
Introduction: Why Do We Talk About Complexity in Management?

The subject of this work is the management of organizations in contexts that are characterized by *strong systemic complexity*. We wish to show that this type of management can nevertheless be creative in the sense that it necessarily evades linear thought. This way of thinking can be adapted for *complicated* problems, but not for *complex* ones. In the former, the application of causal reasoning and optimization methods enables us to arrive at the correct response for a properly asked question (even though this requires a great deal of calculations). In the latter case, it is an illusory wish to establish a precise and exhaustive model of reality and risks as we would be dealing with an emergent process, and we must be content with initiating the processes and performing experiments on both means and ends. The essence of life is in complexity, as shown by philosopher Edgar Morin – particularly in dialogue with economist and systemic specialist Jean-Louis Le Moigne (Le Moigne and Morin 1999). If an organization is to be considered living – i.e. evolving, dialectic, partially unpredictable and thus difficult to manage according to strategic planning formulas – then it requires exploring alternative management styles and thinking outside the box, hence the introduction of the concept of creativity. *The subject of management is living, thus creative, which obligates management to perform in a different way.*

Complexity and creativity are part of the research subjects that draw most of the attention towards economics and management fields. These two fields of research share numerous conceptual and methodological aspects. In both economics and management, complexity and creativity are also transdisciplinary vectors that require researchers and practitioners to revisit certain basic hypotheses and concepts.

Be it in economics and creativity management or in the application of the science of complexity, the number of academic publications, books, even special editions of entire journals in these fields, summer schools, or research centers has seen considerable growth in the last two decades.

Today, not only practitioners but also the political sphere and organizations (governmental and NGOs) often use the terms *economics of creativity* or *complexity management*. Recent developments in these fields of research as well as the synergies in their evolution within economics and management were the main motivating factors for writing this book, which presents recent issues in economics and management.

To tackle the issue of complex system management, we will draw our attention towards recent manifestations in the field of economics and creativity management. However, the present work does not warrant its contribution to the subject of creativity. The focus here is placed on the notion of the complex system. The aim is, in general, to cover a wide range of fields – as diverse as private or public organization set-up, formal or informal organizations, spanning from enterprises to urban systems. Our perspective towards this system will be similar to that of the organization's manager, attempting to provide decision-makers with theoretical representations and useful, concrete examples.

1.1. Examples of complex and/or innovative projects

Launching a start-up and managing an innovative project in an existing enterprise are tricky jobs that elude typical strategic planning

models. The description of the complex system in question is obviously not the same: managing an innovative project implies a detailed understanding of the company's system (the stakeholders in a very broad sense, namely the internal actors and regular partners) as well as its environment, whereas the creation of a start-up implies knowing how to anticipate what may be the future multi-actor system where it will establish its competence.

Another example is that of a *megaproject* such as designing and building a new nuclear center model or redeveloping an urban zone in a state of decline. In the former situation, there is a strong technological innovation dimension even though this is not the only uncertainty that must be managed and the only field of creativity to be involved. In the latter case, it is not a matter of technological innovation – or only marginally – but rather of an operation requiring a great deal of creativity in the most diverse domains, often an innovative way of thinking about how to articulate the collective project, and then its governance.

In the above-mentioned examples, the common feature concerning creativity is that it is not simply a matter of implementing a new idea with a certain functionality in mind (by rationally constructing the optimal response to the question asked), but rather steering a complex system towards a goal which is not completely defined at the onset. To do this, management organizes a multitude of competences and the organization uncovers a large part of the pertinent data along the way.

The literature on management science provides solutions on such issues in several ways. The most promising solution is the entrepreneurship theory developed by Saras Sarasvathy, who popularized the *effectuation* approach as opposed to ordinary causal reasoning in project management (Sarasvathy 2001). Matters pertaining to general (interdisciplinary) theories describing dynamic systems and self-organized processes are also taken into account. Jean-Louis Le Moigne, complex systems theoretician, is also one of the thinkers concerned with self-organization in management (Le Moigne 1994). In fact, following the works of I. Prigogine in chemistry, H. Atlan in biology, F. Varela in cognitive science, etc., Le Moigne has applied this concept to management. Stating a system is

complex implies it is self-organizing. With this attribute, it redefines itself over time and this creative faculty renders it unpredictable. This is the profound reason that connects complexity, uncertainty and creativity, and this is why the manager of such a system has difficulties steering with tools articulating causes and consequences in a linear way. We must break away from scientific thought, at least as much in management as in other fields.

The management of innovative projects and that of complex projects are altogether different subjects, but they correspond to similar processes. One of the goals of this work is to comment on this similarity by highlighting two reciprocal logical chains:

- all innovations, in order to be steered, imply the mastery of a complex system (it does not suffice to have a new idea to innovate);
- the management of complex projects is an innovative act by definition, as complexity never leads to repetitive situations (complexity compels us to be inventive).

In every situation, success depends on the ability to articulate multiple forms of creativity. The creativity of the scientist (science) or the engineer (technology problem solving) does not suffice to ensure the success of the resulting innovation: entrepreneurial know-how is also a must. Inversely, managing a project in a conventional sector though regulated by a complex system of actors and artifacts compels us to proceed by trial and error and to create as an inventor.

