
Innovation Processes, Innovation Capabilities and Knowledge Management

Knowledge management can be defined as a set of processes, principles and techniques leading to the creation, organization, distribution, use and exploitation of the enterprise's knowledge [LOP 11, PAL 09]. The knowledge management processes frequently discussed in the specialized literature are the generation, the transfer and the use of knowledge. Coombs and Hull [COO 98] suggest adding the processes of identification, capture, modification, validation, contextualization and knowledge closure, in order to enrich the traditional vision of knowledge management, deeply rooted in the practices of information management. In a broader sense, knowledge management depends on organizational practices that consist of articulating knowledge processes with knowledge domains, performance fields, and formalized and operational action models [COO 98]. The aim is to offer the firm the means for efficiently exploiting its intangible assets, but equally to access information and knowledge useful for its development.

Despite significant theoretical advances, the influence of knowledge management on the innovation capability of the firm is still unevenly understood by managers. The latter are relatively ignorant of practices and operational techniques that enable the exploitation of tangible and, mostly, intangible resources in view of developing the firm's potential for innovation. The effects of knowledge management on the capability for innovation and the performance of firms have not been studied in a systematic way by researchers. What does the literature teach us about the relation between knowledge management, innovation and the performance of firms? The following section addresses the theoretical and empirical pertinence of this relationship.

1.1. Does knowledge management improve the performance of innovating enterprises?

More and more analysts, managers and researchers are envisioning that the performance of firms depends on their ability to efficiently manage their intellectual resources, and informational and knowledge assets [RAN 06]. Noruzy *et al.* [NOR 13], for example, show how knowledge management positively influences organizational innovation and, consequently, the performance of firms. In their study, the authors suggest that the capability of leaders to transform the systems of norms, rules, values and shared beliefs of a firm has a positive impact on organizational innovation through the moderating role played by organizational learning and knowledge management.

More generally, authors who deal with the question of performance defend the hypothesis that knowledge management has a direct positive impact on the innovation capability, and, indirectly, on the performance of firms. In their research papers, innovation is either considered as a moderating variable between knowledge management and performance, or as the main variable. The questions they deal with are as follows: How can knowledge management favor organizational performance? Does it have a direct impact on performance, or an indirect impact thanks to the improvement of the innovative potential of firms? Answering these questions supposes understanding how the activities of firms as a matter of knowledge management influence their capability for innovation.

1.1.1. Does empirical research confirm the existence of a connection between knowledge management and the performance of innovative enterprises?

For about the last 10 years, numerous scientific studies have proposed “testing” the empirical validity of the hypothesis of a direct or indirect relation between knowledge management strategies, innovation and the performance of firms [YAN 10, LAI 14, CAN 11].

Lopez-Nicolas *et al.* [LOP 11], for example, develop an econometric study dealing with a panel of 310 Spanish enterprises. Considering that the direct impact of knowledge management on performance depends on the type of strategy implemented by the firm, the authors divide the concept of performance into three dimensions: financial, processes and internal. In this

context, the authors propose examining the existence of a direct relation between the personalization and codification strategies, on the one hand, and the performance dimensions, on the other hand [LOP 11]. They then study the indirect effects of each strategy on the performance of firms, by exploring their impact on their innovation capabilities. The results of their econometric study confirm the existence of a positive direct relationship between the implementation of a knowledge management strategy, the increase in the innovation capability and the performance of enterprises. More precisely, the results suggest that the personalization and codification strategies have an equivalent positive impact on innovation: there are no differences in nature or type regarding the impact of the knowledge management strategy deployed by the firm on innovation [LOP 11]. Nevertheless, a detailed analysis of results shows that knowledge management strategies have a relatively higher impact on financial performance than on process and internal performance dimensions. Finally, the indirect effect of knowledge management strategies on the performance of firms via an increase in their innovation capability is empirically validated.

This result is confirmed by Yang [YAN 10]. This author also studies the variables susceptible of moderating the relation between knowledge management strategies and the strategic performance of firms. The author particularly explores the mediating role of the following variables: 1) the incentive and reward system (H1a), 2) process innovation (H1b), as well as the firm's competencies in matter of 3) the integration of previous knowledge cumulated on preceding projects (H2a), 4) the market intelligence (H2b) and 5) the sharing of knowledge between organizations (H2c) [YAN 10, p. 218]. From a panel of 500 high-technology Chinese firms, the author tests the empirical validity of the aforementioned hypotheses. The results obtained confirm the existence of a positive relation between the variables and the performance of firms [YAN 10, p. 220].

