Third generation R&D and strategies for knowledge management

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Abstract *The structures of R&D have evolved towards a bigger articulation between the development of the technological potentialities and exploitation of commercial opportunities. The third generation R&D supplies a more rational frame of action to reconcile several objectives which can turn out contradictory: dedicate enough resources to create new technologies, develop a wallet of industrial and academic co-operation to accelerate the acquisition of new knowledge. The strategies of high-tech firms succeed to create a great variety of knowledge. It is necessary to organize the diversity of the internal and external sources to use knowledge fully as a true competitive advantage. We show how the memory must be constituted of the firm to reach that point. From a study on several cases of MNC we characterize the difficulties of the capitalization of the knowledge, and then we present how the firms can take advantage of an active management of knowledge flows.*

Keywords *Innovation, Knowledge management, Research, Social networks*

Introduction

As the structures of R&D are transformed to become more effective in innovation, they introduce new problems of organization. One of the major problems lies in the management of the knowledge. The creation of knowledge is carried out through technological co-operation (Inkpen, 1996). It is necessary to know how to absorb and diffuse knowledge within the various departments of R&D (Kogut and Zander, 1993). The internal circulation of knowledge represents another strategic stake, all the more extreme since a firm internationalizes its R&D activities. Particular organizational competencies are necessary to assume the proper functioning of the various activities (Duyster and Hagedoorn, 1996). The third generation R&D (Roussel *et al.*, 1991) provides a particularly interesting example of development of these competencies. This paper suggests examining the question from the study of several cases of knowledge management strategy implemented by IT, telecommunications and pharmaceutical firms. We studied over a period of two years the establishment of procedures of knowledge management within multinationals which adopted an organization in the network of their R&D activities (25 firms on the whole).

Section 1 analyzes the challenge of the management of the variety of knowledge. Section 2 examines the expanding of diversity in R&D activities. We explain why third generation R&D is not only a solution but also a problem of co-ordination to diffuse knowledge. Section 3 argues that diversity encourages the introduction of knowledge management tools. The precision of these tools indicates the firm's competence in managing and diffusing knowledge.

1. The challenge of knowledge management

1.1. Innovation and diversity of resources

In organizing their R&D activities, multinational groups actively seek out a diversity of resources. This diversity applies to the modes of product design, technology construction and client relations. It applies both at a multinational level (the main thrust of multinational strategy being to incorporate diversity rather than endure it) and in local establishments: a single R&D unit usually draws on a number of different sources of knowledge (technological alliances, collaboration with universities and engineering schools).

What are the various dimensions of this diversity? Several major examples can be given:

- **Diversity as a product of the technological globalization.** In all the firms studied, the control of R&D is organized internationally. Most firms have turned their subsidiaries into specialist units, following a decision-making process based on an assessment of local technological advantages. The movement towards specialization involves giving a particular site responsibility for the development of one or more technologies. This allocation of responsibilities has proceeded over the last decade against the background of the drive to rationalize operations. Consequently, there are fairly pronounced differences in most firms between the individual sites in terms of their relationship to R&D work, mobility within the company, attitudes to evaluation and the definition of research activities, on the one hand, and development activities, on the other. This explains the desire of corporate managers to put in place procedures intended to establish stable points of reference for the whole group.
- **The necessary diversity within R&D projects.** Project-based organization involves bringing together several professional specialities and competencies in order to work towards the same goal. How can a diverse set of R&D employees be mobilized to achieve the same objective ? Although diversity may be necessary, it nevertheless needs to be controlled. The preparation for a project is highly significant. It is subject to a standard validation process that applies to all the subsidiaries in a multinational group. As part of this process, the autonomous actors in the subsidiaries are called on to justify their intentions and the means to be deployed in giving concrete form to those intentions within the framework of a very explicit monitoring program that is activated prior to and during the project. In this way, interaction between the different professionals is encouraged in order to ensure that proposals link the needs that emerge from knowledge of clients with the resources created from the production of scientific and technical knowledge. The encouragement must be all the greater since the actors are urged to interact on the basis of very different relations to time and risk. Marketing professionals consider short-term risk in terms of the image they have of users, regard the duration of a project as a time frame imposed on them and expect their colleagues to provide solutions that are ready for use. For technology professionals, risk is an inherent part of exploration and of the unfolding of the project; from this point of view, it constitutes a variable linked to the competencies of the researchers and engineers who make up the project team.
- **The diversity as context of academic collaboration.** Whether they are dealing with human resource management or strategies for collaboration with academia, multinationals must link diverse sets of practices in the areas of employment management and knowledge absorption. Academic collaboration is viewed in two highly complementary ways. First, it represents a reliable means of recruitment that is recognized by all firms. Collaboration also exists, of course, for the purpose of carrying out joint research activities. The importance of recruiting engineers and researchers is reflected in a lengthy period of preparation and the measures taken to ensure beyond doubt that the right candidates are selected. The aim is to enter into a collaborative venture with an academic partner around a research or development project. For the vast majority of the firms, this aspect of collaboration is structured around Ph.D. students. These opportunities go hand in hand with actions located further upstream, which involve establishing partnerships with a view to influencing curriculum design. Paying considerable attention to the mix of academic and national profiles, firms select their academic partners with a view to participating in the joint development of graduate training.