Muller *et al.* (2017) pose the question of knowing the manner innovation systems are considered complex systems. Evolutionary economics, of which innovation is the central subject, has, curiously enough, done little until now in regard to the characterization of innovation systems as complex systems – being classically described as networks of actors. A network is better understood as a complex system triggered when feedback loops are produced in connection to the relationship between actors and learning processes. Recognizing the attributes of complexity poses implications concerning governance. For these macroeconomic systems, this means coming up with innovation policies. Correspondingly, we will explore the consequences of complexity on enterprise governance in this work. As

for public policy, the design of European programs in the last decade based on the idea of smart specialization in regional strategy is an interesting example, leading to recommendations analogous to those that we will see at the microeconomic level: such as experimentation, the attention given to decentralized initiatives and the detection of weak signals (Héraud 2016).

1.2. Complex systems, rationality and knowledge

Although it is difficult to provide a precise and universal definition of a *complex system*, we will attempt to target the notion in this initial chapter. The common feature in all complex systems is their level of interconnectedness – the encompassing of a large number of elements, generally organized into multiple interlinked hierarchical levels like Russian nesting dolls – and the direct interactions between these levels. These systems can be adaptive and improved over time. However, it is difficult to steer them, for their structural richness creates self-organization phenomena, with many of the interconnections not visible. Because these phenomena are inevitable, it is better to take advantage of them rather than opposing them. The linear thought of project management *ab nihilo* is not applicable in such a context given that reality follows this pattern and thus cannot be manipulated using these methods.

1.2.1. Outlines of complexity and complex systems

Complexity comes from *complexus*, a Latin expression meaning “interwoven”. Complex thought studies the aspect which connects the subject to its context, in addition to the system, process or organization.

Le Moigne and Morin (1999) reiterate the three principles of rejecting complexity through classical science:

- 1) *the principle of universal determinism*, which says that intelligence is capable of knowing and predicting everything;

2) *the principle of reduction*, which involves becoming familiar with a composite whole through knowledge of its constituent elements;

3) *the principle of disjunction*, which assumes that a proposition can only lead to one single consequence.

For Bréchet (2012, pp. 257–274), complexity is born of recognizing the irreversibility of phenomena. An initial complexity approach (McKelvey 2012) is based on the triptych order/disorder/organization. Complex systems are dynamic systems characterized by a very large number of interactions and feedback. This interactivity renders phenomena that is difficult to describe, analyze and even more difficult to predict.

Edgar Morin distinguishes restricted complex systems from generalized complex systems. The latter, just like the former, are complex in their organization and behavior, but they produce complexity through their function. Generalized complex systems respond to three principles:

1) The principle of universal determinism against the principle of a dialogical relationship between order, disorder and organization.

2) The principle of reduction against the principle that connects the parts and the whole in a reciprocal relationship.

3) The principle of disjunction against the principle of maintaining the relationship between objects, notions, disciplines and knowledge.

Bréchet (2012) revisits the characteristics of complexity in Edgar Morin's sense with a reading key: the theory of organizations. Thus:

– complex systems are unstable, unpredictable systems. This attribute exists because they integrate circular causalities and interwoven processes, which makes them difficult to manage and control;

– a complex system does not respond to expression “the whole is greater than the sum of its parts”. Without being less, the “whole” is qualitatively different from the sum of its parts with its own strengths and weaknesses as compared to that of parts;

- a complex system is the circular (or parallel) manifestation of order, disorder and organization;
- complex systems regenerate and reorganize on their own. Their structure evolves as a function of the environment in a broad sense. Edgar Morin speaks of self-eco-organization, referring to the ecology of populations.

In the work “*La complexité: vertiges et promesses*” (Benkirane 2013), Michel Serres stigmatizes the word *complexity*. In his opinion, the word *complexity* includes too many situations and lacks precision. In order to bring about a proper analysis of so-called “complex” situations, it would be wise to replace this characterization with “there are a large number of objects and figures”. He then states that each science must correctly classify subjects and figures in order to rigorously select ones that must be analyzed, understood and solved.

For economic actors in general and enterprises in particular, complexity is tantamount to an inability to adequately predict and thus allocate resources. Complexity is commonly confused with uncertainty, risk, doubt, novelty, interactions, etc. Although it is the manager’s duty, at the end of the day, to handle every situation arising from different expressions, it is best to ascertain them as per their classification.

To respond to the challenges of a complex system, the manager must foresee action and knowledge strategies, i.e. he must anticipate learning and the acquisition of new information as and when the action is carried out. The manager in a complex system is necessarily an *ambidextrous* manager (as defined by Tushman and O’Reilly, see Barlatier and Dupouët (2016), for more information). He or she prepares scenarios and modifies them along with the appearance of unexpected elements (such as the reactions of competitors or exogenous economic shocks).

1.2.2. Information and learning

The uncertainty tied to the future and the complexity associated with it have been a source of surprise and perplexity for individuals

throughout the ages, but their reactions differ (Gollier 2004) and are often accompanied by the creation of new tools (e.g. the “options” for managing financial risks) or organizational mutations.