Exploring the role of collaboration in matter of knowledge management, Cantner *et al.* [CAN 11] also study the influence of knowledge management processes on innovation and the performance of firms. The authors pay attention to the knowledge processes guided by demand, whose aim is to favor the sharing and the creation of knowledge. In this framework, the authors consider that the management of knowledge has a different impact on the performance of firms depending on the type of innovation that they develop. Three types are thus distinguished: incremental innovation, radical

innovation and process innovation. The hypothesis formulated by the authors then concerns the existence of a positive relation between the display of a collaborative knowledge management strategy and the three types of innovation mentioned earlier (hypothesis named H1, H2 and H3). Building on an econometric study dealing with a panel of 1335 German enterprises, Cantner *et al.* [CAN 11] reveal, on the one hand, that the management of knowledge improves the success of firms in terms of product innovation and, on the other hand, that its influence differs according to the type of innovation (incremental or radical). Finally, the collaborative management of knowledge rests without effect on process innovation.

These papers clearly show that a positive relationship exists between knowledge management, innovation and the performance of firms. If we want to improve our understanding of how knowledge management technique practices and processes improve the performance of innovative firms, it is necessary to go beyond econometrics. What about the impact of knowledge management on the innovation projects carried by the firms? What is the real influence of the “contextual” variable on knowledge management and innovation?

1.1.2. Beyond the enterprise: knowledge management, innovative territories and innovation projects

In the academic literature, the firm is not always the unit of analysis of the relation between knowledge management and innovation. Researchers have studied the role of knowledge management in relation to project management, or to the innovation dynamics of a territory. In this way, considering an industrial cluster in Taiwan, Lai *et al.* [LAI 14] study the moderating role of knowledge management in performance, not of individual firms but of an industrial cluster. In this study, the authors underline the positive role of clusters in terms of information circulation and knowledge sharing among a great diversity of public and private stakeholders [LAI 14]. The sharing and knowledge exchange processes are here essential to innovation within clusters. In practice, the operational performance of the firm in terms of knowledge management and, by extension, of innovation is positively influenced by the collective dynamics boosted by the industrial cluster. It is the institutional and industrial localized context (the cluster) that favors the creation and sharing of knowledge, the two central processes in terms of knowledge management at the service of

innovation. This result is confirmed by Silvestre *et al.* [SIL 14] in the case of industrial clusters localized in developing countries. The authors point out that the innovation capabilities of firms belonging to the mineral cluster (Granite) of the region of Padua (Brazil) are strongly constrained by the clusters' properties in terms of knowledge management. Indeed, the cluster is characterized by a weak entrepreneurial culture associated with the absence of expertise and training connected to the firm's activities, a high level of informality in the relationships between individuals, and the relative weakness of communication and knowledge sharing within the cluster and beyond, toward other industries [SIL 14]. Enlarging the perspective, the papers dealing with the localized systems of production [ASH 05, ASH 07] have shown how the properties of the institutional, industrial, technological and regulatory context, in which the interactions between actors operate, play a moderating role in the relation between the management of knowledge and the performance of innovative firms. The works of Moore [MOO 93, MOO 96, MOO 06] about business ecosystems have also highlighted the importance of knowledge processes in the development of innovative business ecosystems [ATT 16].

The theoretical framework of knowledge management has been equally mobilized by researchers specialized in the study of innovative project management [TOD 15]. Indeed, project management is therein perceived as a collaborative activity involving the combination of different processes, sources and types of knowledge enabling the organization to create value. The management of an interorganizational innovation project then requires the mobilization of knowledge processes such as combination, coordination or socialization, in complement with the generation and integration of knowledge. In this context, the knowledge management practices implemented by the actors engaged in a project have a direct influence on the performance of the project itself [REI 14]. Each step of the development of a project is marked by one or many knowledge processes. The authors refer, for example, to the process of knowledge creation to characterize the cognitive activities performed during the conceptualization phase of the project. This uncertain and dynamic – even ambiguous – phase features activities of the so-called knowledge generation performed ahead of the project [AKB 14]. In the same vein, other authors have highlighted the role of knowledge integration processes during the upstream phases of the project [YAN 05]. If the generation of knowledge is important, it is also essential to integrate knowledge because of its dispersed character, on the one hand, and the radical uncertainty that characterizes innovative projects, on the other

hand [AHE 14a, AHE 14b]. It appears that the generation and integration of knowledge procedures are jointly mobilized during the same phase of the innovation process; thus, the alignment of knowledge processes mobilized during their different phases becomes essential to the performance of the project [REI 14].