1.2. Structures better suited to technological globalization

Multinationals are globalizing their technology strategies by seeking once again to extend their asset base while at the same time developing their contractual activities. Despite this, there is little long-term mobility between the various R&D sites or between the various countries in which the multinationals operate. Nevertheless, such mobility could help to bring about a certain convergence of practices in the various locations. What tends to happen, rather, is that functional managers, whose task it is to relay central management policy, spend short periods of time at the various sites. In fact, the structures of R&D activities have gone through several phases of development over the past 20 years, which explains why the current structures combine a market-driven approach with networking practices.

- In the first phase, which took place during the 1980s, firms devolved their centralized R&D activities to the business units. Prior to this, multinationals had been globalizing their activities while retaining the bulk of their R&D operations in the parent company's territory. R&D was organized centrally to achieve economies of scale in the context of industrial strategies defined on the basis of the technologies in the companies' possession. Thus, a central laboratory was charged with the task of developing these technologies by shouldering most of responsibility for co-ordinating the various co-operative ventures with other firms and academia. The inadequate understanding of commercial constraints within the system was put forward in justification of the decentralization of R&D resources to operational units charged with the task of developing product policy in a more focused way, driven by marketing considerations and the technological possibilities. R&D groups were established as a result of this desire to control technology policy through the market. This brought the actors involved in the design of new products closer together, with spectacular results in terms of reducing lead times. However, this specification of resources also contributed to the increased diversity within firms.
- In the second phase, which took place during the 1990s, this strategy appeared to drift somewhat. In some cases, the business units' decision-making autonomy now turned into technological independence from the multinational group. Various problems emerged. Since each R&D unit was being urged to meet the needs of its commercial controller, it was very difficult for it to justify its own independent exploratory and collaborative activities. On the other hand, none of the units had much opportunity to co-ordinate its activities with those of the others. Finally, there were certain inadequacies in the accumulation and diffusion of knowledge. To exert greater control over the diversity of results produced by innovation projects, the management redefined the centralization of R&D. Since it was impossible to return to the previous situation, it was decided to put in place network-type organizational structures. And so ''corporate labs'' began to be set up, reflecting the need to separate short to medium-term activities from long-term activities and, in particular, to put in place knowledge accumulation systems. Although it is the task of these laboratories to centralize knowledge and to diffuse it to those units that express a need for it, they do not operate like the former central laboratories. Their physical and human resources are divided up among several subsidiaries and they are required to operate as part of a network. This second phase equates to the third-generation R&D (Roussel *et al.*, 1991; Reger and Von Wichert-Nick, 1997).

In more or less formal ways, firms have adopted this organizational principle, which consists of separating long-term exploratory activities from development activities. Diversity is organized on these same two levels. The functions associated with the strategic development of technologies are concentrated on the first level, where responsibility for major academic collaborations and the dissemination of knowledge within the firm also lies. The second level draws on the first but

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is more closely linked to the market dynamic. However, this new organizational structure is subject to co-ordination problems. The cases that best illustrate these difficulties are those of firms that have become highly specialized in service-based products (see Table I).