One of the problems in managing complexity is the difficulty in comprehending the connection between the analysis of the environment, the planning of enterprise strategies and managerial behaviors, and the infinite potential outcomes of managerial actions. In a standard SWOT analysis, the manager is no longer in a position, during state of complexity, to make the connection between resources and the perpetual opportunities that could be seized appropriately if they are put to proper use. The threats and weaknesses are typically perceived in a disproportionate way.

One of the characteristics of complexity is the absence of order and regularity. The resulting situation, with its seemingly random appearance, leads many managers to equip themselves with information systems – even decision-making systems – that enable them to reduce complexity (at least in appearance, and too often by oversimplification). Big data analysis techniques are nothing but the expression of this need addressed with the present technology. The need for information and recourse for adapting better performing tools to guide the decision-maker increases diversity between companies. A VSB, if it does not stem from the technology sector, will, by nature, be endowed with fewer resources and a more limited ability to collect and analyze information than a large enterprise. However, endless collection of information is not always a solution, as Vincent Desportes remarks (2004):

“In fact, the more information one has at his disposal and the longer the timespans needed to process them, the greater the risk is of improperly distinguishing the pertinent from the useless, the significant from the futile, or simply the true from the false. Certainty is much more a matter of understanding than data, yet the multiplication of data requires processing capacities that are adapted to the analysis needs in the useful timeframes. The current problem is less the lack of information than its overabundance; the difficulty lies in

processing and synthesizing on the part of decision-makers who are often nearly drowned in the overabundance of information. There is a dialectic of time and information”.

Faced with the need to steer the enterprise in this delicate situation, new tools have seen the light of day, oscillating between scenario methods and real options. These tools seek to integrate new information in order to exploit it robustly, while maintaining a certain plasticity, i.e. not reacting systematically when managerial information is presented.

As information becomes available, the possibilities to choose from increase. Although they are superimposed they are substituted by options that have already been chosen. The task of selecting and hierarchizing that must then take place typically stems from the manager. This is one of the characteristics of the double-loop learning model to allow these actions (Argyris and Schön 1995).

Research on the complexity of practice in enterprises is difficult to measure, and its impact even more so. Complexity develops in numerous fields (life sciences, computer science, mathematics, etc.); it is less present in management because a manager's discourse, such as an advertising slogan, must be reduced to a few words, and the idea must be simple! Yet complexity is a glutton for words and for the time it takes to explain itself.

In a dynamic and complex framework, learning is an overwhelming element, as pointed out by Mintzberg (2008, p. 240):

“We know that the dynamics of the context have repeatedly challenged every effort made to force the process to mold itself into the framework of a calendar of activities or a predetermined trajectory. Strategies inevitably have some emerging qualities, and even when they are largely deliberate, they appear less formally planned than informally visionary. Learning in the form of adjustments, beginnings, and discoveries arises from chance and the recognition of unexpected forms and it

inevitably plays a key role, if not the key role, in the development of all innovative strategies”.

As underlined by Naud (2007), Mintzberg’s reflections on complexity and strategy imply the notion of unpredictability. Mintzberg also states: “*As the innovative organization must continuously respond to a complex and unpredictable environment, it cannot be based on a deliberate strategy*”. Thus, in order to face complexity, an organization’s strategic behaviors are, first and foremost, a space for initiative. It is in this space in particular that *entrepreneurs* and *intrapreneurs* are distinguished. The spirit of initiative and entrepreneurship remains a major aptitude for facing the stakes of complexity (see Chapter 4).

There is also a particular *pathology* of such systems: coherence issues (limited rationality as defined by Herbert Simon and James March) and steering difficulties that cause large organizations or large projects to often appear irrational in their behavior. For example, *megaprojects* never respect the *iron triangle* budget-timeframe-specifications (Lehtonen *et al.* 2016). Everyone knows in advance, but they all act as if this were not the case. There is an inexplicable incoherence for those who have not understood what the logic specific to a complex project is: large, ambitious, multiple actors and spread out in time.

1.2.3. Rationality

For economic actors, complex environments impact behaviors and rationality, notably:

- in relation to time;
- in relation to space (issue of proximity);
- in terms of decision-making rules;
- in terms of organization (particularly in the pair structure-strategy).

1.2.3.1. *Complexity and the relationship to time*

Time can be interpreted in several ways in economics and management. From *just in time* to real-time data processing, acceleration is the watchword. However, time is a source of regulation, and it is regulated – from the creation of a shared worldwide measurement of time (Besanko *et al.* 2011, p. 112) to the notion of Internet time. Mastering time reduces overt complexity. This need to master time can be found in the prospective processes of economists, processes that are likely to contribute indications on the future. However, prospectivists' work does not fundamentally modify economic actors' relationship to time.

The evolutionary approach emphasizes “path dependency” (Nelson *et al.* 2018), i.e. the recognition of the past, the weight of history in economic activities and enterprise strategies (Barnett and Burgelman, 1996). These path dependencies enables the enterprise to incorporate knowledge from the past and to progress along the learning curve (or the experience curve), but they do not necessarily facilitate decision-making processes or their renewal if the environment is undergoing profound change.

