Creative Management of Complex Systems

Smart Innovation Set

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Creative Management of Complex Systems

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Preface

"Everything is becoming more complicated; we must go ever faster!"

This rather common statement will certainly remind readers of similar ones they have heard in the media or during a conversation. There is undoubtedly a shred of truth in these popular expressions, but to rationally analyze their meaning, we must first distinguish complication from complexity. In fact, the state of being complicated is different from that of complexity – the first is a linear progression even when it does not look straightforward, whereas complexity is an emergent state – novel outcomes emerge over time that were not foreseeable beforehand.

This concept is most interesting to consider when managing organizations, as it requires distinctive planning, managing and operating techniques. Complexity is born of interactions between a multitude of actors that are possibly aware but often unaware of the fact that they belong to the same system, with the formation of feedback loops that render the system's evolution largely unpredictable. Complex systems have very specific properties, particularly the nonlinear response to stimuli that must be taken into account by the managers who are in charge of regulating or steering them. Whereas an engineer can manage a *complicated* system (often by way of technology), it is an exaggeration to the claim that the administration of a *complex* organization is "managing" the system.

Our planet is a complex system, as is our body, the organizations that we create, or our social and economic systems. Complex systems can often be analyzed as a system of systems. For example, a company is a system within the sector-specific system, i.e. of its partners, suppliers and clients, the institutional framework, etc. It is no simple task to define the boundaries of the system being observed (or steered) as complex systems are embedded within other complex systems. However, in order not to become overwhelmed we must deal with any question or specific problem by defining and determining which part of the system to investigate and at what level of scale. There are also a number of methodological choices that must be made at the outset in order to better understand and act.

As the complexity of systems increases with the number of connected elements, the contemporary world generates a veritable explosion in complexity taking into account the digital revolution and the Internet. The globalization of technology, economy and lifestyles brings not only attempts to simplify and standardize (in order to reduce complexity), but also an enormous development of complex interpersonal relationships around the planet, which renders the overall system terribly unpredictable.

Throughout this work, we will define complex systems with greater precision. We will evaluate their adaptive qualities, reactivity to changes in the environment and their resilience. We will also investigate the relationship between complexity and creativity: a complex system functions in a largely self-organized way and this can lead to the creation of novelty, emergent outcomes and unexpected properties, which is another form of creativity. As one can imagine, managing a complex system requires qualities such as open-mindedness, attentiveness and imagination. Those who manage and lead complex systems are acquainted with ambiguity and understand that systems (and people) can be steered but not controlled. This creative management must be capable of interpreting weak signals that have a heavy bearing on the future; they must be able to adopt behavior that is “entrepreneurial” rather than “administrative”. The variety of situations managers may be faced with obligates them to be creative, to use fewer fixed management

rules and more incentivizing mechanisms to make the system adaptive and to encourage rather than block the system's intelligence.

As such, we prefer the following expression to the one given at the start of this chapter:

"Everything is becoming more complex; we must be ever more creative!"

This work consists of five chapters. The first chapter, written by Jean-Alain Héraud and Thierry Burger-Helmchen, presents an overview of complex systems and some motivations that managers may (must) follow while managing these particular issues. This will lead us to managerial and economic considerations, for example, by revisiting classical subjects from economic theory, such as individual rationality or evolutionary processes. In management, we will mention new concepts such as "exaptation", which generalizes adaptation.

The second chapter, written by Jean-Alain Héraud and Fiona Kerr, focuses on one of the primary properties of complex systems: their constant evolution. Complex systems do not present a stationary, immutable system. They are dynamic or, more precisely, evolving. With the help of examples taken from the course of enterprises or more general examples, the authors will gradually outline the competencies necessary for a manager in this kind of environment: being able to think in a complex manner.

The third chapter, written by Fiona Kerr and Jean-Alain Héraud, is dedicated to weak signals. After having defined these discrete facts that bear on the future, they will highlight the need to establish safety nets, identification and filtering devices, and the ability to interpret weak signals within organizations. Complex systems have phases, points of attraction that, through self-organization or a deliberate strategy, may be identified and used. The system the manager must steer may be labeled as "chaordic" – an intermediate situation between order and chaos – as there are powerful leverage points in such a system. The adaptation of the system through innovation is also one of the keys to management in the longer term, hence the importance of building on the skills of actors of particular importance by translating

these from new ideas outside the system: the literature mentions "door keepers", "boundary riders" or "knowledge angels". The analysis of intercultural situations will help illustrate this problem.

The fourth chapter, written by Jean-Alain Héraud, analyzes the entrepreneur's role in complex systems. Sometimes the primary actor, sometimes completely absent from theoretical representations in economics (according to the school of thought), this figure is, in fact, central to the interpretation of the history of real-world systems. It will become clear that a certain rereading of the history of economic thought is very elucidating when it comes to tackling today's important issues such as the entrepreneur-innovator's role within the company and in the entire economic system, processing uncertainty in decision-making, adapting to the market, or creating a market. The human sciences also contribute useful complementary perspectives such as the role of social identities and the imagination's place in management.

Finally, the fifth chapter, written by Thierry Burger-Helmchen, adopts a resolutely managerial approach. He starts by presenting the overarching functions of management science that may benefit from new observations from the perspective of complex systems; next, the author focuses on two functions: strategic marketing and human resource management. In these different cases, the manager has a choice between several types of action, the basis of which may be more or less improvisational and more or less adapted to the situation.

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Thierry BURGER-HELMCHEN
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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*.

Creative Management of Complex Systems,
First Edition. Jean-Alain Héraud, Fiona Kerr and Thierry Burger-Helmchen.

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 scientistic 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. Edgard 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 Schumpter, 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 commentated 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.

2

The Evolution of Complex Systems

Companies and all forms of human organizations function as complex adaptive systems (CAS). The description of such CAS is the subject of this chapter as well as Chapter 3. The present chapter aims to describe the ways in which organizations evolve by interpreting them as *self-organized systems* whose trajectories over time are marked by periods of dynamic flux and adaptation as well as phases of stability. Chapter 3 will be dedicated to the question of steering CAS, as we noted in Chapter 1, adaptive systems cannot be controlled but can be steered over time. Overall, this Chapter presents the evolutionary characteristics of complex systems from the vantage point of an outside observer – a cybernetic, systems dynamic and economic approach. Chapter 3 will assume a more managerial perspective. The management of systems that, due to their "complexity", are likely to organize themselves through radical and largely unexpected changes is obviously a challenging task. We will see what qualities their managers must have in order to overcome this challenge, as well as the types of procedures they must implement in order to intelligently "steer" them within such a context. These two chapters necessarily have a strong connection, which will lead us to deal with the same subjects, but from different perspectives. In particular, the paradigm shifts described in this chapter will be interpreted in Chapter 3 as the emergence of new signals for management, i.e. "weak signals" that the astute manager must know how to decipher.

Creative Management of Complex Systems,
First Edition. Jean-Alain Héraud, Fiona Kerr and Thierry Burger-Helmchen.

Any manager strives to make his organization highly adaptable in the face of the external and internal crises that are a regular part of its ongoing evolution. The question is then knowing how a system adapts when it is largely self-organized (here, we can use the term *autonomous system*). Indeed, in the case of a system that can be controlled in a linear manner, change (rather than adaptation) fully lies in the hands of the hierarchy. If, on the contrary, numerous feedback loops lead to internal structural changes in response to stimuli, then the system becomes difficult to control. It is, in a manner of speaking, overly autonomous. To what extent should the steerage of a strongly nonlinear system depend on its ability to automatically adapt? Can instructions be given that respect the system's self-organizing logic (its autonomy) to encourage its progress in the desired direction? These are some of the questions to be dealt with in a managerial approach to CAS. In order to begin responding to these questions, it is necessary to study the evolution of complex systems and to understand what exactly the term "adaptive" means based on the type of system.

