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R&D and New Competitive Challenges: Between Intensive Innovation Strategy and Internationalization

R&D activity has always occupied a central place in the strategy of large enterprises and in the competitive performance of states. Recently, with a significant change in the competitive environment of companies (such as, for example, competition with new emerging countries, intensive innovation policies, changes in customers' expectations and transformation of business models) innovation and R&D have become essential for both company and national competitiveness.

In this chapter, we first present the relationship between R&D and company strategy and the different generations of R&D and their characteristics, which are currently possible to identify over a long period of time. We then identify and describe the main factors that influence R&D strategy in companies, emphasizing their impacts on the construction of new R&D models. Finally, it provides a practical illustration of the latest developments in the R&D sphere through the presentation of policies that Western companies have implemented in their Chinese subsidiaries.

1.1. Strategy and R&D

The place of R&D in the company is closely linked to technological innovation, particularly in its strategy. It is important to note that innovation is not simply an invention, but it is the result of a design process that a market has endorsed. Ultimately, it is about successfully bringing to market

profitable requests (products or services), for which the company undertakes a reshuffle of knowledge and existing skills in order to offer new products or services. The place of R&D also depends on the sector, competitive strategies and the nature of the company's markets.

1.1.1. *R&D's place in business strategies*

R&D plays a special role both in companies' strategies and in the international arena. Research and development projects not only provide a competitive edge for businesses, but are also vital for the economic competitiveness of countries in their struggles for power and international influence.

1.1.1.1. *R&D responsible for its very unique place in company strategy*

The place of R&D in company strategy depends, first, on the business sector, the nature of the markets and the company's competitive positioning and, second, on its degree of globalization. Therefore, the high-technology companies belonging to the "innovation-driven" sectors (as well as pharmacy, aeronautics, energy, electronic, etc.) [GIR 96] make huge investments in R&D, whereas the businesses in mass distribution invest little or no funds in R&D. The nature of the markets also affects the position of R&D in company strategy. For consumer products manufacturers, the R&D strategy will consist of manufacturing better and cheaper than the competitors, by offering either innovative products that better meet consumer expectations or products with new and highly attractive features (e.g. the new digital applications via smartphones or social networks) or by adding a service to the product (such as integrated remote maintenance with the purchase of a printer). For these companies, R&D activity has long been closely linked to decision-making. When dealing with the B2B sector, that is, those geared toward the sale of products to industry, a large part of R&D is performed close to industrial entities, where the industry is located [LEN 02], in order to respond to the needs of cost reduction and to support innovation efforts. This is done by providing "solutions", on the one hand, and by creating innovative concepts capable of introducing breakthroughs in industrial performance on the other. This is the case, for example, with R&D centers of the cement industry being located near production plants.

The strategy of localizing a company's R&D activity close to its customers is illustrated by the example of Usinor, now known as ArcelorMittal.

Usinor (ArcelorMittal, from 2006) is a company producing raw material (steel), involved in the upstream of industrial clusters, particularly the automobile industry. The innovation strategy, which operates in the automotive market, is also reflected within this upstream company, which is forced to find innovative technical solutions, which are at odds with its dominant position on the market.

Here, the proximity, not only geographical but also organizational and institutional, between the R&D of the upstream company and car manufacturers is a prerequisite to its success. Organizational proximity involves putting in place coordination and cooperation arrangements between R&D players of the iron and steel group and those of the car manufacturers such as shared research projects allowing the exchange of information and knowledge. In contrast, institutional proximity involves creation of common areas of co-exploration for interactive learning required for innovation.

Besides the traditional strategic aspects like the domination by the costs and benefits of global "solutions" for the client, this company's R&D strategy has always been about developing and proposing innovative product proposal (IPP) projects in the field of hydroforming, in which:

– the result of the design project is not linked to a specific object designed directly for the customer;

– the project is likely to shake up the mainstream R&D representation of the company and its customer;

– uncertainty about the customer accepting the innovation is the norm.

These innovative product proposal projects lead to a situation of new cooperation with customers referred to as "co-exploration", in which the two partners explore together, without certainty as to outcome, the concepts likely or unlikely to lead to the creation of added value.

Box 1.1. *Design differentiation approach in the R&D of Usinor (source: Lenfle and Midler [LEN 12])*

The place of R&D in company strategy also depends on the globalization of the business activity. In order to compete, some companies had no other choice but to globalize. The analysis of globalization provided by the economist Pierre-Noel Giraud [GIR 12] serves as essential reading that helps us understand its effects on the breakdown of the value chain and, in particular, on R&D's place in globalized enterprises. The Giraud model is based on the division of the world economy into territories separated by borders. It is based on a distinction between "nomadic firms" and "sedentary firms" and on a differentiation between the jobs of a territory that produce goods and services subject to international competition and those producing goods and services protected from this international competition.

Within each territory, protected by borders, people, capital and goods circulate freely, but not always between territories. This concerns human resources in particular. The nomad firms produce and circulate economic objects between territories. They make territories compete in their comparative advantages to make profit, and their decisions on FDI (foreign direct investment) destabilize or stimulate the territory's economic activities. This is particularly the case with R&D investments. The sedentary enterprises only produce or trade at the national level. Employees competing for the nomadic firms will also be described as nomads. They only compete on a territory if they are competitive, otherwise they are transferred elsewhere. Sedentary or protected employees only compete with one another for the production of goods and services for local use. Thus, the global firm "locates sedentary activities where they must be", and the nomadic activities "in the territories that offer the best conditions": low labor costs with high labor intensity and availability of highly qualified scientific staff for research laboratories.