From this perspective, the absorptive capability¹ [COH 90] of the firm has a direct impact on its aptitude to efficiently manage innovative projects [ESC 09]. Here, the integration of the flux of external knowledge and the cumulative development of internal knowledge [ALE 11] require the mastery of specific competencies on behalf of the firm. Gallego *et al.* [GAL 13] thus suggest that the firm's absorptive capability depends on the intensity of its R&D activities, the latter conditioning its aptitude to cooperate. However, firms cannot depend only on their internal resources to develop cooperative relationships, at the risk of reducing their innovative potential [GAL 13]. The will to open themselves and to interact with external agents, particularly those belonging to the scientific community, thus plays a crucial role in the performance of firms in terms of innovation (see Box 1.1).

Siemens, a German multinational firm specialized in electrical, electronic, automatic and digital technologies, has developed an environment that favors the establishment of innovative partnerships according to a model inspired by the Open Innovation paradigm. The department of R&D of the group (called *Corporate Technology*) develops collaborative relations with a variety of research actors (university and research labs) and firms (*start-ups*) with the aim of inventing and commercializing new goods, services and technologies susceptible of generating value. The support infrastructure for innovative firms (start-up) relies on three entities. The *Technology-to-Business* (TTB) centers of Berkeley, Munich and Shanghai offer to the young external innovative firms outside the Siemens group a whole of resources and expertise in view of sustaining, from the initial phases of their projects, the invention of rupture technologies with strong commercial potential. The purpose for Siemens is to access promising technologies externally developed in view of preparing their internal exploitation. In parallel, the TTB accompanies the creation of internal *start-ups* within the Siemens group with the aim of testing the commercial potential of innovative technologies that do not necessarily belong to its inherent savoir-faire. The *Siemens Novel Businesses* (SNB) constitute the second pillar. Their role consists of favoring the articulation of the

¹ See Chapter 2 for the definition.

invention phase with the commercialization phase. The SNB finance the testing and experimentation phases of new business models encouraged by innovative technologies, before their progressive integration in the form of *Business Units* of the group. The *Siemens Technology Accelerator*, the third pillar of the innovation strategy of the group, has the mission of commercializing the technologies developed and/or supported by Siemens whose business models feature the activity domains in which the enterprise is little active. The cooperation with universities and the research community completes the preceding methods by inscribing the innovation strategy of the group in the long run. The *Centers of Knowledge Exchange* (CKE) have thus been placed in Berkeley, Georgia Tech, *Technical University* (TU) of Berlin, DTU Copenhagen, TU de Munich, FAU Erlangen-Nuremberg and Tsinghua (Chinese University). Each CKE benefits from the financial support of the firm which in return takes part in the piloting of research activities, recruiting of researchers and the distribution and exchange of knowledge.

Box 1.1. The strategy of open innovation at Siemens

1.2. Innovation capability and knowledge management

Innovation requires the mastery of a capability to conceive new ideas, to organize their integration into new products or services, to coordinate the actors and the resources taking part in the development of innovative products or services and to commercialize them, extract revenues from them and generate value for the innovation stakeholders [BAR 14b]. This innovation capability is a dynamic capability [TEE 07] as its aim is to transform the resources available and accessible to the organization, as well as to renovate and enlarge their potential for creating value. The dynamic capacities of the firm are then essential to innovation: they guide the renewal of resources by combining different learning modes (i.e. exploration, exploitation, interaction, experimentation) and transform knowledge into firms' competencies, therefore providing them with a competitive advantage. In addition, dynamic capacities are divided into aptitudes, abilities and elementary competencies related to the accomplishment of knowledge-intensive tasks and activities (i.e. generation, integration, absorption, codification, diffusion, sharing and application of knowledge). Finally, the development of dynamic capacities is influenced by the firm's knowledge management practices and, at the same time, the implementation of knowledge management practices is, by itself, a dynamic capability. In other words, the innovation capability of the firm is a dynamic capability.

1.2.1. The decomposition of innovation: invention and commercialization

“To innovate, is easy. The difficulty is to transform an innovation into real business”. This quotation from Michael Dell (founder of the eponymous enterprise Dell Inc.), in January 2005 before an assembly composed of French CEOs, suggests that it is not enough to invent something new in order to innovate. Still, it is important to be capable of valuing it. Innovation can thus be divided into distinct phases, articulated in time (see Figure 1.1). Economists distinguish two phases: invention and commercialization of the innovation. Together, these two phases define innovation as a process.