2.1. Adaptation, learning and flexibility

In the case of a highly elementary system, a structure is adaptive based on the environment if it learns and responds to the feedback loops in the environment. This is a complicated system and does not adapt – the tires and suspension do not learn from the surface they interact with, for example. This sub-system presents good adaptability if it absorbs a large part of the shocks caused by irregularities in the road. This makes the vehicle not only more comfortable, but also more stable and less fragile. This form of adaptability, in comparison with that of a more complex system, may be classified as *static*.

In contrast to this, CAS, particularly human ones (CAHS), adapt through interacting with their environment, as the rewards and feedback loops in the system cause the CAS to alter their behavior. For an autonomous system, adaptation takes place through sustainable self-organized modifications in the structures – as if the vehicle had

not had to be modified from external intervention, but instead redeveloped itself to better overcome the challenges of the road after having experienced a section of it. Let us note that this miracle is simply business as usual for a living being or a company! If managers consider their organization to be like a vehicle, then they will consider it their mission to reorganize the structure based on modifications required by the environment. If instead they are aware of the possibilities of self-organization in the system they are modifying, then they will understand and allow adaptive structural mechanisms to steer the organization to a certain extent. The design of CAS is thus partly a matter of managers' perceiving the system. If their mental representations lead them down the right route, then they perceive the organization as a complex system (including themselves as part of the system), which is adaptive in a *dynamic* sense, i.e. it forms itself over time through evolutionary changes.

A more precise term than "dynamic" would likely be "evolving". We will come back to the question of evolution later in this chapter, but first, we must define the various models of evolution that are possible. For the moment, let it suffice to say that dynamic flexibility is connected to an ability to learn. What happens in a self-organized system faced with new, unexpected information is adaptation through reorganization. The system does not only react in that moment, like the tire, but also "learns" from the event to change in a sustainable way. This is the beginning of *path dependency* in the sense that future reactions on the vehicle's part will not be the same.

Static or dynamic adaptation

A simple adaptive system has static flexibility. This means reacting to a new situation with an adapted tactic, but one that leaves no trace on the system. A complex adaptive system (CAS), because it is complex, learns from this event. By adapting (level 1 learning), it learns to adapt (level 2 learning) to use Gregory Bateson's terminology (1972). In the terms of self-organized system theory, we could say that it reacts to an external shock by reorganizing at a higher level of complexity. It profits from the event to increase its repertoire of programmed responses, which will make it even more reactive and efficient in the future. It has increased its strategic intelligence.

Up to this point, we have hypothesized that the complex system is capable of adaptation. In fact, this is not always the case, or this at least depends on the nature of the external shock – as well as on what we consider a reasonable adaptation. Strong qualitative changes may endanger the system. Self-organization at a higher level of complexity is the favorable scenario. Another evolution can be foreseen, i.e. system destruction. In addition, spontaneous reorganization, if it has taken place, may not satisfy the organization's management for one reason or another, hence the slightly problematic nature of the concept of CAS, as useful as it may be. The very nature of adaptation is a complex matter. Does the complex system adapt completely independently? Due to a push from its management? Guided critically and vigilantly by its managers? Despite them? When we speak of strategic intelligence, are we speaking primarily of a quality of the management team or one belonging to the entire system (distributed intelligence)?

In any case, we must keep in mind that the way in which self-organized systems learn is largely an intrinsic characteristic. Its method of reaction through transformation is part of the system's identity, like the mechanisms governed by the DNA in living systems. Two similar self-organized systems (e.g. two companies in the same field and of a comparable size) faced with the same external shock (change of market prices or the emergence of new technology) will not react in the exact same way as there are also internal drivers and feedback loops which will differ within each company. The difference in dynamics is not a simple question of inertia, but rather of path dependency; for the history of each system, its trajectory up to the point being observed, is not neutral in relation to the possible adaptations and future trajectories.

2.2. The nonlinear behavior of "imbalanced" systems

If it is important to understand how CAS work, it is because the self-organization processes that characterize them and that often manifest themselves when changes in the environment (external

shocks) come about are nonlinear mechanisms that make them difficult to steer. In physical–chemical systems, these qualitative leaps are typical of imbalanced states. Here, we could mention Ilya Prigogine's "dissipative structures" (see Prigogine and Stengers 1984), when a macroscopic system is penetrated by a flow of matter and energy (which dissipates) and produces unforeseeable self-organized forms, going through profound state changes. To analyze these mutations, physicist Pierre-Gilles de Gennes proposed a general theory of what he calls *percolation thresholds* – rapid switches from one macroscopic state to another based on an accumulation of microscopic modifications. What is observed and studied as a sudden change in quality – fascinating and complicated for researchers to model – is experienced by the head of an organization as a sizeable managerial challenge.

Kerr (2014) examined the behavior of managers and distinguished those who think in a "linear" manner (linear thinking leaders) from those who have mental representations and professional experience better adapted to steering complex systems with nonlinear behavior. Linear thinking leads an individual in charge to pose the hypothesis that the organization directly responds to his instructions. In practice, large directorial gestures can be lost in the system in favor of interpretations and multiple reactions on a loop that will be triggered. "Linear" managers are especially ill-prepared to foresee such deformations in the signals that they are giving off, to the extent that they invest much more in their leadership than their listening skills, and often do not register the multiple reactions, but instead only pay attention to those outcomes they expected to see; they are thus blind to the nuanced and multi-dimensional ramifications of their actions.

There are many nonlinear systems whose reactions are particularly difficult to anticipate in the economic and social world, particularly when observing long-term evolution. Here, we are drawing closer to the concept of an evolving system. In the economic contributions gathered by Lesourne and Orléan (1998), three major problems come to the fore:

– to a large extent, systems evolve in an autonomous manner over time. Here, we can see the definition of autonomy particularly defined by biologists (see Maturana and Varela 1980), i.e. the idea of *autopoiesis*: systems create themselves permanently or during major restructuring;

– the agents involved in these systems have an imperfect knowledge of their environment and they adopt rules of behavior that stem from H. Simon and J. March, called *limited rationality*. More precisely, these founding fathers of the theory of organizations in the economy and the society, proposed the term *procedural rationality* to emphasize that the way in which organizations "think" and decide is not the absolutely rational way that we can assume for individuals, but rather is a set of processes founded on rules and routines. Concretely, this translates into a sort of repertoire of behaviors in the form [question > response] that serves as a reflection;

– the essential condition for governing such systems is recognition of the fundamental uncertainty concerning the information (and thus decisions that individuals are led to make). Managers must find a compromise from their individual rationality – linear and optimizing – and the cognitive and decisional processes of the organization as a largely autonomous system.

The nonlinear transmission of the signal and the question of control

A very simple and well-known example of the problem of the nonlinear transmission of signal is the Larsen effect. This physical feedback phenomenon between the source of the signal and the amplifier that goes to the speaker is a good example of deformation through a(n undesired) self-organized process in the system. Let us recall that the example does not describe a complex system like biological or human ones, but it helps when explaining nonlinearities and self-organizational phenomena. If everything goes well, then the system will react in a linear way; the command is perfectly understood and the microphone signal is correctly translated by the speaker. A nonlinear regime is established if the microphone perceives its own sound retransmitted by the speaker. The sound then starts to be transformed. A percolation threshold is crossed when the whistling characteristic of the Larsen effect appears, taking over in the system. The microphone's signal that normally "controls" the amplification system is not

simply deformed or disturbed by a sound; it is completely replaced by a self-organized signal belonging to the system. The frequency of the whistling has nothing to do with the command; it is an intrinsic characteristic of the complex system formed by the microphone, the speaker and the electronic amplification system. During an intermediate phase, we can speak of a parasite message, but once it has crossed a certain threshold, the message is that of an autonomous system that emits sound at its own frequency.