By repeating Giraud's paradigm, it is clear that R&D's position is of crucial importance for companies from overseas or nomads, that is, those exposed to global competition, that are on the front line of innovation and product renewal; it is less crucial for "domestic" companies or those on the protected market like mass distribution.

1.1.2. *Different generations of R&D*

The governance of R&D is strongly impacted by the level of importance that the company attributes to innovation. Other factors are included in the

connection between the development and creation of scientific and technical knowledge and value proposition for customers.

Management literature has highlighted five generations of R&D management [ROT 94], which are described as follows.

The *technology push* model was the first dominant generation during most of the 20th Century; it is very visible in the policies of R&D enterprises as well as in those of states through large research organizations, such as the CNRS and the CEA in France or NASA in the United States. According to this model, innovation is primarily dependent on the industrial and scientific policies of companies or states according to a top-down view (Schumpeter). Scientific and technological progress guides innovation. The main participants are the researchers and engineers in R&D departments of large companies or scientific organizations. This does not mean it is a closed model. While public–private exchanges are not a particularly recent tendency, openness and networking continue to play major roles in the world of science and technology.

This approach, also referred to as the "producer's model" [VON 01], has been of major importance in the development of areas such as telecommunications, aerospace, nuclear science and robotics through government policies. In enterprises, new products and services are designed and developed by the R&D team and then promoted and sold through the marketing department to be ultimately purchased by the consumer. Innovations can be incremental (i.e. small scale that build on what already exists) or radical (large scale or breakthrough, i.e. they offer solutions that did not previously exist). This model has also been described as an "Emitter innovation model" model [BAD 13] in reference to the fact that, based on a technological determinism, innovation is designed and released to the company or the markets in a linear and mechanical way with a top-down view.

The *market pull* generation emerged toward the end of the 1960s. Building on the consideration that the consumer is essential in defining needs, it combines the logic of supply in R&D based on technology and the logic of demand resulting from the increase in consumer expectations. We start from market needs and expectations to adapt the technology according to the latter. The marketing department, which studies subtle market needs, is central to the arrangement. The R&D function is the

in-house IT service provider for the marketing department and senior management, which provides technical solutions to operational needs.

The years 1970–1980 saw the advent of a third R&D approach which, despite the saturation of markets, began to introduce rationalization efforts through cost reduction and control and through measuring all R&D investment against companies' business strategies and financial expectations for return on investment.

The end of the 1980s was characterized by an R&D approach in which it then became important to merge strategies that intersect the rationale of supply determined by technology and those of consumer-driven demand. This is an integrated approach and crosses several of the enterprise's functions like marketing, distribution and customer service. This characterized the fourth generation of R&D management.

Finally, the 1990s saw the arrival of a radically new design. A company's knowledge capital was to give it a sustainable competitive advantage in its market in terms of its capacity to generate product or service innovation. The enterprise was witnessing the rapid disintegration and outdating of knowledge of its professions and technologies. In the era of "time compression" [ROS 10], short time-to-market products needed the innovation process to speed up. To address very complex innovation problems, the need for R&D was advancing. Enterprises conducting R&D activities in-house were then obliged to rely on an external R&D ecosystem. Consequently, they established more open innovation design practices. R&D then introduced a multitude of internal and external practitioners to the business or organization, maintaining links and relations that might contribute to innovation. It is the generation of *open innovation* [CHE 03].

In a background of intense and accelerated competition, Western companies have no other choice but to get a maximum return on R&D investment by resorting to open innovation, allowing them to take advantage of the network of skills of many partners to speed up new product development and add value. This partnership can sometimes be seen elsewhere with certain competitors as can be seen in the pharmaceutical sector, where R&D efforts to ensure the development of a really innovative and profitable molecule (blockbuster) require huge financial investments (on average, several hundreds of millions of dollars). Enterprises such as

Sanofi have developed, for these reasons, a strategy of open innovation for the whole of the group in a B2B approach.

In the pharmaceutical sector, two main participants coexist: major groups who were historically based on knowledge and know-how coming from chemistry and the smaller firms more inclined toward biotechnology. Public laboratories also play a key role in R&D and innovation in this sector. The firms in the sector are directly involved in scientific advances in biomedical science (science-based sector).

The Sanofi group, the third largest pharmaceutical group in the world in 2016, started to note in 2008, as in the whole of the sector, a decline in the productivity of R&D and adopted a model of open innovation to broaden its resource base in knowledge and know-how and increase its capacity for innovation. It is necessary for the group, at the same time, to reduce its dependence on blockbusters (molecule likely to give a decisive advantage), in order to master the threat of generic drugs, which are increasingly attractive to the national health authorities, and optimize its R&D.

The strategy was to enroll in a three-party collaboration, in which academic laboratories lead public basic research; biotechnology companies lead the upstream phases of research; and the major groups are responsible for the development and commercialization phases. This strategy became a reality for the group, between 2008 and 2014, through 26 generic biotechnology acquisitions (the most important of which was the biotechnology Genzyme) and vaccines to incorporate innovation in the pre-clinical or clinical phase in R&D. It is complemented by the establishment, around the same time, of 104 partnerships and alliances to enrich the knowledge base of the group on topics that were inadequately controlled.

In this model, the policy of open innovation, which focuses on both targeted partnerships and a policy of company acquisitions that develop specific molecules before going to market, enabled a form of outsourcing of exploratory R&D (the R of R&D) to help them acquire a true "pipeline" of molecules that have already been tested and are likely to convert to commercially profitable molecules.

Box 1.2. *Sanofi's open innovation strategy (source: Labrouche and Kechidi [LAB 16])*

This is also the approach developed by a telecommunications operator like Orange, which aims to take a leading position worldwide.