1.2.3.2. *Notion of space*

Enterprises have multiple frontiers with variable porosity (Pénin and Burger-Helmchen 2012). These frontiers are concerned with the activities, influence, culture and mastery of enterprising costs. Crowd funding techniques and connections with user communities are some of the many approaches that enable the populace to benefit from supplementary resources thanks to partnerships, cooperative action, user and provider integration, etc. The enterprise's frontiers, which have become more transient, authorize the rapprochement with other actors to a greater degree than before. Based on this fact, distance becomes less of a constraint. Internalization and externalization operations follow one another so that organizations may outsource the activities that are less efficient in terms of added value and concentrate on their core business. Enterprises thus possess a greater capacity to develop new competencies in order to face the next threats and opportunities. The notions of frontier and distance, reconsidered

in the framework of complexity, lead enterprises to redefine their fields of activity and their core business.

The notion of distance has been particularly developed in economics and innovation management, whether it is a matter of questioning the distribution of multinational enterprises' research centers, their connections with local communities, the distribution of issues, etc. These structures answer to the need to mold a system's complexity to respond better to the enterprise's objectives.

1.2.3.3. *Decisions and controls*

The decision-maker's rationality should not be the same in a complex system as in a basic system. Thus, Cohendet (1997, p. 81) sees this as a self-realizing approach of decision-makers:

“The decision-maker is generally not even aware that he is contributing to the creation of irreversible conditions through his decisions, but if each decision-maker tends to adopt the same technology, irreversible conditions will be created on a global scale by default. There is thus a risk of irreversibility. This phenomenon was originally studied by A. Kahn under the name of the ‘tyranny of small decisions.’ He also showed how a large number of small decisions, when their temporal perspective is limited, can lead to unanticipated, irreversible transformations”.

Decision-making and its implementation in a complex system move towards tension between the decision-maker's conscious desires and the effects of actions that are no longer foreseeable.

An optimizing rationality leads to a set of actions that are part of a process presumed to be as easily controlled as possible. Two major issues arise in a complex system in regard to this logic: the illusion of control; and, the fact that whenever one part of the system is optimized, it is at the expense of other parts of the system, which is then pushed out of balance (Kerr 2014). Also, as Naud (2007) remarks, this “tyranny of small decisions” combined with a

decoupling of the intentionality of actions (causes) and economic effects profoundly changes managers' positions. For many, this gap explains the relative incapacity of some managers to make the right decisions. This decoupling of intention, action and effects is an organizational manifestation of the complexity that acts on the time and space of the decision.

Among enterprises' strategic reactions to face this situation, we find the multiplication of decision-making centers – notably in the form of centers of profit, costs, means, etc. The objective of these centers is to bring the decision-maker, the on-site manager, together with the base unit of complexity. Cost centers also recognize the limitation of the negative financial consequences of great exposure to risk. In a complex system where mastering the elements is an illusion, this organizational approach allows the negative impacts of complexity to be limited.

Nevertheless, the multiplication of decision-making centers creates its own organizational complexity and potential dissonances. The matrix organizational forms of this type are a well-known example. This structure multiplies the hierarchical lines, which enables a large amount of information to be collected and spread more easily, but potentially exposes a single employee to contradictory orders. Thus, an order from the head of a geographic area may contradict one coming from a functional head of marketing. Who should the employee listen to and in which situations in this kind of system? Very few organizations allow the system to self-organize (in this case, the person to choose their own priority) thereby imposing rules, creating ambiguity in the complex system.

1.2.3.4. Structural strategy

Numerous structural forms present various advantages when they are incorporated in a complex system. Their evolution depends on numerous factors which, when isolated, have only a limited impact, but that, when combined, bring about a change in the organization. "Percolation" is a more or less ordered contagion following the agglomeration of micro-variations in managerial actions, relational networks and employee behaviors. If it reaches a certain threshold,

this contagion brings about a qualitative modification in the organization.

In professional contexts, the constitution of a network of enterprises, the adhesion of a large number of actors to a single norm, a coalition, and the formation of a cartel are some of many actions where the quality of the system is modified as a reaction to a complex state (and one that generally brings about a reduction in this complexity).

As Naud points out (2007, p. 139):

“The responses brought about by the strategy to mutations connected with the ability of internal and external environments of the enterprise bear witness to the possibility to lend meaning to professional action despite the losses of reference points and habits. What happens in the propositions of contemporary strategic processes is the possibility of articulating the oldest traditions with the most innovative methods. This possibility shows the integration of characteristics of the economic universe and the evolution of our cognitive capacities”.

The complexity of the systems and economic environments in which economic actors find themselves implies that long-term decisions cannot be made with a sufficient degree of certainty to invest in *non-flexible* resources and infrastructures. On the other hand, for the flexibility of investments to be used in an economically justified manner, evaluation and controls must be adapted. These actions establish themselves as the foundations of management.

Within a complex system, the need for manager control is just as necessary as in other systems. However, the frequency of these controls and particularly the determination of threshold control values are more difficult to establish. The evolution of complex systems is, to a large degree, impossible to predict. The trajectories are very sensitive to the initial conditions (supposing that change can be modeled, it would therefore be necessary to know the starting point

with infinite precision). Thus, the manager has difficulty establishing action plans without ambiguity and has trouble controlling their execution by the measurement of the system's evolution. Furthermore, in a complex environment, a manager often exercises three actions:

1) choosing real options that enable them to exercise strong control in the initial stages (he will exercise an optimizing action);

2) serving as an economic analyst/forecaster, for he must understand the evolutions of these options and notably their interactions as best as possible;

3) controlling and managing the inevitable drifts of the options.