2.3. Autonomy and responsibility

The notion of autonomy in complex systems naturally poses the question of responsibility. We ask this question in the present work primarily at the microeconomic level of the organization in questioning the leader's mission; however, it can also be found at the level of macroeconomic policy or even in certain sociological reflections.

2.3.1. *A sociological approach to the question of "irresponsible" complex systems*

Contemporary sociology has taken hold of the problem of advanced modernity, which is characterized by an increase in the power of complex systemic phenomena where the functional differentiation and multiplication of values and norms make it increasingly difficult to "share values". Rudolf (2016) studied this problem with regard to climate change and reduced responsibility vis-à-vis veritable planetary stakes. This large-scale social example may help us to understand what is happening in microeconomic organizations when they give the impression of great behavioral incoherence.

An interesting debate between the two greatest German sociologists of the 20th Century, Habermas and Luhmann, deals with the question of knowing if it is possible to imagine reconstructing a unit of society and coming to an arrangement to resolve differences of

opinion and overcome the loss of shared meaning. Indeed, Luhmann observed that there are no longer *places* in society likely to represent society as a whole, but places that highlight sub-systems of values or limited particular logics (a parallel can be made with Simon and March's limited rationality). Habermas maintained that, concretely, arrangements are always possible provided that individuals at least share an ethic of discussion. Florence Rudolf notes that if this ethic can fundamentally be considered a "fable" (Luhmann's perspective), it is no less an "acting fiction". Any large human undertaking is accompanied by a story, which contributes to the self-organization process:

> "*human societies are self-constituent because they never stop defying events and elements by integrating them into stories that make sense according to the various senses this word can be given (meaning, vision, direct, etc.)*" (Rudolf 2016, p. 35).

In a highly autonomous system, there is always the risk of a loss of meaning and reduced responsibility, hence the importance of the principle of leadership. At the company level, it is always possible to reference this to management. This distinguishes a microeconomic organization and an institution in the sociology sense of the word.

2.3.2. *The role of the leader*

In the phases of its evolution in which the company seeks new points of reference, if someone must personify the responsibility of giving new meaning to the system, it is undoubtedly the leader – on condition that they are willing and able. The leader's role is to exercise his leadership with a vision for the future; he is responsible for shaping the story that goes with it. *This is how the principles of a system's autonomy and responsibility can be aligned*. However, finding the balance between affirming a vision and listening to the signals (which may be weak) giving an indication of the possibility of a stable future regime of the system is a delicate job.

Concretely, within an enterprise, governance is evident in understanding the nuance of how information is produced, transported and reinterpreted by individuals and collectives. It is necessary to understand how these actors acquire information and what their rules of behavior are, as well as what beliefs and collective mental representations are constructed. Theoretically, the director's mission is to provide the behavioral rules and to realize a stable coordination system; the reality of complex systems, however, is that all of this is largely the result of vague collective learning processes (making up the entire autonomy of the system). The fact remains that the management's mission is to bring the system into a situation of "common knowledge", as best they can, where all the members receive the same operational information and goals and share the same set of beliefs. Aligning implicit and explicit behavioral codes is precisely what is so difficult to obtain when transitioning to a new regime, often because there are a number of goals shaping the system that pull against each other and cause emergent behavior.

Managers with a rather linear vision of command tend to repress spontaneous evolutions in the rules, because they are attached to the ideal of an optimized system and too often pose the implicit hypothesis that the current repertoire of rules is optimal, whereas an evolving context may have already made this obsolete. Their ambition to ensure a unit of values and representations in the organization is completely legitimate, but it is not satisfactorily applied, as it expresses a form of cognitive bias that promotes the status quo. Linear thinkers also tend to stay in their comfort zone, as they are uncomfortable with emergence. Managers who are *complex thinkers* are less influenced by the optimization paradigm, where goals, means and constraints are fully known and knowable from the onset. They voluntarily welcome the idea of emergent goals and new solutions as the actions are carried out. In this case, the management's responsibility does not stand in contradiction to relative autonomy of the system. If autonomy is not translated by an ingrained resistance to change, but rather by the ability to spontaneously adapt over a number of functions in different states of change and flux, the top management

is well positioned to listen to the decentralized evolution of the rules, allowing the adaptive process to unfold while tending to guide the process in the right direction. We will further develop this idea in Chapter 3.

As we could see in the analysis of the behavior of autonomous systems and the challenge that they provide for leaders (managers and other stakeholders), a central problem is that of the unforeseen emergence of new forms.

Complexity and emergence

We speak of emergent phenomena (or properties) in systems when macroscopic indices reveal unforeseeable and often unexplained evolutions – at least at the start of the phenomenon. An emergent path is one which cannot be planned or known at the start, but can only be understood when looking back in order to see which variables interacted to create and shape the emergent behavior along the way. The closest we can come to knowing where the path will go is to observe the weak signals that identify divergence from the dominant path being followed, but they are by nature in the invisible part of the process.

Analytically, it is more rigorous to say that microscopic behaviors trigger macroscopic effects at a given moment. These phenomena are sometimes powerful evolution vectors: the appearance of life on Earth; the emergence of language and constructed thought within humanity; the beginning of currency in economics and so on. More modestly, emergent phenomena are found in the life of microeconomic organizations. They may trigger strategic reorientations like the adoption of a new technological system, product innovation, and the development of new markets. A whole branch of literature running through various disciplines has developed to define and analyze this notion: emergence in multi-agent systems, transition from chaos to order, interaction patterns in complex systems, multiple equilibria in game situations and so on. The major model that captures this is the panarchy cycle.

We wish to emphasize here some essential traits of human systems, namely the awareness and responsibility of individuals with regard to their role in the system, and the need for humans to maintain an internal locus of control, meaning we must feel that we dictate our actions. Within an organization, the micro level is actually made up of individuals who (unlike electrons, atoms or animals) have an

image of the macro system they are part of. They have opinions on the evolution of the overall system and in healthy systems they feel personally involved and jointly responsible (indeed, the lack of autonomy is the major cause of work stress). Spontaneous emergence in such systems is necessarily different from the case that the agents are unaware of the phenomena whose emergence they contribute to, hence the higher level of complexity in human systems as opposed to other natural systems.

2.4. Different evolutionary models

The questions of organization adaptation and the emergence of system structures arise from evolutionary theory – or rather from evolutionary theories, for a number of models simultaneously exist in the natural, economic and social sciences. It remains for us to tackle systemic change in that framework, which is not unrelated to that of the autonomous systems that we just explored, but which present specificities.

Evolutionary theories emphasize the relationships between the system and its environment and the fact that they are "co-evolving" as each impacts the other in various ways. When studying autonomous systems, we try to bound the "systems within systems" breadth of study and concentrate on the emergence of new structures within the system (even though the external environment influences this through slow transition or external shock, we look at the internal systemic environment that dictates the new regime that is adopted). In the following, we shall consider the overall system formed by the organization and its close environment – a way of bridging the two visions.