The Orange Group is a global operator of telecommunications with a large R&D function (5,000 people across the world), particularly in Europe, where some operators have decided to withdraw (British Telecom, for example).

It is organized around the Technocentre in France, "a manufacturing and design facility", Orange Labs that have overall responsibility for technical products and services, a development center that identifies innovative trends in Silicon Valley and an Orange Valley dedicated to rapid innovation.

Orange has chosen to focus on the following three levers of innovation:

– Immersion in an innovative ecosystem: SSII, digital agencies and start-ups allow it to accelerate its innovation process by providing its customers with unique solutions and user-friendly access. Each of the group's research and innovation centers is integrated in a geographic ecosystem as close as possible to the local markets and is involved in public research programs, such as the investment programs for the future, with public–private partnerships or competitive clusters. Orange Labs carry out monitoring activities in Asia and the United States. Orange Institute facilitates the understanding of digital transformations for researchers and decision makers to external companies. Orange accompanies the external companies in a co-design approach, in particular, on the Internet of Things (IoT).

– Opening up of Orange assets to the ecosystem of developers through the application programming interface that makes 15 application programming interfaces (APIS) available on strategic projects for the group.

– Active support for start-up development with Orange partners (Orange Fab, start-up accelerator, Orange digital ventures and Orange Social Entrepreneur Prize). It supports an innovative workplace for the company employees and associates (NUMA, digital canteens), involvement in the French Tech initiative for valuing the digital ecosystem and promotion of intrapreneurship.

This wide-reaching program aims not only to associate the innovation capacity of young enterprises and innovators of all kinds to Orange expertise to accelerate the development of new solutions for customers, but also to open the doors of the enterprise to advance the images its own employees have on innovation in particular.

Box 1.3. *The open innovation of Orange (source: Orange [ORA 16])*

In this last generation of R&D as is illustrated by our two examples, sharing of information and knowledge between networks, clusters, start-ups, centers of public or private research, customers and suppliers, organized in ecosystems, appeared to be powerful levers for innovative design. In order to continue, it is the company that must advance its R&D by being able to use external ideas as well as internal ideas and take both internal and external paths to market [CHE 06].

1.2. Environmental factors influencing business strategies in R&D and their consequences

Having distinguished the different strategies witnessed in R&D matters and the latest trends, we must highlight a few significant factors that seem to us to significantly affect the current context in which R&D policies evolve in global enterprises.

We have made the choice to emphasize three of them that, according to us, exert a major influence on R&D strategy: the central role of innovation, the increasing importance of the consumer and the effects of market globalization.

1.2.1. *The major role of innovation in competition strategies*

Until the 1990s, R&D, examined from the geostrategic point of view, enabled industrialized countries to maintain a "competitive advantage" thanks to the design and production of high-added-value/high-end goods. These goods required a hi-tech innovation. They then had to be transferred to emerging economies, hoping to aid development and, in this way, enable the development of a global "virtuous spiral"[RIE 08].

The intensification of international competition and the growing roles of new economies and emerging markets led Western companies to reconsider their competitive conditions.

The arrival on the markets of new economic players from emerging countries (BRICS[1]) since the mid-1990s, coupled with the new financial

1 BRICS is the acronym for the five major emerging economies: Brazil, Russia, India, China and South Africa.

efficiency requirements of capitalism, has toughened economic competition while changing the place of innovation in firms.

First, innovation has become not only a means for achieving growth, reserved for certain sectors, but a crucial condition for survival, in particular through the policies of intensive innovation. In order to be competitive, it is necessary to differentiate oneself through gaining market knowledge and being attentive to the markets. It is also necessary to translate this into permanent innovation and to position oneself in the new sectors of business activity with a high degree of scientific and technical knowledge.

Second, for an increasing number of businesses, it has become critical to know how to identify and then capture the value created by harnessing knowledge and creating new knowledge in order to further their strategy and develop a competitive advantage. This requirement takes place in a context where market transformations and customer expectations are increasing and require more skill.

The example of the innovation approach of the Saint-Gobain glazing division shows how a company that has traditionally focused on a high level of technological innovation in its products is forced to advance toward the creation of value through solutions that provide benefits and results for clients.

The glazing division of the Saint-Gobain group experienced for many years an initial state of "dispersed and isolated research" in its automotive, windscreen and glazing products. This corresponded to a long period during which its product was relatively frozen. What prompted a reconsideration was the request from the car manufacturer Renault for the supply of a heat-insulating windscreen glazing, which would prevent excessive heat from the sun, so as to save on air-conditioning.

To respond to this, Saint-Gobain established a project team with a dedicated leader and contributors in the identified fields to manage the technical innovations to meet this request. However, other requests arose, such as heated glazing and the addition of an aerial, which made coordinated management of different projects and, especially, the control of their costs difficult.

R&D was then structured in "lines" of necessary skill sets to reuse the skills that have already been acquired in future projects. The lines enable the design of "semi-finished products", generic designs with a certain amount of freedom so they can be adapted to

another product development. Different types of projects are incorporated – development, exploration, new technology – the design of which fall under different research rationales. Managing a line is no longer about having "off-the-shelf" technology, but about the development of organizing skills that will nurture new projects in a context of "repeated innovation".

Progressing to "intensive innovation", the company developed a new "glazing theory", known as a membrane, which both insulates and connects, with the hope of pursuing new features. It is not about innovation for a single client anymore, but about pursuing new areas of knowledge that could fuel new explorations.