In a complex system, as stated earlier, both control and optimization are not possible. Instead, the manager steers a strategy to transform the enterprise and adapt it to the uncertainty of the environment.

1.3. Cognition and the theory of the firm

We will now discuss the *cognitive dimension* of these questions. Describing a system depends on defining its informational structure, as we learned from von Foerster, the founder of systems theory: a system is the structural representation that the observer makes of it rather than a preexisting object (see Delorme (2006) for more details on von Foerster's thinking). It is not an object that a map or a photograph could sufficiently describe, but is a perception to be constructed. A tree, for example, is not what we believe we see and can draw, but a complex system that is evolving and interfacing with other systems through its root system, its leaves, the plants and animals in its ecosystem, etc. One of the difficulties of the systemic approach lies in defining the limits of the observed system. At the end of the day, the system is what the observer decides to consider.

The nature of the information and knowledge at work in a complex system is therefore the core of the matter. This knowledge is always necessarily imperfect, but it is important to know how to distinguish

the levels and varied natures of imperfection. In the evolution of a complex system, there is computable uncertainty (risk) and non-computable uncertainty (radical uncertainty). Faced with the uncertain, those who are responsible for the system and who must make decisions that affect its future must distinguish the uncertain that they can recognize (*known unknown*), but also foresee the possibility of “unknown known”. For example, by analyzing the Fukushima catastrophe, it is evident today that old testimonies, dating back several centuries, clearly indicated tsunami levels with the same magnitude in the same region. This information existed without ever having been considered. Finally, there is the radical surprise of the emergent new (*unknown unknown*), by definition impossible to predict, but against which we must attempt to protect ourselves through foresight exercises that broaden our field of reflection, as well as by attempting to be aware throughout the development of a project of the weak signals that may arise from scenarios that are significant for the future.

As we can see, steering a complex system depends on managing multiple forms of knowledge. It is generally impossible to proceed in a linear manner, i.e. coming up with an optimal response to the question asked (problem solving) based on the known. Causal procedures, in any case, must give way, to a large extent, to an effectual approach in Sarasvathy’s sense (2001).

Some indices of this reading of complexity must be exploited by managers. Indices are more important than solutions, because each complex system is so different from another that it is impossible to provide highly precise lines. Edgar Morin’s thought does not directly provide guidelines for the practitioner, but attempts have recently been made in this field (Bibard and Morin 2018; Genelot 2017; Journé *et al.* 2012). Most importantly, it is the need for analysis, attention and description that must be worked upon. Complexity can be understood notably with the help of the economic theory of the firm and more specifically through evolutionary models.

1.3.1. Creativity and the evolutionary theory of the firm

Creativity as a novel source poses numerous implications for the study of economic organizations and also encounters some pitfalls. Becker *et al.* (2006) emphasize that Schumpeter was not capable of solving the puzzle of the emergence of novelty in economic systems. Sidney Winter proposed a framework to explain the emergence of novelty in a *routine-based system* (Winter 2006). For this purpose, he used certain properties of routines: the possibility of combining them and the unforeseen variations that come about during their imitation (Winter and Szulanski 2001).

The vision of creativity in the neo-Schumpeterian theoretical framework of the firm (Winter 2006) uses a limited conception of reality implementing routines. For Nelson and Winter (1982), routines are not only decision-making rules and standard procedures for overseeing operations at enterprises, but also an abstract way of doing things well. They noticed that the implication of routines is not the same when it is a matter of: (1) analyzing the enterprise's reaction towards a change in the environment by following rules that slowly change over time and with experience; or (2) analyzing innovative change (with all the degrees of innovation that an enterprise may display).

For Becker *et al.* (2006, p. 356), exhibiting reasons that lead to the emergence of novelty is the most serious gap in Schumpeter's work. As opposed to Schumpeter, who sees novelty as the result of a mutation, Nelson and Winter (1982) are more in favor of the following explanation: they consider routines to be the equivalent of genes, which change over time, sometimes in a desired way. It is therefore the positive expression of creativity, but sometimes also an undesired change (oversight, improper imitation of an existing routine). Some random elements of individual creativity disappear when we speak of collective innovation, particularly at the level of the firm or the economic system in the long-term (Winter 1975, p. 102). However, the emergence of novelty has not yet been defined in this general framework, and this is the combination of routines and the lack of precision in the transfer of routines that explain the introduction of novelty.

The first source of novelty is the combination of routines initiating change when numerous small modifications in the environment trigger routines that are not compatible with one another.

The second source of novelty is the imperfect imitation of an existing idea. For a routine, it is not necessary to function in the same way as another in case of replication, but to function with comparable efficiency (Nelson and Winter 1982, p. 121; Winter and Szulanski 2001).

