low inflow of knowledge. This kind of affiliate serves as a source of knowledge for other units of the MNC. The *Integrated Player* subsidiary has high outflow of knowledge and high inflow of knowledge. This subsidiary is not self-sufficient in the fulfilment of its own needs. The *Implementor* subsidiary has a low outflow of knowledge and a high inflow of knowledge. The subsidiary engages in little knowledge creation, being highly dependent on knowledge inflows. The *Local Innovator* subsidiary has responsibility for the creation of relevant know-how in all key areas. This type of knowledge is so idiosyncratic that it cannot be competitively implemented in other markets. The most important mechanisms within this framework are the formal Integrative Mechanisms, the Intensity of Communication and the Subsidiaries' need for Autonomy. In the first case, the more complex the integrative mechanisms, the greater is its information-processing capacity in terms of ensuring effective coordination between interdependent units. In the second case, communication is an important case of the creation and the diffusion of innovations. In the third case, the greater the magnitude and scope of knowledge from a subsidiary, the greater will be the need for autonomous initiative. Non-routine jobs will be more effective if they are operated under decentralised decision making.

Figure 7 The role of affiliates in innovation



Source: Gupta and Govindarajan (1991)

It is important for MNCs to evaluate the internationalisation and the coordination of increasingly dispersed R&D capabilities in order to (i) avoid costly duplication of effort and (ii) to create channels for cooperation between resources in the multinational network (Zander, 1999). This is accomplished by keeping advanced capabilities in the home country and less sophisticated activities in the foreign units of the firm. The improved quality of innovation could be gained by (i) 'cross-fertilisation' within individual technologies and (ii) fusion or recombination of knowledge across related technologies that create synergies that leverage the innovation process. The potential benefits of internationalisation of R&D may come in the form of (i) international duplication (geographically dispersed units maintain technological capabilities in the same field of technology) or (ii) international diversification of advanced technological capabilities (relates to the situation wherein these dispersed units represent unique fields of technological expertise). Zander's (1999) taxonomy, based on duplication and diversification of advanced technological capabilities, considers four types of international innovation networks (see Table 4).

Table 4 Types of innovation networks

Type	*Description*
Home-centered	Firms retain the majority of their advanced technological capabilities in the country of origin.
Internationally duplicated	Firms strengthened their technological capabilities in foreign locations, but where foreign units are typically involved in the same kind of technologies that are represented at home.
Internationally diversified	Firms have a strict division of labour as a predominant mode of operation. Firms will access new growth opportunities and will develop the capacity to integrate and recombine different technologies into new products and complex systems.
Dispersed firms	Firms possess the most significant shift of advanced technological capabilities away from the country of origin. This complex structure builds the pre-conditions for cross-fertilisation and share of knowledge on a worldwide basis.

Source: Zander (1999)

Birkinshaw (2002) addressed how MNCs' R&D networks should be managed. He offered an optional perspective based on two particular characteristics of knowledge: observability and mobility. The first refers to the case in which knowledge may be recognised by observing that is the possibility to retrieve its main characteristics or principles by seeing the process or product. The second relates to the possibility that it can be retrieved, duplicated and reused in places other than the place where the knowledge was developed. An affiliate that manages knowledge characterised by low mobility, according to the author, should be given more autonomy than others that would manage knowledge with higher mobility. In his empirical study with Swedish MNCs he identified three types of research centres:

1 self-contained centres

2 modular R&D centres

3 home-base R&D centres.

The affiliates in the first case would manage high-observability and low-mobility knowledge, those in the second case would manage low-observability and high-mobility knowledge and those of the third kind would manage low-observability and low-mobility knowledge. The affiliates in the first and third case would be characterised by having high autonomy (by vertical specialisation) and in the second by having low autonomy (horizontal specialisation). When addressing the characterisation of an R&D network, the author states that there are mainly two ways of structuring such a network: the 'Loosely Coupled' Network way and the 'Integrated' Network way. The predominant kind of affiliates in the first structure would be self-contained centres and home-based centres and its strategy would be defined at the corporate level but through a bottom-up process. In the second case it would be composed of Modular centres and by some Home-based centres and its strategy would be characterised by a top-down process.