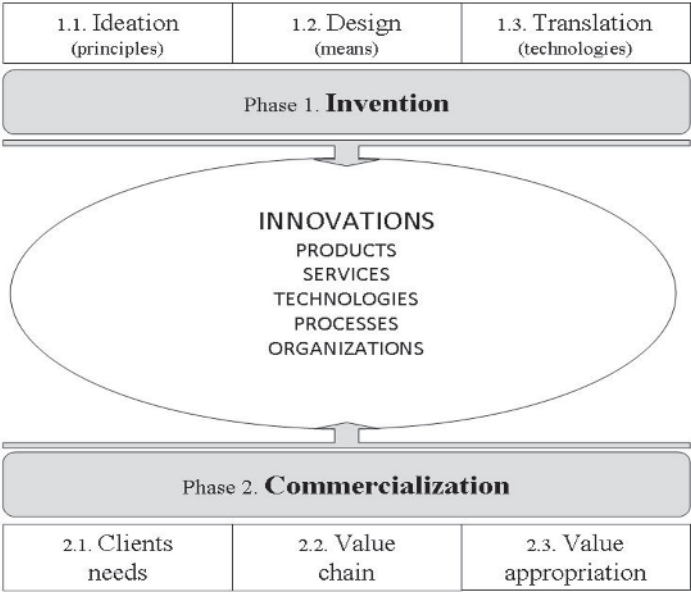


Figure 1.1. *Innovation typology and partitioning of the innovation process*

According to Arthur [ART 05], the invention phase can itself be divided into three stages:

- 1) Ideation of a basic principle;
- 2) Conception of the means to satisfy a need;
- 3) Translation of the basic principle into operational technology.

The departure point of the invention phase is the identification of an economic opportunity generated by the application of one (or various) basic principle(s) in connection with a real or potential need [ART 07]. The economic opportunity can equally result from a scientific and technical discovery [BAR 14a] related to industrial and commercial real, latent or potential applications. This recognition phase and/or construction of a business opportunity is later accompanied by the search for the means to satisfy the constraints that weigh over its performance and to solve the problems that this elicits. Arthur indicates that it is a question of conceiving a way (“a route”; Arthur [ART 07, p. 279]) to connect the solutions and the constraints with the basic principle(s). Then comes what the author calls a “*moment of connection, because it connects a problem with a principle – an effect in use – that can handle it*” [ART 07, p. 280]. For the principle thus conceived to become an invention, it must be translated into a functional technology. This last step of the invention phase consists of taking a “*mental concept to physical embodiment (...) Solutions that were conceptual must be produced in physical form, and sub-problems that were partially bypassed must be dealt with directly*” [ART 07, p. 281]. This translation engages a basic principle development period during which knowledge is cumulated and technological challenges are progressively handled until a functional technology is produced (Box 1.2).

With the intensification of the Cold War during the fifties, the financing of the research activities in the domain of information and communication technologies (i.e. computers, networks, and satellites) became a priority of the American government. The *U.S. Advanced Research Project Agency* (ARPA) was thus created in 1958 by the American Defense Department in order to pilot the projects it financed and to maintain the technological superiority of the U.S. Armed Forces in terms of communication, command and control. One of the most accomplished achievements of the ARPA agency concerns the development of the first distributed communication network: ARPANET. In the mid-sixties, computer science was not yet a mature academic discipline, the number of computers was very limited and the research community was still embryonic. At the end of 1966, Lawrence Roberts (former researcher at MIT) rejoined the ARPA to develop the communication network project of the agency. He published his “plan” for the ARPANET on a memorandum with the title “Multiple Computer Networks and Intercomputer Communication” which he introduced at the ACM (*Association for Computing Machinery*) conference of Gatlinburg in October 1967. In the same year, a research group was reunited by Lawrence Roberts to discuss the specifications of the future

network. This group called itself the *Network Working Group* (NWG). The initial aim of the NWG was to promote informal discussions between researchers, with the aim of exploring intuitions, suggestions or critics susceptible of facilitating the development and exploitation of the network. Based on the values of openness and critical thinking, the group encouraged the participation of users and developers in the tasks of formulation and resolution of problems, and the sharing of good practices. The working notes of NWG started to circulate to the participants from April 1969 onwards. Their edition gave birth to the principal reference in terms of ARPANET documentation called the “*Request for Comments*” (RFC). ARPANET was above all a research project with a purpose to prove experimentally the pertinence of communication and resource sharing theories between geographically dispersed computers. In this context of experimentation and validation of concepts, the task division and the attribution of responsibilities between the diverse participants of the project depended on their respective competencies in their expertise domains. The hierarchy of problems determined, in fact, the nature of the relations between the actors. By chance, the scientific and technical expertise indispensable to the deployment of the experimental network was known by the ARPA agency since the majority of the researchers composing the NWG had previously worked for the U.S. government. However, it was a R&D enterprise, Bolt Beranek and Newmann (BBN), which was chosen for developing the interfaces. The interfaces were critical components of the network because they allowed distinct host sites to communicate via a simple telephone line. In August 1969, seven months after having won the bidding competition, BBN achieved the development of IMP (*Interface Message Processor*) interfaces. In September 1969, a first communication protocol “host-interface” (Host-IMP) was jointly defined by the researchers of the university of California (UCLA) and BBN. UCLA then received the first IMP interface and became the first node of what would constitute the “ARPANET” network. A month later, the university of Stanford (*Stanford Research Institute*, SRI) was selected to become the second node of the network in charge of collecting and putting online the data relative to its functioning. These data came directly from interfaces IMP and from the *Network Measurement Center* (NMC) situated in UCLA. Two supplementary sites were later chosen to complete the architecture of the experimental network: the University of Santa Barbara (UCSB) and the University of Utah (UCU). In the first years of the ARPANET project, the knowledge required in order to access and use the network was disseminated and shared informally between the users. With the increasing number of computers communicating via the network, the problems associated with protocols became more complex and required a standardizing effort and a codification of knowledge. It was more and more indispensable to define generic standards in order to reduce