Box 1.4. *Innovation strategy and management of R&D at Saint-Gobain Sekurit (source: Le Masson and Weil [LEM 02])*

The example of Saint-Gobain shows that the traditional criteria for innovation performance (essentially parametric and based on size, cost, efficiency and product safety, according to defined need) have also flipped; "the character of goods and services has therefore become unpredictable" [LEM 06]: a windscreen is also a smart communication media, a mobile phone is at the same time a camera, a watch is also a computer and an oven is at the same time a library of cooking recipes. Even if this new approach to innovation requires research in cost control (Chapter 6), the need for intensive innovation does not negate the tangible elements to justify R&D performance.

1.2.2. *The emergence of the consumer in R&D*

In the background of the changes just described, the problem is no longer only "to introduce a new product" to the market, a model that could really have meaning in an economy of technology-driven supply or market-driven demand, but to provide a product that meets a range of different need and practices and the search for other types of networks for potential customers or even knowing the importance of considering the capacity for innovation of the customer.

The subtle identification of customers' needs was, up to this point, the prerogative of marketing services who interpreted these analyses as operational specifications for R&D. However, understanding customer expectations swamped with numerous requests and occupied by new concerns can no longer be based simply on "questioning" them on their needs, because they can only develop a need based on the solutions that they already know or imagine.

The challenge is therefore to understand them better and to anticipate what they go through, as well as their difficulties and culture. The approach that prevails now is that of "end-users", where it is not so much about asking the customer the question "what innovation could my enterprise offer that would help you overcome the problems you are facing?". Rather it is to observe carefully what customers are often not able to express themselves because of one-sided understanding, habits, lack of knowledge on current technological possibilities and so on. R&D then uses methods that further resemble those that a sociologist, an ethnologist or an anthropologist would use rather than the traditional distribution of a satisfaction questionnaire.

In order to identify the innovation opportunities, the R&D function needs to adjust its possibilities and resources to match the observed client needs. "Customer research" should be about identifying clients who are specifically experiencing the problems that can be solved by the proposed innovation and for which this innovation "makes sense".

The Nestlé group, which has, for the past few years, aimed to develop a *consumer-centric* R&D approach illustrates this approach.

The Nestlé group, the largest group in the nutrition, health and well-being sector and founded more than 150 years ago, has always placed innovation at the heart of its business model. Henri Nestlé created the company starting with the invention and marketing of the first formula milk, aimed at newborn babies whose mothers had difficulty breast-feeding.

Like different generations of the R&D of global enterprises, the group successively directed its innovation efforts first toward the supply of food products and then toward nutrition and pleasure nutrition. It defines its innovation strategy currently as being geared toward nutrition, health and well-being, that is, enabling consumers to access healthy products in order to maintain good health and prevent diseases.

At Nestlé, the need for interaction with consumers transcends its only marketing function of study of consumption and customer service, to which it has traditionally devoted its efforts. The following points show how customer focus is also a necessity for the R&D department:

– by putting the research and development teams along with those from marketing in direct contact with the consumers (observation in purchasing and sampling, focus groups, immediate collection of feedback, co-creation within pop-up stores ,etc.);

– by promoting quick prototyping of a new product, based on the formation of joint teams blending the innovation approach, R&D function, marketing and the strategic affairs units.

The challenge is to lead all major players of these functions to set about their work in an unprecedented way, "in the consumer's position" or by putting oneself in the consumer's shoes.

This approach, which is unusual in R&D, borrows the methods and tools of design thinking (ideation, test and learn, etc.) and "learning by doing" most commonly used in marketing. It is based on the need to move the R&D professional's frame of thinking while allowing them to be open to new consumer approaches.

Box 1.5. *The Nestlé Group and the "Consumer-centric" approach to R&D*

Here, we deal with "market-driven" innovation processes that are not brought about by an expressed demand but are prompted by an observation from which the needs are derived, which in turn initiates an innovation program and even some new research. Then, we deal with "market push", a concept that enables the shift from the false opposition of the *technology push* and *market-pull* logics, whose foundations appear to be more in tune with what is currently acknowledged about the emergence and development of corporate innovations [TID 05].

In the example of Nestlé, the consumer's role can also be taken into consideration using a "communicative "logic [BAD 13]. Such an approach has been introduced into R&D operations through the installation of devices, which are dedicated to usage analysis, as shown in the example below with the telecommunications operator Orange.

Orange's digital cafe is a community of more than 6,000 people, outside of the company, interested in digital life and who attend virtual cafes led by a *community manager*. Each year, about 40 digital cafes take place via a Web space, which is unique to Orange.

The objective of this facility is to encourage interactions with consumers or users, the "dreamers", generators of useful information for product and innovation design, with a view to producing new proposals. The work is organized within virtual workshops on themes as diverse as the protection of private life, the child and digital life, the quality of existing digital applications and so on; a workshop can last 5–15 days and requires commitment. Based on the community discussions and an overview of the possible usages, the facilitator proposes the synthesis that allows the production of a knowledge database on anticipated customer expectations that in turn would help to create an immediate offer and test its feasibility.

The digital cafe is part of a Web community "archipelago" created by the enterprise, in which different ideas, product news and experiments (Digital Society Forum, Lab Orange, Imagine.com, etc.) are open to users. The enterprise navigates through this archipelago to create innovative spaces and to identify possible breakthroughs. On the basis of this exercise, the enterprise has formalized a method for streamlining its organic ability to innovate.

The digital cafe is an "immersive, dialogical and experiential" facility for innovating [DAM 14].

Immersive, because it shows that in order to understand customer usage it is not enough to carry out a customer survey; one must know the practices "through and through".

Dialogical, because knowledge about customer uses is based on dialog and interaction.

Experiential, because just as the company learns from the "dreamers", the latter gain skills over time through their participation, thereby becoming competent customers.