Example – Nortel Networks Strengthens R&D in China

"Nortel Networks will invest $US200 million over the next three years to strengthen its Research and Development (R&D) capabilities in China. It plans to build a new 55 000-square meter campus in Beijing's Chaoyang District under a memorandum of understanding on cooperation with the Beijing municipal government. The first phase of the campus, which covers 27 000 square meters, is expected to be completed at the end of 2004. "China is extremely important to Nortel Networks, both as a market and as a source for technology talent. We expect to continue to leverage the technology and innovation we develop in China by deploying it in the global marketplace." said Frank Dunn, President and Chief Executive Officer of Nortel Networks. Nortel Networks' current R&D facilities in Beijing and Guangzhou will continue to play an important role along with the new campus in developing Internet Protocol (IP)-based voice and multimedia services, third generation (3G) wireless services, next generation networking, and other leading edge technology solutions. When asked about Nortel Networks' 3G strategies in China, the president said the 3G is 'dynamic' given the rosy prospects worldwide. "All the three standards are fundamentally capable as far as technology is concerned," he said, adding the company will keep doing R&D in three standards – European based WCDMA (Wideband CDMA), US based CDMA2000 and China's homegrown TD-SCDMA (time division synchronous code division multiple access) systems. In the Chinese market, Nortel Networks teamed up with Datang Mobile Communications Equipment Co Ltd in August to build a laboratory to explore the commercialisation of the Chinese TD-SCDMA."

Source: China Daily, 17 September 2003

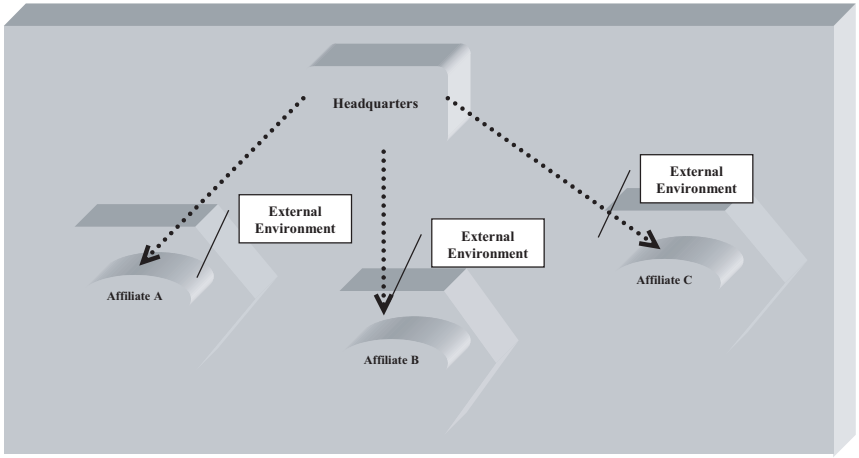
Example – Datang and Nortel Set up Lab

"A laboratory to explore the commercialisation of the TD-SCDMA (time division synchronous code division multiple access) was officially launched yesterday in Beijing by Datang Mobile Communications Equipment Co Ltd and Nortel Networks. "It's a milestone for us to accelerate the development of the home-grown 3G (third generation) standard," said Zhou Huang, President of Datang Telecom Technology and Industrial Group, the parent company of Datang Mobile, at a press conference yesterday. The two sides signed an agreement last month to establish the laboratory. "The cooperation between us will greatly boost the commercialisation of TD-SCDMA," he said. According to the agreement, both sides will apply their state-of-the-art technologies to conduct systematic tests in the areas of interoperability, network performance and system functions based on TD-SCDMA. The laboratory is the most advanced in China focusing on the commercialisation of TD-SCDMA. Nortel Networks provide key 3G-related equipment while Datang Mobile offers wireless access equipment. "We are now advancing into a new stage of integrated testing," said Tang Ru'an, Chief Executive Officer of Datang Mobile. According to the timetable, after a series of lab tests, tests focusing on the application of TD-SCDMA will be carried out from October to December. "TD-SCDMA is a very optimised system," said Robert Mao, President and Chief Executive Officer of Nortel Networks (China). He believed that the lab will promote acceptance of the standard and enhance Nortel Networks leadership position in providing 3G solutions in China. Among the three acknowledged 3G standards – European WCDMA, US CDMA2000 and TD-SCDMA, the home-grown one is regarded as the least matured among the three. Tang said early this year he expected the TD-SCDMA technology would go into large scale commercial use sometime after the first half of 2004, and hopes TD-SCDMA can eventually win global market shares of up to 10%, higher than in China."