the access costs to the network to a minimum. The *Network Working Group* (NWG) was precisely in charge of specifying the protocol techniques and of codifying *host-to-host* communication standards in view of facilitating the diffusion and the adoption of the network. The generation and codification of knowledge had a major impact on the evolution of the project. In June and July 1984, John Reynolds and Jon Postel cosigned the RFC 901 and 902 notes which established the protocols and conventions facilitating the transition of the ARPANET to the INTERNET. The drafting of the RFC notes was pursued for a long time after the *Network Control Protocol* (NCP) standards became *Transmission Control Protocol/Internet Protocol* (TCP/IP) standards throughout the eighties. The RFC documentation is still used within the computer science community.

Box 1.2. *The invention of the Internet: a collaborative research project supported by an open community of knowledge management [BAR 14a]*

The second phase of the innovation process merely concerns the definition of a value appropriation regime. The purpose of this phase consists of selecting and then combining the distribution channels of innovation, including the customers' needs, the value chain of innovation, the partner network implied in the exploitation of innovation, and choosing a juridical regime for the protection of the intellectual property and the allocation of appropriation rights issued from the commercialization of innovation [TEE 86]. This decomposition of the innovation process calls for a reflection on the nature of the tasks and activities that the organizations perform in order to innovate. The invention and commercialization phases indeed mobilize different knowledge types and processes and require specific aptitudes, competencies and capabilities.

1.2.2. Innovation activities and aptitudes

According to Romijn *et al.* [ROM 02], the innovation capability of the firm results from a set of organizational aptitudes enabling them to create new technologies by absorption and recombination of existing and available resources. Wang and Ahmed [WAN 07], on their behalf, distinguish three components of the firm's innovation capability. The first component concerns the identification and the capitalization of market opportunities (adaptation component). The second component involves the recognition of the value creation potential of external resources, the assimilation of these

resources and their application to commercial ends (absorption component). The third component specifically concerns the development of products or new markets (innovation component). Burgelman *et al.* [BUR 04] particularly suggest that the innovation capability can be divided into design competence (i.e. anticipation, planning and allocation) and realization competence (i.e. organization and commercialization). Innovation then requires the ability to conceive a new product or a new technology responding to a need or a new demand (conception capability; Ulrich [ULR 95]), but equally to know how to deploy the most efficient organizational form in view of developing and commercially exploiting the invention [SAN 96]. Here, the increasing complexity of technological innovations supposes mobilizing and integrating a variety of internal and external knowledge [COH 90], the latter being possessed by a large number of participants in the innovative process [BAL 11]. Moreover, the innovative enterprise must at each stage of the process obtain the financing adapted to the maturity level of the new technology, product or service that it is developing before its exploitation [GOM 01]. Finally, the firms must find ways of making profit from the innovative investment by choosing the most efficient appropriation regime in view of commercially exploiting the innovation [TEE 07].

Each of these design activities (of product and of organization), financing, collaboration between the parties, knowledge integration or profit appropriation resulting from the innovation depend on distinct organizational aptitudes (see Table 1.1). These can be implemented by an individual entrepreneur, a firm or a set of organizations that collaborate to innovate [BAR 14b]. In this view, the innovation process necessarily appears to be organized, piloted and coordinated by a firm (or a group of firms), or an individual behaving as an entrepreneur and an innovator. For Hatchuel *et al.* [HAT 09, p. 161], *“every innovation demands a collective action and an organized environment that at least provides the competences, the social artifacts and the necessary resources”*. As a consequence, these organizational capacities evolve jointly with the economic, technological and social mutations which affect the internal and external environment of firms. The competencies, artifacts and resources that enable innovation today are not the same as those which were available for the large commercial firms of the beginning of the 20th Century. Chandler [CHA 62] has shown how the exploitation of diversification strategies by the great industrial enterprises at that time (i.e. DuPont, Ford, General Motors) had led them to develop a multi-divisional organizational model in which the R&D activities were routinized and the innovation strategies were based on two pillars: the

optimization of their internal innovation capability and the adoption of a closed regime of value appropriation [BAR 14b]. This organizational and innovation model has long corresponded to the challenges posed by the standardized mass production of goods and services. However, for about the last 20 years, this model has been less and less efficient, especially because of the changes that have taken place in the internal and external environment of the firms. The opening of national markets to competition, the multiplication of knowledge sources, especially external, the diversification of financing sources for innovation and the rising mobility of the qualified work force [CHE 03] have modified the practices and the strategies developed by the firms to manage their knowledge, to nurture their learning processes and (consequently) to innovate.