2.4.1. *The large models inspired by the natural sciences*

A classical article on self-organized systems is a good introduction to this issue: Robert Ayres' "Self-organization in Biology and Economics" published in 1988 by the *International Institute for Applied Systems Analysis* (Ayres 1988).

Two large evolutionary models of systems saw the light of day in the 19th Century: in physics, Clausius' model of thermodynamics, and in biology, Darwin's theory. Thermodynamics teaches us that any closed system that is not in balance cannot go on working forever due to the increase in entropy. In other words, any system that is off balance and presenting ordered and original structures can only survive if it consumes an external source of free energy. We also speak of *negentropy* to characterize this contribution that compensates for the irreversible growth of entropy in the system. Later, statistical thermodynamics and cybernetics will interpret negentropy as *information* (Boltzmann, Shannon). To analyze human systems, we will consider free energy, matter and information extracted from the environment globally as fundamental resources of organizations that allow them to survive and develop.

Biological systems are examples of off-balance systems (also called virtual stability by Voorhees 2008). This is true for organisms and species. In 1945, Lotka suggested that the direction of biological evolution could be explained in terms of the ability to understand and use the environment's free energy. The organisms that most efficiently use free energy as food will be the most competitive in a given ecological niche, thus giving them an evolutionary advantage. Organisms have also evolved towards increasing diversity, with the development of a food chain, the appearance of parasites and so on. The entire living world has ensured its development and longevity in the face of environmental crises thanks to this formidable diversity, which increases information and reduces internal entropy. In fact, this occurs at the price of using an outside free energy source, here the Sun for the biosphere, but solar thermodynamics is a very long-term affair. The destruction of biodiversity by humans, on the contrary, is a real threat to the system's ability to survive, but that is another matter altogether.

In the living world, evolution includes not only the ability to capture free energy, but also the information available in the environment, by converting them into morphological information like

the organs of an organism or, at a fundamental level, its genes. Indeed, a gene is nothing more and nothing less than a set of compactly stored information in molecular form, which will itself command the form and behavior of the individual. The genetic informational silo primarily made up of the DNA is the result of both a long genetic evolution of the species and epigenetic changes due to interaction with the immediate environment – both are the equivalent of a learning process.

The self-organized system of the biosphere is primarily characterized by:

– persistence;

– replication;

– the modification of the environment;

– the ability to modify.

We will return to this interesting list later, for it enables us to interpret the various ways in which not only natural systems, but also economic and social organizations evolve. We will recall the persistence and reproduction of organizational routines (or procedures), the adaptation of these routines to a new environmental context and the creation of an environment adapted to its routines.

2.4.2. *Human evolution*

The human world resembles the biosphere it stems from, but it goes beyond this in its ability to capture energy and information in the environment. Indeed, humans establish multiple external information sources including technical artifacts and language. All possible forms of knowledge (tacit and explicit) and organized information (qualitative and quantitative) are put to use for competition between individuals and their organizations, to continue capturing ever more free energy.

The first economists who thought about human systems as self-organized dissipative structures were K. Boulding and N. Georgescu-Roegen in the 1960s. Since then, environmental awareness has considerably spread throughout society, and it has become common to think of the planetary economic system as a structure dissipating free energy (as well as rare matter and environmental diversity) according to an irreversible process (resources > raw materials > finished products > waste).

The storage of structural information in the form of morphological differentiation and functional specialization exists in economics as in biology: the division of labor, organization of branches, professional qualifications, invention portfolios and so on. The self-organized system to be considered is increasingly the one formed by economics and technology, two sub-systems whose permanent interaction produces not only growth, but also particularly an accelerated qualitative change punctuated by adaptation crises. Technical-economic evolution and its societal consequences work very quickly compared with evolutionary processes in the biological world.

While the parallels that we just discussed between biological and human systems are pertinent, our goal now is to see what models of evolution are suggested by biology and to what extent human societies conform to these. We shall attempt this without being reductive.

2.4.3. *The evolution of economic organizations*

Unlike the neoclassical approach that makes use of the mechanical physics paradigm, evolutionary economics is inspired by biological models. There is regular reference of the neo-Schumpeterian school of thinking – Nelson and Winter – but there are other approaches like that of the neo-Austrians (see Chapter 4). Regardless of the case, evolutionary approaches in economics observe the system's dynamics not in terms of mechanical convergence towards equilibrium, but in terms of qualitative changes like dissipative structures in thermodynamics. However, the most important model taken from the

natural sciences seems to be the evolution of species. Evolutionists remain fascinated by the Darwinian approach and establish an explicit parallel between the biological concept of the *gene* and the organizational concept of the *routine*.

In the Darwinian metaphor, individual organizations like firms are characterized by operating instructions called routines, which were established throughout their history, just like genes throughout the history of species. The procedural rationality of organizations permanently implements this genetic code inherited from one time period to other – or imitating other firms in the same sector. As with Darwin, the reproduction of genes is not always perfect, leading to interference and diversity, which can be exploited by evolutionary mechanisms. For Darwin, competition between the individuals in a given environment is meant to eliminate individuals with less efficient genes and favor the reproduction of innovative sub-species that are better adapted to the environment than the average member of that particular species. In economics, the market can be considered the selection environment that will favor the survival of firms with better-adapted routines.

This theoretical vision can be placed in opposition to the fact that firms are not only autonomous systems devoid of consciousness or direction. It is the responsibility of managers to observe whether or not the current system of routines has adapted to the situation, even anticipating future modifications in the environment and encouraging the emergence of the most favorable individual and collective routines. We are then no longer using a Darwinian model, but rather a Lamarckian one. Lamarck came up with an alternative interpretation to Darwin's, where individuals modify their genes, stimulated by competition and environmental pressure, at the margin; they then pass these "improved" genes on to their descendants. This is the theory of *acquired characteristic transmission*, which was not accepted in biology (although researchers in contemporary genetics seem to slightly correct the fully Darwinian model). In economics, the optimistic hypothesis can be posed that firms are more Lamarckian than Darwinian. The stakes lie fully in adapting.

We can go beyond this by considering the third characteristic pointed out by Ayres (see section 2.4.1) when he describes the evolution of living systems, namely the possibility of modifying the environment. The living world is teeming with examples of organizations that go so far as to choose or adapt the ecological niche that best suits their genes. Humanity is the optimal example of a species that has shaped the planet to provide it with the most competitive advantages possible (short-term). The Neolithic Revolution is a perfect illustration of this, with the transformation of forests into fields of grains, the management of water sources, the wiping out or domestication of numerous animal species and so on.

We will conclude by considering at least three large levels of evolutionary adaptation:

– passive evolution, where organisms allow themselves to be selected passively (Darwin);

– reactive evolution, where organisms adapt (Lamarck);

– proactive evolution, where organisms transform their environment.

2.4.4. *Proactive evolution: from adaptation to exaptation*

The literature on entrepreneurship and project management often considers the third level distinguished above to be the model of creative management. Dew and Sarasvathy (2016) used the term *exaptation* to describe a strategy that goes beyond the simple adaptation of the firm to its environment. The strategy involves building a market niche to lend value to an idea or competency developed internally. The authors consider this type of behavior to be the basis of evolution in numerous sectors. The mechanism involves rerouting existing resources (equipment, competencies, networks, etc.) towards emergent uses.