Source: China Daily, 27 August 2003

Asakawa (2001) stated that autonomous overseas laboratories were often connected to the external research community (see Figure 8). In this case, external linkages of knowledge and ideas among the scientists might endanger the internal coherence of a company. The author stated that the lack of balance between internal and external linkages might be responsible for autonomy-control tension. The cause of this problem would be the perception gap between parents and affiliates concerning the degree of autonomy and the degree of information sharing.

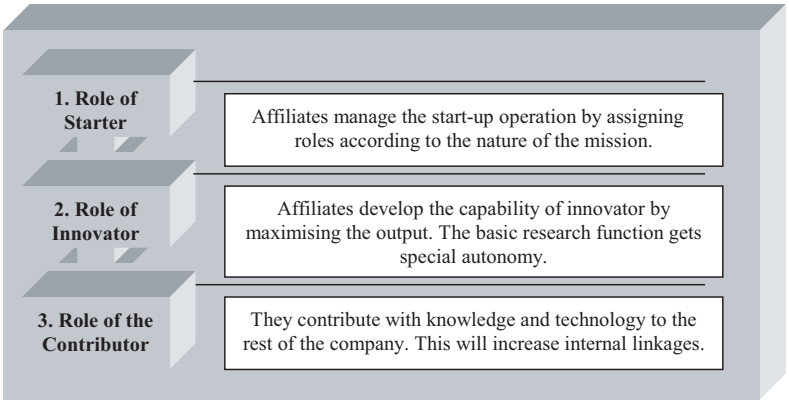
Figure 8 R&D in a decentralised MNC



Source: Asakawa (2001)

The relative power of the affiliates is expected to increase when there is a thin relationship between external environment and headquarters and when affiliates have privileged access to local environment. The role of affiliates moves through three stages: Starter, Innovator and Contributor (see Figure 9).

Figure 9 The innovation process



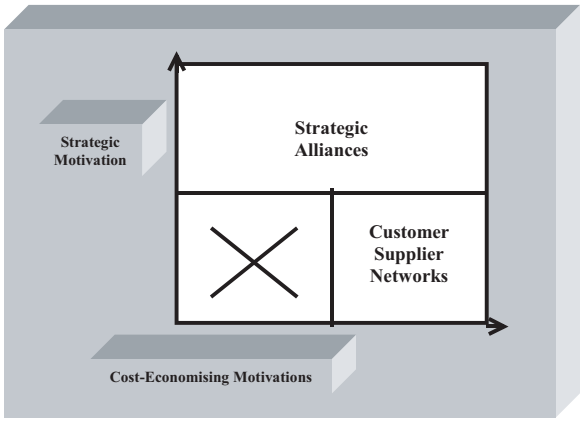
Source: Asakawa (2001)

From Phase 1 to Phase 2 the transformation is called disintegration. At this stage, the affiliate needs autonomy because their innovative activity needs to protect their originality. The autonomy allows affiliates to carry out their tasks without influence from the already developed techniques. The change from Stage 2 to Stage 3 is called the phase of reintegration. It is in this phase that the tension over autonomy control is expected to arise. The parent will be motivated to reacquire control in order to stimulate strategic coordination according to MNCs' objectives, and the affiliates are tempted to gain greater autonomy.