Organizational aptitudes	Definition	References
Product design	To design an architecture product/system responding to a new need	Ulrich [ULR 95]
Organization design	To deploy an organizational and industrial form adapted to the architecture of a new product, service or technology	Sanchez and Mahoney [SAN 96]
Integration, absorption and combination of knowledge	To absorb and integrate, by combination, the diverse know-how relative to the invention and commercialization of a new product, technology or service	Cohen and Levinthal [COH 90]
Collaboration	To mobilize and coordinate the variety of organizations taking part in the process of innovation. This corresponds to the capability of firms to develop innovation in a collaborative environment, sometimes open and reticular	Baldwin and von Hippel [BAL 11]
Financing	To mobilize the resources (i.e. private investors, banks, public financing) necessary to the financing of the different phases of development and innovation	Gompers and Lerner [GOM 01]
Appropriation	To choose/define a juridical framework favorable to the protection of innovation and the appropriation of profits issued from its commercial exploitation	Teece [TEE 07]

Table 1.1. Examples of organizational aptitudes associated with the innovation capability [BAR 14b]

In an open and knowledge-intensive global environment, the innovation capability of a firm depends on a combination of organizational aptitudes whose acquisition, maintenance and development depend both on internal and external factors. Internally, the quality of its human resources and the learning and experimentation processes it mobilizes for its R&D activities, but equally for its production activities, are determining factors. Externally, the innovation capability depends more and more on the quality of interactions that the firm entertains with its partners, including customers, suppliers, public agencies and universities. These interactions allow it to access a variety of external resources complementary to its internal resources (i.e. information, knowledge about technology and marketing, and human resources) and which appear essential to innovation. The firms thus implement open and collaborative innovation management strategies, requiring new capabilities for detecting and integrating external and internal knowledge, and creating value from them (Box 1.3).

The project *One Semi-Automated Forces (OneSAF) Objective Systems* (OOS) was launched in 1996 by the US Army. It is an innovation project in the field of simulation and modeling techniques used for education and training. The aim of the OOS project is threefold. The idea is to (1) improve acquisition cycles for simulation and modeling software, (2) to touch an enlarged community of users and (3) to obtain greater flexibility in terms of combination and integration of software applications and scenarios. The project manager designated by the *Deputy Commanding General* (DCG) is the *Army Program Executive Office for Simulation, Training, and Instrumentation* (PEO STI). The aim of the project manager (PEO STI) is to use the internally and externally available resources by linking military users of the OOS system to the extended community of developers and users of simulation and modeling software. Before that the US Army entrusted the contract to a supplier, a group comprising government representatives was constituted in view of formalizing the technical needs of the final users. An integrated team (*The Architecture-Integrated Product team*, A-IPT) was then engaged. This team, comprising the project manager (Army), a small group of civil and military *lead users*, a governmental *Think tank* (MITRE) and a research and technology enterprise (R&T, Alion), bound themselves straightaway to codify the concepts and the initial architecture of the project. Four key concepts were thus formalized. The first concerns the necessary opening of the usage domains, in connection with the diversification of the profiles of users of the OOS. The second involve the flexibility of the architecture of the OOS product. The third concerns the diversification of integrated technical systems. The last is related to the management of access rights

and the modification of the source code between the civil and military stakeholders. The management of these four concepts of the OOS project needed the deployment of four categories of competence, each being associated with some essential dimensions of the project: technical competences, governance capabilities, and values and regulations individually and collectively aligned. Together, these competences formed the building blocks of the innovation capability mobilized by the members of the OOS integrated project team.

Box 1.3. *The OOS project of the US Army [BAR 09]*

1.2.3. Dynamic capability and knowledge processes

The capability of firms to integrate and combine internal and external resources was defined by Teece *et al.* [TEE 97] as a dynamic capability. The dynamic capability thus indicates a transformation process of firms' assets and competencies into products, services or technologies, generating value for the users or consumers [WAN 07].