In relation to the problem posed at the beginning of this chapter, defining and investigating adaptive complex systems, we can see that

precision can be provided through evolutionary theories. The most innovative CAS are not simply capable of adaptation, but they perform exaptation. They do not adapt their behavior to the environment, but instead build a favorable environment for themselves. Here, favorable means "likely to add value to their distinctive competencies". This is the way in which a firm escapes direct competition on a given market where it may not have a significant competitive advantage by creating its own product or its network of consumers or users, even by attempting to influence the institutional system, as is the case with the examples described by Dew and Sarasvathy (2016) in the field of pharmaceuticals. There is also an internal evolutionary stake insofar as it is not simply a matter of adding value to present knowledge and actors, but also of backing future abilities. It is thus a market creation strategy founded on the objective test of the firm's dynamic distinctive skills.

The exaptation strategy: two examples in pharmaceuticals

Dew and Sarasvathy (2016) referred to the case of Marsilid (Iproniazid) and that of Viagra (Sildenafil) as two successful forms of exaptation in the pharmaceutical field, but with strongly differing conditions.

Marsilid was used after World War II to treat tuberculosis. Luckily, physicians observed that one side effect was an improvement of depression associated with certain illnesses. It was approved with this new use in 1958, thereby creating one of the very first anti-depressants. This is a simple case of using an existing product for an emergent market. The niche market was there, just waiting for administrative authorization to use the medication, which was already well known and widely produced. This is a dream situation for manufacturers, as the authors emphasize. Exaptation was largely facilitated by the fact that medical personnel had already started spreading this new use in the hospital setting before administrative authorization was given.

Viagra is a more complete example of exaptation on its manufacturer's part, as the new market had to be created in a highly proactive way, using a variety of means. At first, the medication was used to fight hypertension. Turning it into the flagship medication against erectile dysfunction was the result of a socio-technical and institutional construction that Pfizer intelligently orchestrated. With this new

use, Viagra was not simply a medication in the classical sense of the term, targeting patients, but also a product that could be bought online by simple "consumers". Viagra is more than an innovative pharmaceutical product; it is a market innovation and even a societal innovation, in a sense.

With the market construction strategies that we just saw, the present model of systemic evolution is particularly *complex* in that it is not a confrontation between an organization and its environment, but the self-organization of a comprehensive system comprising, in the case of Viagra, a firm, the healthcare system, patients and various users. This case is typical of the radical innovations that involve society as a whole.

2.5. Implications for management

The previous analyses lead us to believe that managers must consider the complexity of the systems that they steer with an adaptive attitude: thinking in complex terms, anticipating breakthroughs in the organization's trajectory, listening to weak signals, establishing a context that is favorable to individual and collective learning and using intelligent incentive systems.

2.5.1. *Thinking in a nonlinear way*

Earlier we discussed aspects of self-organization theory (autonomous systems) and evolutionary models in terms of different perspectives on the same mechanisms. The creativity particular to autonomous systems such as Prigogine's dissipative structures seems to stand in opposition to the deliberate strategic considerations of exaptation. However, in real life, and in organizations, a complex system incorporates both phenomena, which often present two complementary faces. Organizations are shaped and driven by "guided autonomy" (Kerr 2013) and do not just maintain a fixed routine over time, but evolve according to their own learning dynamics. Their evolution is irreversible and occurs by way of multiple states of flux

and stability over time. As for the piloted system for which the leader has chosen to create a new market niche, it is not a simple organization executing a pre-established plan, but a complex multi-organizational system that progressively co-constructs a new situation (eco-system).

Based on this fact, strategic heads must be prepared for two kinds of exercises:

– Given that the system is largely self-organizing and presents an alternation of phases with regular regimes and critical episodes of regime change, leaders must be on the lookout for internal phenomena, particularly weak signals that are harbingers of change.

– Given that the system is made to be steered, managers are responsible for revealing and influencing a possible direction for applying the dynamic competencies that characterize the organization. They must also create the story that goes with it.

The relationship with the environment must be investigated, for the idea of a complex adaptive system, as we have seen, may go in an unwanted direction if left to non-directed, passive adaptation. The object of the adaptation can be both the environment and the firm as they are co-evolving. The philosophy of *effectuation* in Sarasvathy's sense applies to exaptation: starting with the actors' present and existing skills or those easy to develop to imagine possible, advantageous futures in dialogue with the environment. Unlike the *causal* approach, where the precise goal is known in advance and where the manager's role is to bring together and optimize means, the *effectual* approach involves exploring possible goals that are compatible with the logic of the evolving autonomous system. In practice, of course, management must implement both causal and effectual procedures, but too many companies are managed as if projects could only be designed in a causal manner. The inevitable emergence of solutions and self-organizing goals is then considered a sort of unexpected goodwill that unwillingly seizes the Cartesian manager bent on thinking in a linear way. Thinking in a nonlinear way, on the contrary, means accepting that sometimes "means stem

from ends", or at least that both fields are simultaneously evolving (in a more or less coordinated way).

2.5.2. *Anticipating breakthroughs*

In its long-term evolution, the organization is faced with breakthroughs, whether these be major changes in the environment or internal operating regime changes (technological, organizational, etc.). A major responsibility of the management is then born. Respecting the system's autonomy does not mean allowing it to steer itself, especially when it is giving off contradictory signals. Chapter 3, dedicated to the concept of weak signals, will highlight the importance of managers knowing how to decipher these and steer an organization in a state of flux. In the theory of evolving systems, these signals correspond to emergent phenomena typical of critical periods, to still-minor messages that do not respect the system's current representations and values. People also speak of "non-confirmatory" information in the sense that it is not coherent with the organization's current grammar, its *codebook*. The signal is not "weak" in an absolute sense, but relative to the system's interpretive ability. The role of the intelligent leader is to pay attention to it, for this emergent phenomenon may be the sign that is a harbinger of a future regime change.

How to miss a strategic shift by refusing to recognize the pertinent signals

Counter-examples are sometimes more telling than models given as examples. We could mention the very classical case of Kodak's misfortunes during the digital revolution. Before Sony introduced the first digital cameras in the 1980s, Kodak led the photo market. It was not enough to surpass its competitors in size; it dominated the entire technological and commercial system in that sector, from fine chemistry to (optical) cameras to clientele service developing film. Could we simply say that it did not see the digital revolution that would ruin its business model coming? Not at all, because we owe the invention of the digital camera to one of its engineers, Steve Sasson, in 1975. The firm's top management simply did not agree to go that direction at the time, with internal remarks like, "That's cute, but don't tell anybody about it". Why didn't they want to talk about this idea? Because it was a message that did not fit into the organization's dominant

language: “It is filmless photography”. Systemic inertia was assumed by the management itself. The genius idea was labeled as a non-pertinent signal.

The theory of *percolation* in physics constitutes a good metaphor for processes precipitating organizations into a structural mutation: the microscopic behaviors in opposition to the majoritarian rule (inverse magnetization, network failure, etc.) initially develop in an almost imperceptible way, but after a certain diffusion threshold of these anomalies, the whole system is upturned, with considerable macroscopic consequences (change in a magnetic state, material break, etc.).

Conceiving a breakthrough harks back to interpreting an anomaly. The anomaly is not considered as noise (to use Shannon’s expression), but as surprising information. In the Kodak example, we can clearly see that the management chose to treat the important signal as interference because it did not fit the nomenclature of acceptable information, as it did not confirm the dominant story.

The concept of *noise* can have even more meanings in the evolutionary theory of complex systems. The principle of “order through noise” applies to the evolution of autonomous systems faced with an external shock. In this approach, the self-organizing system can swing brusquely to another state (or operating regime) in response to an outside message that is unusual, one that does not confirm the current representations. If the new information is significant and does not fit into the repertoire known by the system, the system is led to rebuild itself at a higher level of complexity in order to face it. And if it is not capable of evolutionary adaptation, then it risks disappearing.