3.3 Strategies for technological cooperation

Firms use joint ventures as an internationalisation vehicle to share complementary knowledge. Cooperative strategies seek to coordinate two or more firms' technologies while eliminating redundancies and diminishing risks of failure. Cooperating strategies are undertaken at the most efficient level to capture the maximum profits and market opportunities for the product. Communication coordination and diversity between and within firms serve to build trust and superior performance to support the coordination of such 'vehicles' of innovation. According to Narula (1998), alliances are developed to diminish transaction costs, for strategic reasons, for developing new technologies and for tactical reasons. Technological alliances are limited because there is the risk of after-alliance fusion and because alliances need resources that not all partners might be able to spare. In some cases, the alliance may be established between parts whose contribution will differ on the nature of the resources. For example, there are cases in which some firms contribute with financial assets and others in which firms contribute with intangible assets such as knowledge. Narula (2003) differentiates two strategies to implement R&D cooperation agreements: one is to establish a strategic alliance and another is the constitution of an R&D network (see Figure 10). Technological agreements are established in the short-term in order to seize cost efficiencies. Strategic alliances try to enhance long-term value. Some firms use technological networks to keep a close presence to competitors while others might engage in alliances to form competing teams to obtain higher results.

Figure 10 Motivations to technologic cooperation



Source: Narula (2003)

Research and Development in emerging technologies has a high probability of being developed by alliances. The reason for this to happen is that this kind of R&D needs a confluence of technologies from unrelated fields, and the limitation of resources of MNCs might impede them from advancing alone. The need for flexibility, the quest for market power, the creation of economies of scale and complementarities are other reasons why MNCs decide to do so. Furthermore, alliances allow firms to have flexibility and optimisation of returns in low-growth scenarios.

Firms have higher probability of choosing foreign firms as partners in these alliances. The justification for this is that such a partner might bring additional advantages while searching for R&D adaptive to foreign market conditions and to capture at the same time the knowledge spillover from foreign innovative systems.

Tidd and Izumimoto (2002) stated that the transaction costs may not be the most significant factor affecting the decision to acquire external knowledge. Strategic considerations such as competitive advantage, market expansion and extending product portfolio may be equally important. Table 5 shows the types of collaboration (Subcontracting, Licensing, the Consortia, the Strategic Alliance and the Joint Venture), their advantages and disadvantages and the correspondent duration in time of such forms of collaboration.

Table 5 Types of collaboration

Type of collaboration	*Duration*	*Advantages*	*Disadvantages*
Sub-contract	Short-term	Cost and risk reduction	Search costs
		Reduced lead time	Product performance and quality
Licensing	Fixed term	Speed of acquisition	Contract costs
Consortia	Medium term	Expertise, standards	Knowledge leakage
		Share findings	Subsequent differentiation
Strategic alliance	Flexible	Low commitment	Potential Lock-in
		Market access	Knowledge leakage
Joint venture	Long-run	Complementary know-how	Strategic drift
		Dedicated management	Cultural mismatch
		Potential for learning	

Source: Tidd and Izumimoto (2002)

International differences in intellectual property rights protection are also very significant factors in the way firms choose the internationalisation 'vehicle': with less secure protection, firms choose R&D joint ventures rather than contractual partnerships. The level of technological change in industries was found to have an inverse effect on the preference for international R&D joint ventures (Hagedoorn *et al*., 2005).

Takayama *et al.* (2002) analysed the specific case of the evolution of product development alliances. Strategic alliances are used to coordinate the obligation to work within parameters of efficiency and the need to stimulate product creativity. According to them, this process goes through five stages:

1 Each firm has a strategy for promoting its original core field.

2 They use a product alliance to complement the product pipeline of the core activity.

3 The firms' own products have a longer product life cycle and reach a larger amount of sales than the alliance product.

4 The alliance product replaces the firms' own product, creating a new core field for the firm.

5 The alliance product is pulled out once a firm launches its own product.

Simonin (2004) proposes a model of organisational learning that captures the process of knowledge transfer in international strategic alliances. He investigated the simultaneous effects of learning intent, learning capacity and knowledge ambiguity (tacitness and partner protectiveness) on technological transfer. He refined the concept of Learning Capability into three distinct and specific concepts based on resource specificity, based on incentives specificity and based on cognitive specificities.

Example – NEC and Digital China Holdings Ltd. form a strategic alliance

Japanese information technology giant NEC is vowing to become the biggest projector maker in the Chinese market by forming an alliance with the nation's biggest IT distributor, Digital China Holdings Ltd. The companies officially formed a strategic alliance (October 2003) with Digital China acting as the general distributor of the Japanese firm in China that will use its 500 partners in 170 cities within China to support the development of the projector market for NEC. The two companies will first start with eight models of NEC projectors, aiming to sell in education, government and military sectors. Song Luning, general manager of the Chinese company's projector business, pointed out that with intensifying competition, the average price of a projector has dropped by about 20% every year, so cooperation between producers and distributors has become more important for companies to cut costs and expand market share. Song believes the gap between NEC and other leaders was not so big, and the alliance between Digital China and NEC View technology will allow the Japanese company to quickly catch up.