1.3.2. Creativity and knowledge

For De Woot, entrepreneurship has been recognized as an essential function of economic development. The spark of creation and creativity are increasingly present in and outside of enterprises (De Woot makes this remark in 1971). There is no better agent of progress, change and growth than the enterprise. The vitality and dynamism of enterprises determine technical progress and all the promises that accompany them. The primary characteristic of enterprises is change thanks to an organizational function: creativity. The study of firms, even over a short period of time measuring 5 to 10 years, shows that they evolve, adapt and react to the environment and internal pressure. Initiative and creative capacities are historic characteristics of entrepreneurs. The role of the entrepreneur is to establish an organization devoted to economic creativity, change and innovation. He is capable of acting and making the necessary decisions to motivate their appearance. By saying this, we are partially aligning ourselves with a Kirzner-style approach (1979) with creative activity based on the vision (detection) of opportunities. In fact, creative capacities are the basis of entrepreneurial action.

Recent works recognize the essential utility of creative capacities of organizations and individuals. Creativity is continuous, but its cumulative aspect is not as well established (contrary to the notion of knowledge). Creativity enters the enterprise's organization with all other factors of production. Thus, creativity is interdependent on these other factors. Creativity is a form of adventure. It requires an ability to absorb knowledge and inspire organizational and technological

change. As such, the flexibility of the firm and also its strategic reactivity are challenged by creativity.

For De Woot (1971), *economic creativity* may be put forth as a *function of the enterprise*. He describes it as the production and distribution of goods and services that are qualitatively modified by various forms of creativity (technical, organizational, esthetic, etc.). This definition of creativity covers both progress and production, a vision also shared by numerous contemporary authors. The separation of the creative act into different stages, as is done with the innovation process, took place more recently when creativity became a function of the enterprise (like marketing), leading to a form of specialization and professionalization. This is also one of the reasons for the economic definition of creativity to recognize an action, a process that brings about “useful” novelty. How could the economics of the enterprise and management develop a function that is not useful? Amabile makes this notion the cornerstone of her theoretical construction on organizational creativity (Amabile *et al.* 1996).

Creativity is not only change or the display of variety, it is fundamentally a qualitative change. Creativity leads to change and progress in scientific, technical and economic matters. Dynamic capacities share certain resemblances with the more general approach of creativity in the sense that production and distribution cannot be performed in a sustainable way if there is no dynamic improvement, i.e. a function of renewal and progress taking place within the enterprise.

From an organizational standpoint, creativity requires the firm to be flexible. Reactivity requires a flexible work structure so that the members of the organization are capable of expressing this freely. Organizational creativity also leads to organizational change in the firm.

From a managerial standpoint, any decision that reduces the organization’s creativity is a bad decision. Creativity, as with all exploration (as defined by James March), is a process that consumes resources, in addition to or in parallel with others, but it is above all a profound process that feeds other functions within the enterprise. It is

interesting to question whether the organizational ability to imitate, just like the growth of greater flexibility, depends on the organizational structure, the delegation of power and prerogatives, participatory leadership or even modern management tools (Anderson *et al.* 2014). De Woot (1971, p. 131) also points out that self-confidence is necessary for the proper execution of a creative activity. The determination and involvement of each member of the organization are conditions for success. Excessive managerial control would likely just restrain creative activity. Finally, creative activity must be voted on politically and institutionally.

Numerous works in economics and management deal with innovation but significantly less with creativity. However, the interest in this field is growing. In particular, researchers previously interested in matters of knowledge management, technological change, or the economics of science have appropriated the field of research in the economics and management of creativity. The economics of science, which deals specifically with the impact of basic research, deserves particular attention, because it recognizes the impact of creativity on the generation of discoveries and inventions to be studied. In the linear representation of innovation, creativity can be found in every process ranging from science to technology, from innovation to its diffusion. All of these elements can be found in a more complex vision (that of Kline and Rosenberg), but they are interwoven into feedback loops. In both cases, creativity manifests itself all over, but in a differentiated matter depending on the nature of the field (discovery, invention or innovation), with different motivations and rules.

At the end of the day, without the appearance of creativity, it is not possible to create value and sustainable economic development. In any case, in the absence of creativity, there can be no breakthrough innovation (Christensen 1997), as we will see later.

1.3.3. Creativity and novelty within a system

Szigety and Fleming (2006, p. 36) have contributed to demonstrating a form of asymmetry existing in evolutionary processes in the presence of creativity. These authors focus on breakthrough

inventions, a phenomenon that has received little attention because such events are rare and the results difficult to generalize. It is thus more difficult to draw any managerial advice. These radical inventions are the extreme, the singularity that qualifies the study of creativity. The fundamental economic question in this case is the determination of the characteristics of the environment and the processes that lead to the appearance of this creativity and the singular distribution of results. The creativity that impacts enterprises and an industry in its integrality is articulated through an *evolutionary epistemology* in Campbell's line of thinking (1960). This approach requires multiple degrees of analysis, for a number of levels are impacted (the project, the enterprise, the network and industries).

Numerous researchers in various fields have presented the elements of creativity in evolutionary models. They emphasized that knowledge is the result of an evolutionary recombination process involving existing knowledge (Laperche 2018). Among others, Campbell (1960), following the Darwin's premises (1859), describes how every evolution (and learning) system operates according to the triplet *variation – selection – retention*. For Campbell, this triplet enables the essence of the evolution of creative thought to be captured. Simonton (1999) develops the creative aspect of this process, as does Basalla (1988), who uses it to describe technological change through inspiration from biological evolution. Simonton and Basalla analyze learning as a random evolutionary process, but one that may be influenced. The "value" of this creativity will only be judged by experts, the economic impact of the idea, or the use others make of it by recombining it to advance knowledge.