There are thus at least two types of unusual signals managers must pay attention to:

– signs that are harbingers of significant modifications, like microscopic reorganizations that precede a phase change before a percolation threshold;

– outside events that may potentially destabilize the structure.

The major strategic error in both cases is neglecting this information. An organization's management decides to neglect it, through either a form of fixed obstinacy or fear of change. These two attitudes are negative and harm the organization, both in the short- and long-terms. Whether they are presages of evolution particular to the system or an outside challenge, non-confirmatory information is not just "bad news" but something to be taken into account.

2.5.3. *Managing learning and encouraging agents*

Ancori (1992) analyzed memory and learning as articulated in the systems that neurobiology describes and developed parallel with the self-organization of economic and social systems. This type of work is interesting in terms of helping us to view the issue of adaptive complex systems from another perspective compared to those that have been explained up to now by asking the question: how do systems learn?

Biologist and psychologist Jean Piaget (1969) put forth a particularly instructive theory of learning, although it was developed for the field of pedagogy – a field that would appear far removed from management. We must be clear that this reflection on education is quite different from an analysis of the individual operations of the learner, for Piaget orchestrates the entire system of the student and the teacher (and the general context of learning). Adaptation comes into play in his reasoning and manifests itself as the search for equilibrium between the subject and the environment ("equilibration" theory). In learning, there is assimilation, i.e. the integration of new external data into existing patterns, then accommodation, which is the process of modifying patterns according to these data. Based on this fact, learning does not take place through the accumulation of knowledge; it is an abductive, nonlinear process due to these mental restructuring mechanisms.

In addition, the gaining of education depends on the student giving meaning to knowledge due to it being comprehended as an indispensible tool for problem-solving. It is therefore essential to constantly articulate the world of information with that of meaning, motivation and practice. This concept of learning fully applies to firms' management.

One of the identifying features of a CAS is that it learns. In the organization, changes may be the result of hierarchically given instructions as well as spontaneous learning. The more complex the system is, the more significant a role learning plays in its adaptive capacity, and this is distributed throughout the system. Thus, the art of management in these contexts is one of steerage more than strict control. Successful managers are comfortable with the notion of the organization as a place favorable for learning, and this in no way detracts from the boss's final power, which is to partly prioritize and/or decide between the alternate options that appear. Besides this "go/no-go" function, another dimension of steerage is the encouragement (or incentive) system that is put in place.

Significant economic literature has been developed on this subject, particularly in the wake of Richard Thaler's works (see Thaler 2016), which were rewarded by the Nobel Prize jury in 2017. The interest of economic science in questions that draw near to psychology goes much further back, with the founding works being written by Tversky and Kahnemann in the 1970s (notably Kahneman and Tversky 1979). The classic hypothesis of the perfectly rational actor has been questioned by this school of thinking, which has not hesitated to strongly consider experimental tests (an attitude that should be welcomed, as it is not systematic among economists). Today, experimental economists speak of "cognitive biases" to explain the difference observed between observed and predicted behaviors. Psychologists would speak of "framing effects" that shape a person's actions or decisions through the internal filtering and shaping of information.

A significant contribution by current research is distinguishing the *extrinsic* encouragement that private management or public policies classically put in place through bonuses, profit-sharing, taxes and penalties and so on and actors' *intrinsic* motivations. It has successfully been shown that the "principal" (the boss, the State, the insurer, etc.) can, in many cases, count on the (free) intrinsic motivation of the "agent". We use here the vocabulary developed by the economic theory of incentives in situations of asymmetric information (agency theory). Research on various concrete "principal-agent" situations has even highlighted cases where the extrinsic (read: monetary) motivations come to undermine intrinsic motivations. Steering a complex system with humans is also taking these realities into account.

Steering this kind of system also depends on new managerial instruments called *nudges*. Ouvrard and Stenger (2018) analyzes new forms of complementary regulation or even regulation that can substitute classical instruments in the case of environmental policies. The nudge is a useful motivation, a helpful hand, given to an actor wishing to influence his or her behavior in the sense desired by the organization. The policy of nudges is the art of exploiting "cognitive biases" like those that behavioral economics has pointed out. Such a policy also allows people's internal locus of control to remain intact. Cognitive biases are actually attitudes or motivations that classical economic reasoning does not wish to consider (due to epistemological closed-mindedness) and that experimental economics reveals, whereas they are central to behavior for a psychologist or neuroscientist.

2.6. Closing remarks

As Henri Atlan explains very well, the living world corresponds to a category of intermediate complex systems *between the crystal and the smoke* (Atlan 1979). In the absolute order of the crystal, everything goes so well that nothing fundamentally changes in the environment. The crystal is hard enough to resist most attacks without any modification in its appearance. However, faced with an overly strong external constraint that upturns its arrangement, it breaks.

The smoke is an organization made up of matter with so little structure that nothing seems to affect it; it adapts to every variation of the environment.

The crystal is not an ideal model for the organization of the firm, for very rigid hierarchies and fixed routines cannot promise anything good in terms of adaptability. The smoke is not a desirable model either, because it is the paradigm of constant chaotic change, as nothing can become embedded. The ideal firm does not exist, but we can at least define a living firm: it is an organization whose structure presents enough order to give it an identity and enough flexibility to change this word as necessary.

That leaves the question of the ideal manager. Biologist Alain Prochiantz, in an interview for the French daily newspaper *Le Monde* (June 13, 2018) concerning the relationships between art and science had this to say: "what draws the artist closer to the scientist is most likely that ability to grasp what is beyond the image, to seek the invisible behind the visible." The creative manager that every adaptive complex system needs also matches this description. Let us hope that the engineers, businessmen and financial officers who are often at the head of companies will know how to be both researchers and artists.

3

Steering Complex Adaptive Systems: Managing Weak Signals

In the previous chapters, we highlighted the need to look at organizations as complex, evolving systems, i.e. discussed how they adapt in multiple, often self-organizing ways that can be steered but not controlled. In this chapter, we will return to the concept of the complex adaptive system (CAS), understanding that adaption includes the twofold ability to *adapt on its own* and to *bring about desired changes through governance* in response to external or internal challenges. A synthesis of these two objectives leads to the concept of *guided self-organization*.

The goal of this chapter is to understand what is happening in the organization and what explains its apparent behavior in order to guide us in both the design and management of such entitites (including new firms and complex projects). We will often use the term "steer" rather than "manage" in order to draw attention to the fact that, as with captaining a boat, proper governance involves considering the behaviors of both the boat and the sea – understanding that both are critical to undertaking a successful voyage. Steerage cannot be a fully deterministic activity. Consequently, it is a more innovative use of the term management.

The classification "adaptive" corresponds to an intrinsic quality of the CAS organizational system. A crucial aspect of adaptability is the emergence of the phenomenon that we will call *weak signals* and the

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capacity within the structure to identify, read and interpret them. In a cognitive description of the system, we are dealing with atypical information, in the sense that it does not match what individual mental models, or organizational routines, are used for recognizing and processing. In a linguistic metaphor, we could speak of foreign words that our ordinary syntax is not prepared to articulate.

For the organization, the *weak signal* is information that is off the radar, outside the normal parameters of relevant information or easy interpretation – hence the proximity of this concept with that of "noise". The concept of noise is used in many contexts to similar effect – in electronic systems, it is unwanted signals or disturbance; in the theory of information, this unwanted data clutters up input quality. The art of the observer or system steerer lies in spotting this information as potentially relevant and in distinguishing it from global systemic noise. Therefore, how can we detect such exotic signals? And how can we build a language capable of interpreting them in a meaningful and shareable way? This is the steerer's role, and this is what sets a real leader apart.