The premise of this approach is that innovation does not belong to a function (R&D) and that it must be seen as an extensive, open design process.

Box 1.6. *The digital cafe at Orange*

The example of Orange shows that it has developed a true "communicative model" of innovation based on the intensive use of the Web [BAD 13] in the digital economy sector in particular. Now, "Innovation is the adoption of a new practice by a community […] Success in innovation intersects the areas of expertise of the innovator powered by the designer, his/her expertise in the field of social interactions and his/her ability to recognize and seize opportunities" [DEM 10]. In this model, remote dispersed communities are demanding a freer organization to propose new innovative combinations, along the lines of what Google promotes via the Internet and social networks, for example.

Innovation is a concept aided by use, which itself is overturned by "social technology" (McKinsey), that is, spontaneity, flexibility, serendipity and adaptation in design, which the user communities know how to display.

1.2.3. *The effects of market globalization*

The globalization movement affects R&D organizations. It triggers a review of the geostrategic and economic approaches of its management models.

Although it has been long affiliated with senior management, R&D has for several years been involved in a decentralization movement: on the one hand, for the operational units that drive specialization in product ranges and markets that require R&D activities linked to their specific strategies and close to the markets they control, and on the other hand, for markets that are geographically diverse due to the internationalization of enterprises, to enable adapting the products to the needs of these markets.

Globalization of an enterprise's strategy is expressed not only by internationalization, that is, the access of a business to markets outside of its country of origin, but it also corresponds to a phase of the enterprise' development, in which the firm's entire value chain, from finance to the distribution of goods and services, is managed at a global level, taking into account the competitive advantages of the location for each element of production.

The internationalization or globalization of R&D of industrial enterprises has been analyzed across the following four phases, which in fact partially overlap [LAP 12]:

– the first phase is one of "low-intensity globalization of R&D" which continued until the 1980s;

– the second phase is one where internationalization of R&D was essentially located in the area of the Triad. This is a concept developed in economic geography by Kenichi Ohmae in 1985, which combined East Asia, Western Europe and North America during the 1980s and the 1990s;

– the third phase followed in which internationalization of R&D resulted in localization in the emerging countries back in the 1990s;

– finally, from 2010 onward, there is a fourth phase that sees the emergence of a reversed innovation process (or reverse innovation) located mainly in emerging countries.

1.2.3.1. *The phase of low-intensity globalization of R&D*

In the competition of industrial enterprises, the traditional strengths of the Western world existed for decades not only in the technological monopoly of major manufacturing processes and procedures but also in the materials and innovative products. These assets that have led companies to focus on products with high added value have demanded a consistent innovation strategy in order to explore eventual breakthrough innovations which allow the creation of products or more competitive processes. These strategies have meant that over the last century, Western companies have dominated in R&D in many sectors (steel, aeronautics, pharmacy, etc.) and in geographically localizing R&D near the decision-making centers of these firms. The main issue of this first phase was to safeguard scientific and technical knowledge as intellectual capital and only transfer product patents and licenses that are sufficiently standardized to foreign countries.

1.2.3.2. *The beginnings of internationalization*

The 1990s marked a major change, which saw the design and production of products with high technological value being localized abroad mainly in the Triad in a transnational approach. During this period, the presence of companies on international markets was no longer limited to product marketing, but included their R&D activities. It then involved, on the one hand, expanding the design processes by leveraging specific areas in the

world that had a high scientific concentration such as the clusters located most often in the large Western-based cities. These areas also attracted the main global investment in R&D. On the other hand, it involved being able to break down the design of technological products into independent parts, in particular, in the areas of electronics, biotechnologies and information systems, with the objective of eventually entrusting them to subsidiaries abroad or to partners in these countries. It was during this second period that *open innovation* strategies developed [CHE 03], which highlight the importance for enterprises to build a wealth of expertise from networks to advance innovation via "global networks of open innovation" [SAC 08].

Access to networks of expertise based in overseas territories was also analyzed/considered by Jacquier-Roux and Paraponaris [JAC 11] as an opportunity for the enterprises "to benefit from tacit knowledge that we can only grasp by having a presence and by penetrating networks already in place in the area". This tacit knowledge, which can equate to the intellectual capital of the firm [NON 95], is at the heart of exploratory learning and the processes of innovation. The problem with establishing an R&D center overseas is allowing researchers to participate in networks of co-production of tacit knowledge, such as social networks or institutional research networks, and the co-production of codified knowledge that constitutes patenting.

1.2.3.3. *Localization of R&D in emerging countries*

Since the early 2000s, the localization of R&D activities in emerging countries has been developing. The division of labor between countries that are the intellectual designers and the hard-working manufacturing countries is no longer sustainable. The emerging countries where industry is developing rapidly are investing in their education and research system to become innovative (China, India, etc.)

This third phase of globalization of R&D has the following multiple objectives:

– to take advantage of the scientific and technical development potential observed in several regions and in several sectors (information systems in India, biotechnologies and pharmacy in China);

– to benefit, initially, from a scientific and technical workforce cost well below that in the West;

– to ensure the relay for the development of enterprise activity, particularly since the economic crisis of 2007–2008, where Western growth has slowed considerably, in countries where growth is being maintained with regard to the period at a rate of 5–8% per year;

– finally, to strengthen the design capacity of Western firms with the aim of creating products that are specifically dedicated to emerging countries, as has been observed in the pharmaceutical industry, where large companies such as Novartis or Astra Zeneca have established R&D centers in China first, to advance research on diseases such as gastric cancer or hepatitis, and in India second, to engage in research on tuberculosis.