This approach enables Fleming and Szigtegy (2006, p. 339) to define a "revolutionary" idea or a breakthrough: "a new combination that generates a disproportionate portion of future research directly or indirectly". This measure, based on the number of publications in scientific works, can be completed through a measurement of the resultant industrial dynamics.

Most models are based on psychological premises since creativity is only apparent within the mind of individuals. Creativity as a *variation* takes place in the mind of economic actors. This is a sharing process between individuals, within a team, which allows improvement in ideas through a cumulative process. The selection and retention of ideas is, however, the task of a group or team that creates a great deal of oscillation between the original idea and the one that is finally retained (Weick and Sutcliffe 2007).

1.4. The entrepreneurial dimension

As we highlighted in section 1.1, the archetype of a complex system is the *megaproject*. For example, the construction of a large public infrastructure is complex in the sense that it involves a multitude of actors and stakeholders whose objectives, knowledge and decision-making procedures are often extremely different. Another dimension of complexity is, however, a fact that the megaproject is a bet on the future, with a broad temporal horizon, which opens the field to self-organized structural changes that are difficult to predict. In the case of an urban project, it is clear how the question is asked concerning action on a largely self-organized system: aside from the extreme scenario in which an entire neighborhood is torn down in order to build something completely different in its place, the urban planner's involvement comprises playing with a living system and anticipating its reactions. This type of temporary but structuring participation can be characterized as a form of adaptive design. Based on the fact of *in itinere* discovery processes, the knowledge factor appears to be a dynamic variable and not an initially available stock. In essence this design is creative because along the way there is partial co-construction of the project with multiple stakeholders. The same issue arises in more modest projects starting when there is a veritable entrepreneurial act.

The entrepreneurial dimension in project management, regardless of the project, stems from the fact that an adventure must be undertaken with other actors (partners, clients, suppliers, competitors, an institutional context that is likely to evolve, etc.). Another point of view, linked to the previous one, is that the major actors in the

operation must demonstrate predictive capabilities and not simply knowledge in the technical sense of the term, since the knowledge elements necessary for the decision have not all been revealed at the starting point. This is the meaning with which we use the word “adventure”.

At this stage in reasoning, it is important to revisit the notion of creativity. If we return to Robert J. Sternberg’s definition (see introduction in Sternberg 2011), the fundamental ideas of the project – to be fully creative – must be *new* and *pertinent*, but it is best – in our opinion – to add a third dimension, which is the *will to undertake*, i.e. a taste for risk, pugnacity, and the ability to convince, not to mention the ability to lead other actors and motivate them (leadership, empowerment). Based on this conception of the project, the following are the most appropriate questions concerning its design and governance:

- what sources of new ideas do we have? (novelty criterion);
- what filters should be set up to sort out ideas? (pertinence criterion);
- what type of project holders shall be recruited? (entrepreneurship criterion).

Complex projects sometimes correspond to relatively modest entrepreneurial forms (in appearance). A breakthrough idea in any field, even with limited means, can also lead to a complex innovative process. The complexity is qualitative; it is not a matter of size – although size increases the probability of complexity. Indeed, if the idea is outside the box, the potential innovator finds himself in a context where many parameters remain to be defined. The small innovative enterprise – a start-up – will be led not to adapt to an existing market, but to create its own market. Potential users in order to be satisfied are concerned with a general functionality of the product and not with the product itself (or service) that they already know. In other words, creativity is *distributed*, in the sense that the innovator is not alone in this system, but must co-create the product and its usage environment with other actors, the consumers or users, the prescribers, the producers of norms (regulatory, technical, even

cultural ones), etc. As evident as an innovation may be, if it is based on a breakthrough idea, it will be absolutely necessary to construct a complex system of actors and knowledge before it succeeds. The latter case (knowing that not all innovations follow this model) goes back to a particular evolutionary model, as we will see later (section 1.4.2).

1.4.1. The philosophy of effectuation

The most creative projects stem from a philosophy of action that is rather different from the classical model of innovation taken from research and development (R&D). Let us recall that the *effectual* approach proposes concentrating on the effects of actions rather than the causes of situations. The image of the biological system is useful to understand the difference in approach:

- the “causal” method of treating the illness is to consider it the result of a pathological cause, for example by administering a drug that is intended to compensate for the cause of the imbalance;
- a more systemic “effectual” approach involves imagining the various consequences of many possible strategies (including that of administering the drug) on the organism and choosing from among all foreseen scenarios the one that is preferable for the patient by considering all notable effects.

This medical image illustrates similar issues in many fields of decision-making. In the case of urban redevelopment, rather than completely rebuilding after the destruction of what already exists, there is a general desire to understand and influence a certain urban dynamic through more “homeopathic” or “catalytic” operations (Palazzo and Pelucca 2014). The urban project, for example renovating an area in decline, stems from the same philosophy as *effectuation* in project management according to Sarasvathy. Rather than denying what exists as a whole, it is taken as the starting point and bets are made on the evolutionary capacities of the system based on beacon operations that indicate a direction. Thinking of a system’s evolution rather than seeking to create one as a patchwork of elementary bricks is the core of creative management when it is spread throughout a “complex” context.