A person who knows how to manage business in a stable state does not need to be an entrepreneur in the noblest sense of the word. Yet stability is not the common state for a complex system such as an organization for any period of time – a state of dynamic flux comes into play, and indeed an organization is a system of "multiple states of flux", meaning that there are always some areas which are stable, some bedding down change and some in a state of dynamism or change at any one time. In order to cope with such differentiation and potential ambiguity, those who lead and manage successfully in such an environment are "complex thinkers", a competence allowing them to deal with this state of messy yet normal emergence.

This enables them to be visionary, yet visions and mental representations that break away from the usual schemata cannot be pulled from a magician's hat, relying just as much on accumulated experience and the synthesis of knowledge and experience (into what we call *wisdom*) as on the visionary individual's imagination. An essential aspect of knowledge likely to feed such strategic intuition – visions that are pertinent to the system's future – is this

category of weak signals that emerge in the organization, most commonly at the interface between the organization and its environment.

3.1. Navigating the ocean of signals

Weak signals are atypical forms of information and thus ones that risk going unperceived; however, they must also be distinguished from rare, insignificant events. The art of steering lies in recognizing them as signs that are harbingers of change, and once they have been recognized, we must know how to wait for the right moment to act on them – or more precisely, with them. They may be internal or external: an unexpected change in the boat's behavior or an indication of a coming change in the weather conditions. They are emergent properties in the global self-organized system, and they must be processed simultaneously with the other, more typical dynamics of the system, like the inertia that we will deal with later in this chapter.

3.1.1. *Understanding the nature of the ocean*

It is clear that the system we are observing here is halfway between order and disorder or, in Henri Atlan's words, "between the crystal and the smoke" (Atlan 1979). We can also use the expression *chaordic*, i.e. a mix of order and chaos.

The "chaordic" organization

The term "chaord" was coined by Dee W Hock, the founder of Visa Card International. Hock (1999) refers to the birth of a chaordic age, and Hock (2005) analyzes the management of VISA as an example of a chaordic organization. Such complex, dynamic systems are ordered but not completely foreseeable.

The definition that contemporary science gives to *chaos* is not pure randomness, as although the path appears random, it is actually following a specific scheme (a "fractal teleology"), in which the trajectory path is shaped by "attractors", which cause the seemingly random behavior. For example, no one can precisely

forecast the weather conditions a few days in advance, but at least all of the possible states are known and even a list of the most probable ones.

The events that manifest themselves in chaordic organizations are never exactly the same twice, but they appear in a sufficiently ordered way to avoid leading to complete anarchy, and to allow change to be embedded successfully (something that those who constantly layer one change on another do not understand the importance of).

For such a system's management, the name of the game is knowing how to subtly steer the organization by playing on the interconnections and seeking new stability conditions through a policy that is more motivational than authoritarian. Knowing how to recognize and act on the weak signals requires managers to demonstrate the abilities to observe, identify and strategically adapt. Part of what is considered by the observer to be a weak signal is in fact already a form of systemic adaptation, often pre-emptive in nature. The goal is to formulate strategic propositions that take this emerging information into account, undergoing organizational change by dynamically steering it instead of trying to get it to adhere to locked-in strategic plans that will, by default, be wrong. This is what distinguishes deliberate, planned strategy from emergent strategy in the traditional managerial literature. The chaordic organization floats between order and chaos, and its strategic management must navigate between the two risks of planning (utopic and inefficient) and business behavior that goes with the flow through simple reactions to events (which is not strategic).

3.1.2. *Observing the ocean*

Once we begin to understand how things are connected in a complex system, it can become overwhelming as we see increasingly more connections – the team is a system but connects with the department, the department with the section, the section with the company and the company with the market – just like a Russian matryoshka doll, there is one inside the other. Complexity shows us how each influences the behavior of another – hence the term

co-evolving complex systems. Just as the political or economic environment impacts an organization, so the organization can impact the environment, especially if it is large, and creates a significant positive or negative impact on the system. One is not independent of the other. Yet we cannot work at every level of the system. Our scope would be impossibly large. Therefore, how do we know where to draw the boundary and concentrate our gaze?

3.1.2.1. *The system dynamics lens*

The best way to consider this is to remember that "the question bounds the system". This means that at any one time, we look at a particular aspect of how that system is operating, whether to improve something, deal with an issue, report on operational progress, design a new strategy and so on, the part of the system to look at is what is relevant to the question being asked. This stops people from being overwhelmed by not knowing what to leave out!

In our metaphor of sailing the sea, the sailor knows that the boat is not distinct from the ocean, but is instead part of an interactive system formed by both. The quest of adapting during the dynamic voyage includes the consideration of many things – the "internal system" includes your supplies, the capabilities of the boat, time constraints and the experience and skill of the crew. External conditions include weather conditions (both forecasted and emergent), tide, wind, current and wave size and type. The skill of the successful sailor lies in identifying both weak and strong signals from various parts of the system – reading the interconnected system and keeping their radar up to pick up changes in any parts of the system, then deciding on how relevant they are (both identifying and understanding the signals).

In terms of a company's long-term strategy, this co-evolution of internal and external conditions gives us another way to look at a major strategic choice: adapting to the environment and/or building an environmental niche. Co-evolution means adapting its skills to the environment and also adapting its environment to its skills.

Apart from *evolutionary* change as discussed above, there are also events that better match *revolutionary* change in complex systems,

when external events have a large impact and change the internal dynamics of the system – in this case, the organization. The general theory of adaptive cycles explains resilience in terms of a system's slow accumulation of resources and increasing connectedness, which lead to decreasing resilience over time. Thus, in order to adapt, these cycles are interposed with stages of crisis, transformation and renewal (Holling *et al.* 2002; van Eijnatten 2004). The interdisciplinary theory of complex adaptive systems offers a number of models that we can use to understand this process. Prigogine's model of *dissipative systems* is used when describing convection, cyclones, hurricanes or chemical bifurcation, which then change the state of the system. *Panarchic systems* (Holling *et al.* 2002; van Eijnatten 2004) add a further level of detail, which is the different time frames of evolving hierarchical systems with multiple interrelated elements that sit within each other and act upon each other in an organization, creating the possibility for a fast jump loop (revolt, innovation) that allows small-scale local change to quickly affect the much larger evolutionary path. Panarchic loops exist in all natural settings – a forest is such a loop, with a cycle of new trees requiring at times the death of old forest. In the living world, as in organizations, we also observe systems that reorganize at a higher level of complexity following external shocks throughout their lives (Henri Atlan). In this situation, there is a direct connection between environmental shocks and the internal mechanisms of self-organization.

The butterfly effect is a term sometimes used for a small input having a large effect, and we shall explore this further into this chapter. Of relevance here, General Stanley McChrystal (*Team of Teams*) writes that this term is commonly misused in popular culture, having become synonymous with "leverage" – the idea of a small thing that has a big impact, with the implication that, like a lever, it can be manipulated to a desired end. This misses the point of Lorenz's insight. The reality is that small things in a complex system may have no effect or a massive effect, and it is virtually impossible to know which will turn out to be the case.