The Nestlé group has, for its part, established an R&D network everywhere in the world linking the upstream research centers, including that of the headquarters in Vevey, Switzerland, and development centers that are closest to the markets (see Figure 1.1).

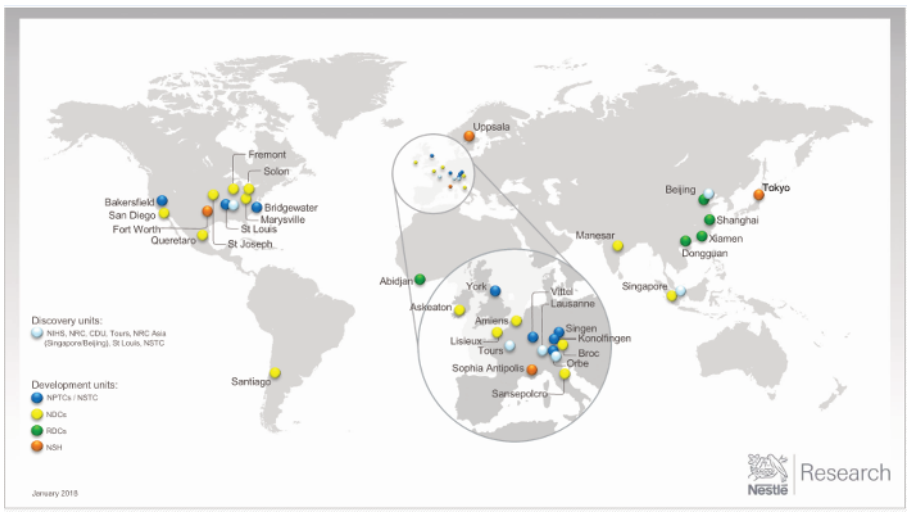

Figure 1.1. *Map of the Nestlé group's R&D center locations. For a color version of this figure, see www.iste.co.uk/gilbert/innovation.zip*

1.2.3.4. *Toward reversed innovation?*

The tendency toward the localization of R&D in several countries through "hubs" is an evolution that has been witnessed in recent times. This is where they connect with different local players that are universities and

other local research centers, clusters and the local public authorities, organized in an ecosystem that favors innovation and creates links in the field of innovative exchanges, training or research. The motivation here is multifaceted. There is the economic logic of drawing closer to those markets where economic growth is now taking place. There is also the need for proximity with prestigious academic and research organizations and training institutions to capture innovation and identify the talent. Finally, there is a need for identification of a fabric of small entrepreneurial firms to identify opportunities for technological development or uses to fuel innovative projects.

The concept of "reverse innovation" appears in this period [IMM 09] upon the initiative of General Electric President J Immelt. While he advocated for this strategy from the 1990s onward and successfully implemented it in his own company, he also considered that it is almost inevitable for all the other industrial enterprises. From his point of view, the Western companies will need to develop the entire design process in emerging countries in order to successfully compete with "champion" companies of these countries, which are better placed to propose products, including technological ones, on world markets. The consideration of the constraints of these countries, their limited access to resources and their vast economic needs proposes new avenues for designing new products by capturing needs and local uses and then attempting to develop global products that could potentially be successful on world markets.

Reverse innovation implies a fundamental revision of the design strategy of enterprises in developed countries centered on the research and development of hi-tech products destined for consumers with high purchasing power. In contrast to the traditional design of R&D, it proposes a more frugal technology design and less intensive design engineering [MID 17]. It is a "bottom-up" innovation process.

Reverse innovation is also the mirror image of the strategic management model formulated in the 1990s: "think global, act local" or "glocalization" that wanted enterprises to develop a global R&D strategy aimed at supplying local markets with a holistic engineering design. Since then, companies that rely on reverse innovation have developed the opposite approach: "think local, act global", illustrated by L'Oréal's R&D policy, for example, in which it is no longer about designing global products for global markets, but about starting with product innovations made in emerging countries to make

them global and distribute them globally adding to them where necessary through technological improvements that may be necessary in more mature markets.

The traditions of conventional innovation wanted innovation in Western enterprises to be carried out, on the one hand, through top-of-the-range goods, that is, by making more sophisticated products and, on the other hand, according to the capabilities of the technical design of the country of origin and then for it to be launched in the rest of the world. The example of the design of the Kwid, an Indian vehicle from Renault–Nissan, shows a possible split in innovation strategies.

The process implemented by the end of 2011 moves away from usual company practice in vehicle design: to first offer the vehicle on the Indian market, it had to be designed under a strict set of specifications: to drastically reduce costs, they adopted an original design of a small SUV and then modernized it, for example, by installing integrated navigation tools and making it more spacious than the competing models.

The project design story boils down to a permanent struggle by the project leader and his team to "free themselves from the technology, habits and usual management of such a project" [DET 17]. It becomes a reality through strong self-determination in relation to the engineering of the parent company who directed the project team to no longer consider any technical standard issued as secured, for example, questioning the number of securing points on the wheels, reducing the cabling weight, reducing the thickness of the seat runner and a factory without walls or doors.

The project was then controlled by cost targets according to the principles, methods and tools (design to cost), which took into account as closely as possible not only the design choices and customer value objectives but also company costs of working in cooperation with the suppliers. These are up to 97% "Indianized" and offer original solutions even technologically, as collaboration with suppliers started well upstream.

In addition, the project sets up a creative development process where innovation is focused not only on the upstream design phase, but also on the development stages and even the market rollout.

This "fractal innovation" [MID 17] permits an advanced capacity for exploration and learning in the teams and increased responsiveness to sudden changes at all stages of the project. Also, a new method of innovation was developed that neither Renault nor Nissan used; it is a global project based on an innovation approach reversed via the research of frugality in industrial investment.