The concept of dynamic capability depends more specifically on the distinction between the operational competences of the firm, considered as first-order competencies, and the capacity to transform its operational competencies, considered as a second-order competence [ELL 09]. Danneels [DAN 08] equally regards that the difference between operational competencies and dynamic capabilities depends on the distinction between operational and transformational routines. According to Wang and Ahmed [WAN 07, p. 39], the transformational competence depends on four knowledge processes. These processes aim at the integration, reconfiguration, renovation and recreation of tangible and intangible resources and of first-order competencies, particularly in the technological (i.e. production technology, information and communication technology) and commercial (i.e. understanding and anticipation of preferences and needs of users or consumers) domains. In the same vein, Verona and Ravasi [VER 03] recognize that the dynamic capabilities of the firm are fundamentally anchored in its processes of knowledge creation, absorption, integration and reconfiguration.

The dynamic capability of the firm thus enables it to develop new aptitudes to perform certain tasks and to satisfy new markets. In this sense, it is similar to a process of organizational learning, which aims at building new operational routines and competencies. From this perspective, Zollo and

Winter [ZOL 02] consider that the dynamic capabilities as well as the operational routines of firms are the result of different learning processes. The dynamic capabilities result from deliberately reflective learning processes, involving the verbalization and the codification of collective (largely tacit) knowledge. The operational routines are the fruit of a learning process resulting from the accumulation of experience under situations of repeated tasks. The authors then propose to represent the development of dynamic capabilities throughout a knowledge evolution cycle consisting of four phases:

1) The generation of new knowledge, essentially tacit, by combination of internal as well as external knowledge and information, and by reformulation of existing problems.

2) The selection of the generated knowledge through the evaluation of their potential to transform existing tangible and intangible assets, as well as their degree of legitimacy with regard to the existing norms, values, rules and routines.

3) The diffusion of knowledge by replication to all the units that constitute the firm. The diffusion is equivalent to a test period susceptible of producing useful information in view of evaluating the performance of new knowledge in different contexts from those that prevailed during the variation-selection phases.

4) The retention (i.e. the capitalization) of knowledge indicates the phase of transformation of new knowledge into operational routines corresponding to structures of stable behaviors that enable the firm to respond to a variety of internal and external stimuli [ZOL 02, pp. 343–344].

We understand along with Zollo and Winter [ZOL 02] that knowledge management processes and the dynamic capabilities are “*intimately connected*” (“*closely intertwined*”; [CEP 07, p. 427]) since the development of dynamic capabilities demands, in fact, the accumulation, the codification and the sharing of knowledge.

Building on the works of Jensen *et al.* [JEN 07], Herstad *et al.* [HER 15] arrive at a similar conclusion, demonstrating that the development of firms’ dynamic capabilities depends on two types of learning processes. The first type is based on the codification of knowledge relative to the resolution of local problems according to a scientific and experimental method. This learning process is associated with a specific mode of innovation

called “*science–technology–innovation*” (STI) by Jensen *et al.* [JEN 07, p. 682]. This mode depends on a learning procedure by experimentation implying expert individuals who combine tacit knowledge by making them explicit, thus facilitating their communication, their disembodiment and their generalization under the form of invention patents [JEN 07, p. 683]. The second type of learning engages individuals in a process of accumulation of experiential knowledge in and by action and interaction. This type of learning is associated with an innovation mode called “*doing–using–interacting*” (DUI) by Jensen *et al.* [JEN 07, p. 684]. Herstad *et al.* [HER 15, p. 139] indicate that in complex innovation projects, both modes coexist. Together, STI and DUI innovation modes allow us to understand how firms manage the variety of tacit and explicit knowledge mobilized in order to develop innovation (i.e. know-why, know-who, know-how, etc.).

1.2.4. Innovation capability as dynamic capability rooted in the management of knowledge

The dynamic capability and the innovation capability of the firm share a certain number of attributes associated with the way in which knowledge is produced and used by the firm. Indeed, if they are not similar to a sub-category of operational competences, the dynamic and innovation capabilities can be divided into sub-categories of organizational aptitudes dedicated to the management of a variety of knowledge types and processes.

Teece [TEE 07] thus consider that the dynamic capability of the firm comprises three types of aptitude:

- 1) To make sense of the threats and opportunities which are present in the environment (*sensing*).
- 2) To seize the business opportunities by deploying a strategy which identifies and articulates the required competencies in order to generate value (*seizing*).
- 3) To reconfigure the available tangible and intangible resources in order to sustain the dynamics of value creation (*reconfiguration*).