For any ambitious project (innovation within an enterprise, construction of a large public infrastructure, etc.), the operation does not take place in a neutral space free of history. The project is necessarily part of a territory whose trajectory is going to change; it implies numerous interests and no one can define all of the positive or negative effects to be expected from the onset. There will be *exploration* of means and desirable goals and not only the exploitation of known means to achieve given goals in advance, to use March's words (1991).

1.4.2. Evolutionary models

The evolutionary approach to the economic system in the long-term, inspired by Schumpeter and an entire "evolutionary" school of thinking – that was applied to inventorying not only macroeconomic mechanisms but also microeconomic ones (evolutionary theory of the firm) – harks back to two possible models inspired by the evolution of species: Darwin's evolution where the market performs the function of selecting firms whose organizational routines and competences are the best adapted, and Lamarck's evolution where the firm itself develops its routines to remain competitive. Schumpeter's "evolutionary" vision changed in this regard between his first works, where entrepreneurial creativity is largely exogenous, and his later works, where firms make an effort to maintain their technological lead through R&D. The former vision (Schumpeter 1934) is more Darwinian, whereas the latter (Schumpeter 1942) is more Lamarckian.

Nevertheless, a third evolutionary model could be mentioned, namely Baldwin's, where individuals attempt to modify their environment instead of seeking to adapt to it (see Weber and Depew (2007) for a commented review of Baldwin's works). Works in management have analyzed numerous cases of this type where innovation does not involve modifying its product or activity to perform better within current markets (*adaptation strategy*), but in starting with areas the firm has already mastered to build a niche market that will enable it to prosper. In this case, we speak of *exaptation*. The creative management of complex projects corresponds

more closely to the case where innovation is co-constructed between the system and its environment.

Dew and Sarasvathy (2016) explain how the exaptation model helps design such a strategy. It is not only a matter of adapting the organization to its environment (Lamarck), but also and primarily of building a niche market where it can fully benefit from its skills and other comparative advantages (Baldwin). It is worth mentioning that these skills are not static; they must be considered evolving factors. They will be developed through iterative interaction with their environment. This strategy is part of the philosophy of effectuation, where the available means are the basis for developing them in the service of a goal that remains to be defined and not a precise goal for which means are constructed.

1.5. Conclusions

Strategies of progressively creating goals and means that interact between the system and its environment correspond to an idea of complexity management. It is worth noting that an orientation towards open innovation models (Chesbrough 2003) seems increasingly mainstream in numerous sectors and is a central part of this framework.

We can summarize the theoretical reasoning underlying every chapter of this work in the following way:

- Steering the system (e.g. a firm) considers the fact that it has a memory of its past and that it is self-organizing, both in the present and the future. This is what makes it a “complex” system.
- Steering thus involves providing the system with orientation and not in attempting to reconstruct it in the service of a new strategy as if everything could be planned and controlled.
- The most important thing is therefore knowing the system well and watching it closely, as both enable us to anticipate its evolutionary potential and choosing which dynamic skills can serve as a support or as a function of the environment and the laid general objectives.

- The extension of skills will take place through joint learning of the system and the environment. This co-evolution also illustrates the holonic nesting of the organization in its environment and the way in which they change one another.
- The planned evolutionary model is not in the order of adaptation but of exaptation.

To connect this organization or project management approach to the economics of innovation, we will emphasize that exaptation harks back to the idea of creating the market for the innovative product (or at least a market niche). We are not using a model where innovation is a competition strategy for a given market. We are not, for example, using a model of patent-race games, where all of the competitors have the common knowledge of the (same) goal to be achieved.

The interpretation of the market as a dynamic scene being co-constructed and not as a static exogenous arena also corresponds to different representations of what the real economy is. It is not certain that the classical Schumpeterian representation is more pertinent – or rather, it is necessary to consider the most recent works of the founder of evolutionary economics (Schumpeter 1947), who foresees a sort of creative dialogue between the entrepreneur-innovator and the macroeconomic system (the *creative response*). A more fitting analysis framework is possibly that of the Hayekian tradition, particularly Kirzner (1979), as demonstrated in Héraud (2017).

The complexity approach in management poses both the question of innovation seen as a creative process involving multiple actors and that of the nature and role of the entrepreneur in the economic system. Are managerial responses always meant to reduce complexity? Rationalization and lean management are managerial responses to production system complexity, just as Taylor's "one best way" simplifies the worker's activity and his interactions with other employees by replacing the freedom of gestures with routines and supposedly optimized processes. Depending on the situation, the managerial response may be an intensification of complexity through an enrichment of the organizational dynamics. Thus, operations for alliance, fusion-acquisition, fiscal constructs and the globalization of

supply chains are organizational responses that correspond to complex environments by increasing their own complexity. Here, it is a matter of managers providing an optimization or survival response if these measures are put in place through prevention.

In the remaining work, we will deal with a number of facets connected to the creative management of complexity.

As such, Chapter 2 deals with the evolution of complex systems and Chapter 3 with their steerage – by going into greater depth concerning the concept of weak signals. Chapter 4 returns to the links between entrepreneurship and creativity in the economic literature. The orientation of Chapter 5 is connected to the classical functions of management, marketing, human resources, and the link between strategy and organization.