The result is compelling: investment is three times less compared to the conventional vehicle design and the cost price has been reduced by half compared to a vehicle like the Dacia Sandero in the entry range.

At present, the Kwid has found its market in India (120,000 vehicles sold from 2015 to 2016). It has since been exported from India to South Africa, Sri Lanka and Brazil.

Box 1.7. *The Kwid: Renault–Nissan's reverse innovation (source: Midler* et al. *[MID 17])*

In the example of the Kwid, the R&D know-how from markets other than those of the manufacturer's country of origin (in this case, India) were taken into account, regardless of the innovation practices of the head office and with a global perspective furthermore. This program has also been analyzed as being "symbolic of a return to a transnational model" – like that of the 1990s – as described above [DOZ 12].

1.3. R&D strategies tested overseas: the example of China

As a country where the considerable pace of economic development for more than 20 years has provided significant growth for Western companies, analyzing the R&D strategies that they have developed in China offers a key to additional insight into the challenges that internationalization poses to Western companies. The comparative approach between French and German enterprises in their setting-up strategy in China shows how they are forced to profoundly review their strategy of R&D.

1.3.1. *Western companies' choice to locate their R&D in China*[2]

Initiated in the mid-2000s, the establishment of R&D centers in western China illustrates the shift in R&D strategies around the world and the tensions they create.

Foreign direct investment (FDI) from Western countries has flowed massively into China over the past 20 years. The massive migration of technology and know-how to Chinese companies that are largely controlled by

2 This part is based on a study of French and German companies in China [BOU 11].

the state (which was key to the setting up of Western enterprises) has contributed to "upgrading" the Chinese economy, which has reached a level of technology that allows it to find its own place in the community of groundbreaking scientific nations.

The case of Western companies who have chosen to set up R&D activity in China illustrates the mutations at work and shows their very significant impact on the management of the R&D and expertise there.

1.3.1.1. *Innovation and technology transfer: a different approach to globalization*

Since the end of the 1990s, China has moved gradually away from its image as "the world's first workshop" to establish itself as a power in the area of innovation and research. According to the OECD, Chinese expenditure in R&D increased from 0.6% to 1.98% between 1995 and 2012 (in percentage of GDP), while the number of researchers increased by 77% over the same period. China is far from being behind or inferior to the West in terms of techniques (as we often naively imagine). It has therefore become, according to some observers, an "R&D nation" for foreign economies, which are no longer reluctant to set up their poles of competitive clusters there. For the record, Europe and the United States dedicated 2.07% and 2.79% of their GDP, respectively, in 2012, to R&D expenses.

In the area of R&D, the case analysis of Western enterprises, both French and German, who have a local presence shows that the objectives of setting up in China are not limited to a quest for cost reduction. It is about creating qualified teams for research activities. For this reason, the number of publications, patents and students in China has significantly increased in recent years. It is necessary to be located in growing markets, where new consumer practices are likely to emerge. Finally, it is also useful to take advantage of the "outside critic", who is offset and potentially innovative, which could be provided by a research team working on the other side of the planet. The sectors that invest in the R&D clusters in China are mainly the high-tech ones (telecoms, automotive equipment, transport and energy, etc.). A study conducted by Allouche *et al.* [ALL 08] showed how setting up the R&D activities of companies such as Orange and Schneider Electric was an effective strategy in their approach to innovation. Nevertheless, for most European companies, the strategy has instead been up until now to keep the latest technological developments so as not to surrender them when setting

up in China. In fact, in the areas that could be considered as strategic for the Chinese economy (aeronautics, defense, railway transport, etc.), the dominant model for Western enterprises was to transfer the most "underrated" technology to China in order to control innovation and advances in research and development. This strategy has long been preferred by companies such as Alstom, particularly in the 2000s, which, after having established an engineering team in the field of transport in China, quickly removed it due to the fear of providing Chinese teams with the mastery of the new technology developed in the field of rail transport and transport signals: the enterprise's R&D policy was that there should be no center for R&D in China that would work on the core business, a strategic choice that was deeply rooted in the company culture until July 2010. When the transfer was necessary, rules were applied to the developed products for the protection of intellectual property. These were very specific for each party in the joint venture. At the same time, German and Canadian manufacturers Siemens and Bombardier, which have adopted the opposite strategy, that is, the acceptance of R&D technology transfer to the Chinese, gained an enviable position on the Chinese market.

In the field of agri-food, other strategies in the area of R&D could be identified; this is the case of companies like Lesaffre, for which the question of the technology transfer is no longer the real question.

Lesaffre, the world's number one producer of baker's yeast, is a family business originating in the north of France. It has 48 plants in 19 countries with a turnover of 1.2 billion in 2010. It employs 7,000 people. The group, established in China for several years, put in place a very proactive strategy as early as 2008, aimed at becoming the leader on this market and put in place a platform for global export. The group considers that China, which now only represents 5% of its turnover, will constitute with the Asia Pacific 25% of activity before the end of the decade. In fact, for Lesaffre, the question of accepting or rejecting technology transfer no longer exists.

According to its president in China, Lesaffre is already in the second stage of innovation development and technological transfer.

Although fundamental research (which is working to identify new strains of yeast for the whole group) remains in Marcq-en-Baroeul (France), the company has quickly grasped the need to develop in China in order to understand customer needs in closer local markets by engaging commercial and technical teams (with regard to nutrition, the 27 Chinese regions are like different markets). These teams help the company to continue to differentiate itself

from its competitors, to develop and push its industrialization know-how and its quality standards while respecting global standards. Lesaffre goes even further: the managers of this medium-sized enterprise are, on account of its turnover figures (MSC), convinced that by being present in China, where there is a decent-sized competitor (Angel), the company also has access to specific knowledge which, combined with its own assets, serves as a technological advantage. This is all the greater because this company, as we have seen, is in close contact with the local environment.