1.3. The problem of technology transfer

The aim of technology transfer is to consolidate innovation capacities. The purpose of transfer is to establish continuity in the linkage between the internal and external levels of knowledge management. This continuity is subject to certain tensions that can explain the success or failure of technology transfer (Lambert, 1993). Among the points most frequently identified, a distinction needs to be made between strategic dimensions and organizational dimensions (the links between the two being self-evident).

- The ability of the firm, and particularly of its senior managers, to develop clear ideas in two areas: future technological opportunities, commercial opportunities and customer preferences.
- The role of organizational mechanisms designed to support the various stages of the innovation process. The match between the degree of centralization and organization in the organization and the type of technological problem and knowledge at issue seems to be a major factor in determining the effectiveness of the transfer process (there seems to be a strong need to develop ''mutual adjustments'' within and between teams, and a no less important need to identify a number of opportunities to accumulate experience) (see Table II).

2. Managing diversity: build good competence

2.1. Knowledge and competence

The firm is an institution that acquires new knowledge and also creates knowledge over the course of its history. This knowledge is conceived as a resource that can be drawn on in the course of innovation projects. It is part of the firm's assets and has to be protected and used in accordance with the activities in which the firm engages. Knowledge can be defined as a stock that is the object of regular inventories to identify the potential for innovation. In this case, we are dealing more with declaratory knowledge, which exists independently of the actions likely to

Table I The separation of research and development: the difficulties of co-operation
A is a firm with more than 20,000 employees created out of the merger of several companies. In the mid-1990s, it changed its R&D structures by dividing up its R&D activities into smaller elements and devolving more power to the business units. The aim was to shift the company's operations towards telecommunications services, the design of corporate IT systems and the integration of communication systems. These activities represent short-term development projects of undoubted profitability that management thought could be structured by recombining existing knowledge. The company used to have a fairly powerful corporate R&D function that maintained highly structured links with university IT departments. This function found itself downgraded until management became aware of the need to supply business units with technological knowledge. The two areas of R&D activity were then redefined as follows. A central R&D function was set up to take charge of learning processes based on the recovery and re-use of existing technologies. It forges technological alliances and collaborates with university departments with the aim of absorbing knowledge that is no longer being developed internally because of the strong focus on the ''service'' component of products. Finally, it seeks to diffuse useful knowledge to business units. The latter are responsible for product development and design and also engage in service activities; they have, on the one hand, to take account of the needs of their professional clients and, on the other, to take the initiative in selecting their own collaborative ventures outside the firm. However, difficulties have been experienced in coordinating the activities of these two areas of R&D activity. The knowledge developed at each of the two levels is not of the same kind, and the two sets of actors do not really succeed in initiating discussion of common problems. The business units' customer orientation and the academic collaborations of the central laboratory cannot be combined seamlessly to advance the company's technological development. To get over these difficulties, a system has just been set up that is intended to help engineers to establish their professional reference points (''professional communities''); it consists of identifying individuals' needs in this respect (in terms of professional activity and co-operation) and suggesting training programs likely to strengthen professional links.

Table II The wholesale externalization of research

B is a company that has externalized most of its R&D activities. In this sense, it constitutes an extreme case in the organization of knowledge absorption. The company used to be a manufacturer of mainframe computer systems but has now diversified into services linked to the new communication technologies. Its R&D activities have been divided up: exploration of the potential of information technology has been entrusted to large public research laboratories, while the design of products incorporating these technologies has been allocated to the company's various R&D departments. The absorption of new knowledge is guided by the needs of the business units, which identify the products of the future likely to be relevant to the company. Links with academic research laboratories are structured through an economic interest grouping, the terms of which are negotiated for a five-year period. A steering committee on which both parties are represented decides on the launch of new research projects, while an operational department is responsible for project management. Internal project co-ordination is the responsibility of experienced researchers employed by the company who divide their time between the two organizations. They have the task of translating the needs for new products into exploratory projects and of exploiting the commercial possibilities of new concepts developed independently by public-sector researchers. The transfer of knowledge from the laboratories to the firm has proved to be somewhat awkward in practice because of a certain incompatibility between the firm's traditional bureaucratic mode of organization and the laboratory's ''open knowledge'' approach. Nevertheless, the collaborative links between the two partners have created a space for exchanges that enables company staff to be in continuous contact with students (lectures given at the university, supervision of industrial placements and doctoral theses) and to be part of a scientific network described by the researchers as ''virtual friends in computing''.