In this context, Teece [TEE 07] deems that the integration and combination of knowledge assets is a key competence (*core competence*), thus underlining the decisive role of knowledge management practices. From

this viewpoint, the dynamic capability of the firm depends on the combination of generative and interactive knowledge processes. Jyoti *et al.* [JYO 01] identify seven knowledge management processes that allow an impact on the development of the dynamic capability of firms. The seven processes that are frequently implemented by firms to manage knowledge are the sharing, formalization, creation, protection, conversion, use and acquisition of knowledge [JYO 01]. Gebauer *et al.* [GEB 12] particularly suggest that innovation depends on the firm's absorptive capability, the latter being influenced by the interaction between learning processes and the combination of knowledge.

This position implies that the knowledge management processes and the dynamic and innovation capabilities are closely intertwined [CEP 07]. Indeed, the creation and evolution of the firm's dynamic capabilities require the accumulation of experienced knowledge (e.g. by a personalization strategy) as well as the articulation of knowledge (e.g. according to a codification strategy). Calantone *et al.* [CAL 02] identify many factors that have an impact on organizational learning and, by extension, the innovation capability of the firm. The authors especially quote the engagement of individuals toward learning, their aptitude to share a common vision, their open spirit or their capacity to share knowledge [CAL 02]. These factors have a moderating effect on the innovation capability of the firm through the influence they exercise on organizational learning. It then appears that firms' dynamic and innovation capabilities depend on common processes of shared knowledge and learning. These processes underlie not only the transformation of firms' resources and competencies (dynamic capability), but also the invention and commercialization of new products, services and technologies (innovation capability). Michailova and Zhan [MIC 15, p. 576] evoke the notion of *dynamic knowledge capability* to indicate the double-generative and integrative character of firms' innovation capability, as well as the internal and external factors that influence its acquisition, its maintenance and its development.

In this work, we define the innovation capability as a dynamic capability. This innovation capability depends on the combination of operational competencies (i.e. routines, aptitudes and abilities) that the firm mobilizes in order to invent and commercialize new knowledge incorporated in new goods, services, technologies, procedures or organizations (Figure 1.2).

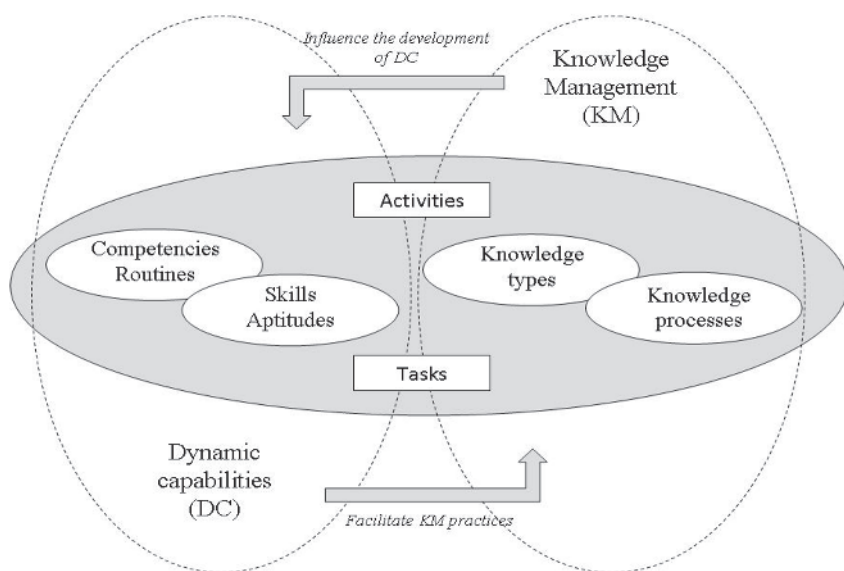


Figure 1.2. *Innovation dynamic capability and knowledge management*

The innovation capability of the firm derives from the management of knowledge types and processes supporting the achievement of tasks and activities relative to the diverse phases and stages of the innovation process. In turn, these management practices influence the development of the firm's operational competencies whose renewal and transformation is based on an organizational learning cycle.

In our opinion, this definition has many merits.

1) First, it allows us to avoid the semantic ambiguities between the concepts of dynamic capability, innovation capability and organizational learning. The innovation capability is, in fact, defined as a dynamic capability that derives from the combination of operational competencies relative to the management of various knowledge types and processes mobilized to innovate.

2) Second, it offers a framework that allows us to articulate knowledge types and knowledge management processes with the tasks and activities performed during the invention and commercialization phases.

3) Third, it enables us to represent the development, evolution and use of the firm's innovation capability as an organizational learning process anchored in the interactive and generative processes of knowledge management.

If we accept the idea that knowledge management processes determine the innovation capability of the firm, then the study of knowledge types and processes becomes necessary to understand how firms innovate. The second chapter of the book specifically explores the processes and types of knowledge mobilized by the firms to innovate, and identifies the knowledge management practices associated with them.