Box 1.8. *The R&D strategy of a medium-sized enterprise: Lesaffre bakery*

Setting up an R&D center in China is not just about technical capacity. This strategy must also consider cultural and human capital dimensions. Like the entities developed by Chinese employees in this context, R&D centers "off-shored" by Western companies are often neglected.

The analyses conducted in several of these R&D centers [LEB 12] reveal a profound gap between the innovation vision of head office and the Chinese vision, which is manifested by a lack of understanding. Therefore, Chinese researchers and engineers at an Orange center for research and technology monitoring complained about the lack of follow-up given to their projects and innovation proposals. The Chinese business models do not have the same conditions for success as the business models in Europe, and it is more difficult for them to convince and to argue with their head office the merits of a research or development project.

In addition, the favored organization of work practices that are based on matrix teams in which the different stakeholders of a project are separated by great distances complicates even more the business processes or even slows down the decision-making process. This is another discrepancy between the understanding of the authority of the parent company/head office and the understanding of the authority in China. For many Chinese designers, research and innovation have become common in Chinese companies and are needed as a free local practice of Western know-how. The Chinese five-year plans 2006–2010 and 2011–2015 for science and technology and innovation development are in this respect an important investment aimed at lifting China to the rank of technological nation.

In German enterprises, the position with regard to technology transfer differs significantly from that of French enterprises. Despite the very real risk of illegal transfers, Germany has relied on a relatively early scientific and technological cooperation with China, embodied by the signing, in 1978, of a bilateral government agreement. The following year, China and Germany decided to discuss the German standardization (DIN): the diplomatic business trips of technical specialists and economic representatives increases significantly, such that over time, many of the standards of the German model have been adopted in China. A new method of cooperation on projects is put in place, followed soon after by an institutional cooperation that leads to the creation of centers of bi-national research in 2004 and 2005. The Federal Ministry of Education and Research worked in partnership with the Chinese Ministry of Science and Technology as well as with the Chinese Ministry of Education.

In addition to intergovernmental scientific collaboration, German private not-for-profit research organizations developed a direct cooperation with their Chinese partners; therefore, the Sino-German Center for the promotion of research (Deutsch-Chinesisches Zentrum für Wissenschaftsförderung) managed jointly by the German Research Foundation (Deutsche Forschungsgemeinschaft, GFR) and the National Natural Science Foundation of China came into being in Beijing. The Fraunhofer Institutes have furthermore opened two research centers in partnership with the High Technology Research and Development Center of the University of Astronautics and Aeronautics in Peking: the Sino-German Joint Software Institute (JSI) in Peking and the Sino-German Mobile Communication Institute (MCI) in Berlin. The Max Planck Institute created in turn, in 2005, a Center for Computational Biology in Shanghai, in collaboration with the Chinese Academy of Sciences. The Leibniz Community have been working since 2004 on setting up a network linking its own institutes, the research institutes in China and its industrial partners, in order to be able to separate, distinguish and test biologically active substances coming from plants from traditional Chinese medicine. Finally, the Helmholtz centers work in cooperation with an extended network of major Chinese institutions, especially in matters of the environment, health and energy.

At present, many German companies view China as a market of strategic importance. According to these companies, the evolution of the European economy will depend on the success of positioning in this market, among other elements. This is particularly true in light of the very rapid

technological progress made by China, which results from a proper innovation effort or a technology transfer taking place. The presence of German companies on the Chinese market is therefore crucial to preserving German and European competitiveness as well as to developing joint standards.

Consequently, for the German companies, technology transfer should not be a "problem" because "the only risk that can threaten the competitiveness and innovation of the German economy lies in a possible shortfall in the domestic innovation and research policies. The fact that China launched a set of programs to rise to the rank of technological nation then became widely known. However, evaluations of their true progress differ. For Germany, this can only be an incentive to preserve their competitive advantage and our capacity for innovation on two levels: due to the proactive attitude of the businesses involved and through the creation of a supportive political environment by the state. However, under no circumstances can Germany rest on its laurels – "the competition never sleeps" [STÄ 10].

Therefore, we can see that European, French or German companies planned the transfer of Western technology with a great deal of delicacy: ensuring, for example, the fragmentation of know-how in the organization and processes, including the management of IT, knowing how to identify the main risk sources and always keeping control of key skills.

1.4. Conclusion

The mutual effects of intensive innovation and globalization allowed new players to enter the scene of world competition, which in turn created new challenges for businesses.

Pushed to develop their activities outside of their historical markets, Western companies have also been led to internationalize their R&D activity. Analysis of their practices in this regard shows that their R&D strategy depends significantly on the exposed or unexposed nature of their competitive positioning.

If the majority of R&D strategies align with the need for rapid innovation expansion, then there are several factors that must be considered in order to analyze the differences in the practices of the enterprises studied. First, it is the major role of innovation that leads some to develop global products for

profiting on very large markets like telecommunications and mobile phones, while others try to grasp the value created by innovation in emerging markets. The growing importance of the client, already present in other business activities like marketing, quality control and sales, is now also present in R&D, where it becomes an integral part of the innovation process with a logic of co-design or collaborative design. Finally, there are practices of localization of R&D in BRICS, for example, to take advantage of the newly emerged "technological nations".

The example of China and its attractiveness for enterprises in the sphere of R&D management reflects the tension between the need to capture knowledge and talent in this new high-tech champion nation and the desire to protect the innovation capital that has been accumulated.