bring it into play, than with procedural knowledge, which is incorporated into the action. This distinction calls for further clarification of the links between knowledge and competence. We are in fact dealing with a circularity that merits further explanation:

- The further knowledge acquired by a firm's employees, the recruitment of new employees, the acquisition of a new company or even a merger may create the conditions for a gradual transformation of competencies of the members of the organization and, through a process of diffusion, those of the firm as a whole.
- The acquisition and absorption of new knowledge requires specific investment as well as competencies in coordinating with the external environment, in other words competencies in assimilating new experiences.

There are indeed several types of competencies, some individual, others collective, that play a more or less decisive role in structuring scientific and technological knowledge. Professional know-how links these forms of knowledge with procedural forms of knowledge. Firms develop competencies in organizing these various forms of know-how in order to identify knowledge and commit it to memory. They also develop competencies in co-ordination in order to diffuse that knowledge within its various departments and subsidiaries. Finally, a competence in collaboration is required in order to extract maximum benefit from the partners' resources. Any collaboration is in fact the object of a multiplicity of decisions taken by the partners, who have to decide on the forms the collaboration is to take and negotiate the terms of the transactions. We are dealing with a circular process in which firms are seeking the knowledge they judge to be necessary and for which they have to equip themselves with certain capacities for acquisition and synthesis.

These competencies in the development of new activities are defined as specific, tacit, intangible, accumulated over time, durable and scarce, and therefore difficult to imitate (Prahalad and Hamel, 1990; Barney, 1991). It is interesting to link the various levels of

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competence by showing that there are systems within firms that combine aspects of knowledge management with aspects of human resource management. These systems are devised and implemented in a ‘‘multi-level’’ way: within firms, between firms and their academic and technological partners and globally in the case of the various sites operated by multinationals.

2.2. Tools dedicated to the identification of R&D competencies

Consolidating the circulation of knowledge within R&D units, creating synergies between the various professional groups and making the individual units’ capabilities more transparent are major preoccupations for firms unable to exploit very high levels of staff mobility.

To manage these recruitment policies, and more generally to develop employment policy, firms have set up, for the most part fairly recently, human resource departments dealing specifically with R&D personnel. In some cases, ‘‘corporate’’ functions have been set up to bring recruitment and collaboration with universities (partnerships, joint training programs) under one umbrella. Charged with managing the careers of R&D personnel, the task of these departments ultimately is to support a part of a firm’s knowledge management system. Their efforts are directed towards reducing the differences in personnel management between the various subsidiaries (particularly in matters of remuneration), developing tools for evaluating competencies and harmonizing the portfolio of internal and external training programs, which developed in a fairly piecemeal fashion during the 1980s.

From this point of view, the management of competencies is a major element of human resource management. It takes concrete form in:

- The compiling of documents listing the competencies employees possess, with attempts being made to match these competencies to jobs deemed essential (job chart) in the innovation chain. These documents are management tools that make it easier for managers to create the picture of their organization they are trying hard to achieve. They provide a basis for making comparisons between the various units and help to some extent to produce common reference points for R&D jobs.
- Annual or bi-annual evaluations of individual competencies, often using the 360° method, in which an employee is evaluated by several people in his or her sphere of activity. The evaluation of R&D employees is carried out in different ways in different locations. While it seems to be common practice in English-speaking world, it has been introduced with a certain degree of caution in R&D departments operating in Germany and France. Nevertheless, American multinationals have succeeded in establishing this particular management practice in these countries without encountering any obstacles (see Table III).