Example – IBM and Kingsoft form alliance

IBM and Chinese software firm Kingsoft (the biggest domestic office automation software vendor) formed an alliance in 2003 to develop office software for different operating systems, in order to challenge the dominance of software behemoth Microsoft. Kingsoft, one of the biggest challengers to Microsoft's dominance in China's office software market, used to focus on the compatibility of its products with Microsoft's, but it has since been making more moves to develop Linux applications to shrug off the influence and control of the US giant. According to the agreement, Kingsoft will write office software on IBM's development platform, which will be based on an open standard and support both Linux and Microsoft Windows operating systems. IBM will also provide its software middleware and training to and technical exchanges with the Chinese software firm to share its experience in the development of Linux. IBM, one of the biggest supporters of Linux, has more than 5000 engineers working on research in the field, whose experience is believed to be critical for Kingsoft. IBM will enable Kingsoft to greatly shorten the development process and improve the quality and functions of its products.

4 Conclusions

The main findings of our literature review are:

- The worldwide scenario nowadays is characterised by phenomena of enhanced frequency of innovations, the shortening of techno-economic life cycles, the rapid generation and commercialisation of new technologies and the outbreak of strategic alliances between large firms.
- R&D has diverse associated uncertainties: time horizons of the different projects, volatility in the amount of labour and capital allocated, and specificities associated with within-firm organisation.
- The R&D process requires interaction, communication and cooperation with marketing, production and top management.
- R&D is a heterogeneous process in the sense that the sources of innovation change from sector to sector.

- R&D serves to support manufacturing subsidiaries and to come closer to customers and markets, to hire skilled personnel, to monitor foreign technological development and to increase the inflow of new ideas into the corporation and to choose sociopolitical environments.
- Overseas R&D in MNCs is dependent on the current state of the group's technological trajectory. It is interdependent with the key processes of reformulation and the regeneration of core knowledge and commercial scope.
- The less codifiable the technology, the higher the probability that the technology transference would be made within the firm.
- The central feature of international R&D management involves balancing the need for overall corporate coordination and creativity (integration and differentiation).
- The high level of local resources facilitates creation and diffusion but makes difficult the adoption of innovations by subsidiaries.
- It is important for MNCs to evaluate the internationalisation and the coordination of increasingly dispersed R&D capabilities in order to avoid costly duplication of effort and to create channels for cooperation between resources in the multinational network.
- Technologic cooperative strategies seek to coordinate two or more firms' technologies while eliminating their redundancies. Alliances are developed to diminish transaction costs and to collect advantages from technological complementarities.

Firms manage R&D according to their momentum and according to their structure (allocation of resources, distribution of power, vicinity to markets). R&D creates knowledge that is a strategic input into processes of production, product design and managerial techniques, and this knowledge and its creation process have impact on the performance of the firm and its sustainability through time. We have learned that the equilibrium of the management of R&D (knowledge) is vital and the trajectory towards equilibrium is complex, as it depends on several factors. R&D conditions and is conditioned by the process of internationalisation of the firm. Momentary disequilibria that come from firms' short-term need to adapt change the balance between two fundamental forces: integration and diversification. Firms' strategies are a reflection of the need to balance these two factors, constrained by the need to achieve high levels of excellence and competitiveness in long-term trajectories of success. And this is where managing R&D plays a vital and decisive role.

Acknowledgements

The research was conducted with the financial contribution of the International School of Advanced Study of the University of Turin (ISASUT). I would like to thank Professor Giuseppe Tardivo, Director of the PhD Programme of the University of Torino, for all the unconditional support. The article was completed during my stay at ESCP-EAP Paris. I would like to acknowledge all the precious availability given by Professor Franck Bancel, as well as all the working conditions provided by those responsible at ESCP-EAP Paris.

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