Table III Tools for managing the internal market in competencies

C is in the process of refocusing its activities on the telecommunications business. One of its divisions has 4,500 employees, 57 percent of whom are senior and middle managers (75 percent of them are graduates of engineering schools, while 25 percent are university graduates who have done postgraduate work). The average age of these managers is 40 at one of the sites and 50 at another. The basic unit for R&D activities is the project. This mode of organization gives rise to a middle management problem: it is difficult to find employees who are sufficiently young but who have acquired a certain level of experience, particularly to fill project manager posts or simply to fit into a team in an operational capacity. Since average pay levels in the telecommunications labor market have shot up rapidly, C can expand its recruitment program only modestly if it is to keep its wages bill under control. Because of a certain degree of inertia in its internal labor market, the company has strengthened its management of competencies by seeking to establish a stricter correspondence between employees’ career paths and their actual competencies and by facilitating internal mobility between the established units and recently acquired companies. The human resources department has developed an expert system for the management of competencies and careers based on competence mapping: identification of basic competencies, classification into ‘‘families’’ and evaluation of personal competencies by means of individual assessments. A transitional matrix linking jobs and employees and jobs to jobs has been developed with a view to responding to future needs.

2.3. Networking practices

The co-ordination of the actors is a major element in successful innovation. Several different coordination situations can be identified: those that develop in the course of projects, those that make possible the linkage with external partners and those that occur during less constrained periods of activity, when projects are not running, which can be very useful for the accumulation of knowledge. From this point of view, the networks of relations that develop within R&D units and associated functions are accorded the same attention as the networks that develop out of academic collaboration. The general objective is to improve the flow of information within the R&D function. To this end, the availability of resources is promoted, i.e. those preparing a project are encouraged to consolidate their knowledge base. In more dynamic terms, it is a question of accumulating knowledge, not necessarily in a centralized location but rather by diffusing it to the units most directly concerned, because of the nature of their remit, with the nature of the technology or academic contact. The need in matrix organizational structures to strike a balance between the project-based approach to management and one based on technical functions makes itself felt very often in firms, as does the need to bring different professional profiles together. It is in this way that knowledge management seeks to be transnational. Nevertheless, firms' networking practices are also strongly contextualized. Such practices are always based on the individual involvement of researchers and engineers who feel the need to stabilize their cognitive environment. And even at local level, academic collaborations are constructed within networks whose form depends both on the institutional possibilities and on the visions of the various individuals in positions of responsibility.

These networking practices can be divided into two groups that do not obey the same rules with regard to the circulation of knowledge:

(1) essentially bureaucratic networks that seek primarily to codify knowledge and are geared to the identification of information; and

(2) networks that synthesize the initiatives accumulated over time.

The first often takes the form of knowledge management tools such as technical databases. These databases synthesize accumulated experience in the areas of product design, patents, design procedures and software and technical tests. In these various forms, knowledge is codified to quite a high degree, which makes it more worthwhile accumulating it centrally and diffusing it to the various units. The other, less codified forms, such as those relating to project management practices, are not yet being examined as frequently or on such a widespread basis, despite real concerns in this area. Nevertheless, there are signs that attempts are being made to combine the most objective data with feedback from experience. The limitations of such an exercise are similar to those of project-based management: for lack not only of time but also of a properly defined collaborative space, knowledge is not being accumulated as extensively as it might be (see Table IV).

Table IV The internal codification of knowledge
D is a large multinational that has expanded vigorously over the last two decades through its policy of exogenous growth. It has its origins in the chemical industry, but has reoriented its investment towards the life sciences. Long established in Europe, it set up in the USA for commercial and, above all, technological reasons. Control of its R&D activities recently shifted to a center in America, where the various procedures for launching and monetary projects are laid down in detail. In each of the subsidiaries, a project manager is responsible for applying these procedures and disseminating the results obtained at each of the evaluation phases to his colleagues in the other subsidiaries. These results are gathered together in an electronic document compiled at central level in the USA and made available to the various directors. This centralization makes it possible both to compare the efficiency of each project in terms of deadlines, cost and technical reliability and to identify the new knowledge produced within the company and to disseminate it to potential users. The nature of the knowledge circulating within the company tends to be codified, even though details of the experiments also figure in the documents.

The second type of network tends to be structured more around the behavior of R&D personnel. In their various ways, these networks are intended to create professional interactions to complement those that develop in the course of projects. It is important to support innovation projects with procedures that make it possible to capitalize on feedback from experience, to accumulate knowledge and to identify not only the needs for technical training but also employees' expectations in terms of the direction of technology strategy. The originality of these procedures lies in the fact that they are based on networking practices that are independent of hierarchical organizations. These practices respond to the needs of the various professionals for reference points: presentation of findings, advancement of scientific and technical knowledge, clarification and diffusion of views on R&D activity. In some firms, these exchanges take place within technical communities that bring together researchers and engineers with a reputation for professional expertise. They operate by co-opting individuals who have both achieved recognition for their work within the company and acquired a scientific and technical reputation in the outside world. The community meets at least once a year at a conference and its members are in permanent contact with each other, exchanging the fruits of their research. Within the firm, central management consults its community in order to draw up long-term technology development programs. In the shorter-term, members of the community are regularly consulted by project managers, either for their technical expertise or to facilitate access to the knowledge and competencies of individual employees. It is thanks to the experts who make up these very communities that their company's technological memory is kept alive.

Drawing on these principles of autonomous organization, corporate management pays particular attention to any form of consultation that can help to concentrate the identification of information needs and to diffuse the benefits of experience on a large scale (i.e. throughout the multinational). Since the end of the 1990s, arrangements of the technological forum type have developed in this way (see Table V).

As far as knowledge management is concerned, the principal finding is of a patchwork of different practices. The business units base their knowledge management on their understanding and interpretation of the market. This process is brought into play by corporate managers who are greatly concerned with the quality of internal dialogue, particularly between researchers and business units. Under these conditions, networking practices sometimes have certain shortcomings when it comes to the identification of competencies.

2.4. The management of competencies

The processes by which resources such as internal networks are mobilized can provide support for the structural rationalization programs implemented by multinationals. However, a firm can never be sure that these networks produce more homogeneity than diversity when it comes to the circulation of knowledge. The resources committed to these networks are a response to local initiatives rather than to the needs of transnational structuring. The management of knowledge is a particularly revealing example of this.

Table V The circulation of experience and the building up of professional competencies
E is divided into divisions on the basis of technological competencies. The number and scale of projects make the circulation of knowledge within divisions problematic. An intranet tool displaying the technical information in use in the various divisions has been in place since the 1990s. However, this tool is not considered adequate for the task of balancing individual initiative and team spirit in order to produce innovations driven by the needs of users of IT equipment. Several arrangements have been put in place in each business unit to promote the circulation of knowledge and of associated experiences. These arrangements include workshops and forums at which proposals for technological innovations and reports on experience are presented. The proposals that are adopted receive support by being promoted among members of the business unit. The dissemination of the knowledge underpinning each proposal is intended not solely to launch an innovation project but also to strengthen the cohesion of each unit's internal network. One of the strategic objectives of the company's human resource department is to extend this dissemination of knowledge as part of its program to develop each division's competencies.

The validation of technical competencies has emerged as a multi-dimensional issue. It is, of course, a more individualized means of personnel management. However, it is also an opportunity to evaluate the effects of exercises in the circulation of knowledge, such as technology transfers, between the partners in collaborative ventures. Moreover, the inherent limitations of the apparatus of evaluation notwithstanding, the management of competencies can be a way of identifying the potential that exists within an internal network. Two observations should be made:

(1) not all firms equip themselves with the means to identify in such a direct way the knowledge accumulated through individual competencies; and

(2) competencies tend to be evaluated not so much by multinationals themselves but rather by individual R&D units, which feel a need to formalize the knowledge in the possession of their work-forces.

Despite the fairly widespread existence of competence management policies within the R&D function, few firms manage to set up expert committees (made up of human resource, R&D and project managers) responsible for recognizing cognitive gains. These committees examine the files of candidates for promotion up a technical career ladder. The files are analyzed from several points of view and candidates are questioned on their aptitudes and sources of knowledge. While the outcome for candidates is a prospect of promotion, for the committees the procedure constitutes a space in which experience can be compared and a record of technological management maintained (see Table VI).

Implemented in this way, the management of competencies is not the sole responsibility of the human resources function but is also undertaken within an evaluation space divided between the projects and the various areas of technological expertise. Most firms have not sought to implement this type of competence identification procedures, perhaps because they can in fact become a new source of diversity. Multinationals already have to deal with the question of differentiation when introducing knowledge management systems. The identification of various forms of technical expertise gives rise to a different kind of diversity in terms of where the responsibility for evaluation lies. Allocating responsibility to different individuals can lead to

Table VI A body of technology consultants engaged in identifying expertise

F is a pioneer in the internal circulation of knowledge. Until the end of the 1980s, management limited its engineers' attendance at academic conferences to protect its stock of knowledge, which was reckoned to be far in advance of that in academia. The company's technical community is made up of 300 members working in several different subsidiaries. It is divided into spheres of technological competence in order to establish points of reference for each sphere and to ensure that they are diffused within the various divisions (information bulletins, internal seminars). The following criteria are used to select members: technical excellence (patents, publications), profile in the outside world (particularly in academia), ability to forge links with the socio-economic sphere (technological alliances, governments) and their ''vision'' of technological and commercial trends. The members of the community are consulted as a matter of course when innovation projects are being selected. They are also involved in the committees set up to evaluate staff competencies; six has developed a number of processes for the management of technical competencies (recurrent training programs, quarterly assessment interviews, internal social barometer in the subsidiaries, problem-solving and experience-swapping groups) by means of which knowledge can be accumulated. Over time, these processes have fostered a very strong attachment among the workforce to a certain technological image of the company.

The question of technology diffusion lies at the heart of this firm's development; for this reason, particular attention is paid to the evaluation of the transfers that take place following a collaborative venture. There are procedures for identifying technical expertise at a European level across all the subsidiaries. Candidates for promotion compile dossiers detailing their experience. Each dossier is examined by a committee of experts drawn from several of the company's subsidiaries. This is a competence management device that imparts a certain dynamism to employees' careers. It also enables R&D managers to record employees' level of knowledge, to identify internal and external diffusion networks and to maintain a record of technological management that extends beyond the management of each unit.

confusion between the various areas of responsibility and in the long term to an increase in diversity at a time when management is trying to control it.

Part of this increased diversity is due to the existence of innovation projects, although a not inconsiderable share is explained by the needs of knowledge management. When project teams are being constituted, and when they are carrying out their assignments, it is the technical managers and general management who assess the aptitudes of the various employees. At the point of recruitment, and over the course of individuals' careers, competencies are evaluated by the human resources department. Finally, in the course of collaborative ventures with academic researchers and interactions within internal networks, the competencies of existing and possible future employees are assessed by other functional managers, and these assessments have some influence on decision-making. This whole evaluation chain has many discontinuities that have not yet been brought under control by the management of multinationals. These discontinuities stem from the object of evaluation (which changes with the function of the evaluator) and from the purpose of the evaluation (evaluations can be carried out for employment management purposes in order to determine pay, as well as to encourage creativity from the point of view of innovation management).

3. Conclusions

The processes of knowledge and individual competence management constitute a potentially rich source of innovation for firms that is not completely contained within the structures of R&D organization. Controlling these processes requires the architectural competencies that currently constitute a challenge for multinationals.

Through its structures and processes, the management of knowledge represents an attempt not only to take advantage of opportunities but also to resolve organizational problems. Knowledge is recognized as being a competitive issue as well as an organizational issue. The low level of mobility between subsidiaries and between research laboratories and business units does not aid the circulation of knowledge. Finally, the introduction of project-based management makes it possible to organize R&D activities more efficiently while at the same time reducing the opportunities for knowledge accumulation. The practices put in place in order to overcome these difficulties show that several different paths can be taken. At the same time, they illustrate the changes firms are undergoing as technological globalization advances.

In other respects, there is much to be gained by analyzing the production of knowledge against the background of organizational dynamics. In doing so, we have revealed the procedural and incremental nature of knowledge-related processes in the organization of R&D activities and, more broadly, at multinational level. We have also determined the extent to which the management of competencies influences this structuring of organization, indicating in passing the prospects for joint investigation of the various management methods. From this point of view, the study of the management of knowledge and competencies puts third-generation R&D into context. Relations with higher education and research establishments are in fact part of the decision-making systems of multinationals operating in a multidimensional environment. We have illustrated their immersion in this environment by examining their attempts to control diversity. We have also shown that these attempts give rise both to solutions and to new organizational problems. It would seem that we are dealing with a necessary dynamic and a venture that has to be embarked upon by firms aspiring to play a global role in the construction of technological capabilities.

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