A specificity of complex systems is the existence of nonlinear connections. In linear systems, cause leads to effect in a way that can

be planned and traced, and even though the path from one to another may be complicated, the *known unknowns* can be defined and built into a forward plan. In complex systems as discussed earlier, the path to the outcome cannot be predefined as it emerges along the way, only becoming clear when tracing back the journey. Gupta and Anish (2011) describe organizations evocatively as "webs of non-linear feedback loops that connect to other people and other organizations by webs of non-linear feedback loops". This is a great metaphor for explaining why it is so difficult to trace how a process or idea grows, travels and changes over time.

Another thing that is useful to apply to organizations in dynamic environments is that cause and effect are proportional to each other in linear systems or processes, whereas in nonlinear cases, they are not, making it less easy to predict the impact of activities and the reactions that occur at both the individual and organizational levels. The explanation for this in system's terms is a little technical, but we are all familiar with examples of organizational change or political unrest where a large action has caused very little impact, and also where a small action has had an impact way out of proportion, often called the butterfly effect.

The technical reason is linked to our previous discussion on the stability of organizations that at any given time, some parts of an organization are stable and other parts are changing. For example, one department may be undergoing a restructure, an IT system change or new operational equipment. This is called *multiple states of equilibrium*, and for this situation, there are always multiple solutions – one reason why strategy is more difficult and long-term plans will always be wrong! In linear systems, there is one stable state (equilibrium) and hence linear processes can be optimized; on the contrary, complex processes and systems, such as organizations and economies, cannot – something many theorists, consultants and leaders fail to understand, with negative consequences.

Thus, organizations are by nature paradoxical, travelling between drivers for stability and control and the opposite ones of decentralization and adaption. This is accentuated by organizations being a human system, as people require fluctuating levels of security

and stability, excitement and innovation. Leading such a dynamic system has been likened to being the conductor of an orchestra who knows the whole music score and thus coordinates each instrument accordingly, or Meadows' lovely description of "dancing with the system". It is a critical skill because if the organization is too driven towards stability, then it will fail, as it cannot adjust and change as required, but if it is pulled into chaos, then it disintegrates, so a successful CAS lies at the border of stability and instability – on *the edge of chaos*.

3.1.2.2. *The economist's lens*

The paradox is that chaos could bring more stability in the long-run as long as it can be brought back into a level of order. We can draw a parallel here with the concept of crisis in economics. Jacques Attali speaks of "order from noise" to characterize the crisis, which is undergoing systemic evolution through qualitative leaps. The expression *order from noise* comes from the theory of systems (Heinz von Foerster), and *noise* must be understood as *random perturbation (or deviation)*. Such perturbations can help a self-organizing system to find more stable states in its "fitness landscape". Unexpected signals contradict old logic and lead to a new form of organization through a systemic crisis. Attali (1976) explains that *crisis is the installation site of order and not the exacerbation of disorder within organizations*. The crisis is not a breakdown, but a process of resorbing imbalances accumulated throughout the previous period of "normal" operations. It is therefore system metamorphosis.

In the latter approach, order from noise, the weak signals may be local micro-crises that pre-empt necessary global reorganization, but that an inattentive observer would not pick up. At the international level, for example, Attali reminds us that large worldwide crises generally start with one country, maybe even a simple, local event, before spreading across the planet. Shrewd analysts can anticipate global metamorphosis if they decipher a sign that is a harbinger of global crisis in a weak signal, if they perceive a serious contradiction within the system as a whole.

Sources of metamorphosis: systemic crisis or exogenous shock?

From an economic vantage perspective, at least two detailed models can be distinguished to explain the metamorphoses of living systems and particularly human systems:

– In the tradition of dialectic thought, particularly under the influence of Karl Marx in the economic and social sciences, radical changes in systems' structure and logic are explained by internal crises brought about by growing contradictions within the old system. This resembles spontaneous self-organization as described in physics, going through percolation thresholds. In mathematics, this also reminds us of catastrophe theory (René Thom), where continuous processes end up causing qualitative leaps.

– In a tradition inspired more by biology, an outside shock can trigger the self-organization process. Economist Jacques Attali applied this model to the interpretation of global crises. He stated a theory of order through noise inspired by thermodynamics, but typical of social systems: "When an energy structure organized by information is attacked by noise, something invisible to the structuring code, this noise can end up structuring the organization into a new hierarchy founded on a new informational level, itself defining a new set of codes in relation to which any other informational level is noise" (Attali 1976, p. 93).

To return to our concept of complex adaptive systems (CAS), we can reinterpret them in the framework of *order from noise* theory by stating that as part of the adaptation process, weak signals are created through the system reacting to changing conditions, mainly on the periphery of the system (in this case, where the organization interacts more directly with the environment, such as clients, vendors and partners). They are often mistaken for noise (irrelevant data, unacceptable interference) as they are not predictable. They are unexpected and often invisible to most actors whose perception is still being shaped by the strong signals of stated goals, rules, measurement of what is seen as relevant data and so on. They are structuring interference because they will bring about systemic evolution, which will take place according to the system's self-organizing logic. Indeed, the system maintains its identity through metamorphosis: the butterfly's genes are the same as the caterpillar's. The ability to adapt manifests itself not by having seen the direction of the future in

strategic plans, but by being able to pick up such weak signals, to observe and understand their importance and to move to act on them in a timely way in this dynamic situation. Put another way, it is the ability to reorganize according to a new "grammar" imposed by the appearance of some new "words". This adaptation is the manifestation of system resilience, which is not inertia; quite the opposite, it is proof of the ability to change.

3.1.3. *Taking a course*

Since we are talking about human systems here, it is important to introduce the dimensions of choice and intention into our analysis, as we are reminded by Mitleton-Kelly (2003) in particular. The innovation process, for example, is a major case of human CAS at both the micro- and macroeconomic levels, characterized by the intention and will of the person Schumpeter calls the *entrepreneur* (see Chapter 4 of this work for other definitions of the entrepreneur). This project leader, the actions of whom may change an entire aspect of the world in the end, is a strategist. To further his vision, he makes use of information, skills, financial means and tactics to convince and lead partners. This human dimension is essential in the process through which a new order will emerge by adopting new ideas, objects, methods, attitudes and so on.

3.1.3.1. *The necessary autonomy of individuals*

In a system involving humans (alongside physical and virtual artifacts), there is one essential point to consider: all people seek to maintain a position of internal control over their thoughts and actions. If they are placed in a situation where they have no choice, this will create anxiety, which, in turn, not only triggers health issues, but also creates forms of disengagement, non-cooperation and even marked aversion towards the organization. The organization will not only lose potential creativity, but also suffer in its ongoing activities. A bad manager ignores the intrinsic motivations of other actors.

Good leaders, on the contrary, know that in order to ensure "intelligent" operations in the organization, they must create an

understanding of the organization's intentions and goals shared by all of its members (Kerr 2014). It is a powerful concept to manage the organization like a thinking system made up of individual human intelligence, which, if aligned, can create amazing outcomes shaped and driven by succeeding in a shared goal and intention. Creating a collective intelligence is part of the goals that governance must set for itself. When the vision is clear and shared in regard to what the organization is there to achieve, it is possible to develop the desired abilities to learn, adapt, innovate and be resilient.

3.1.3.2. *The role of human interactions*

Shared intention is created through interaction and connection. These are therefore central in the operations of the CAS. They predominantly take place through informal networks of individuals, which are based on relationships. This flow of horizontal exchanges is distinguished from the formal information and communication networks that are orchestrated by the hierarchy (Wheatley 2006; Seijts *et al.* 2010), and in an adaptive organization, both work well in terms of allowing people to gain the information they want when they want it, in the most useful way and at the right time.

Informal communication networks are essential in the management of weak signals, as often the information is not in a form that can be formally presented to those measuring what is "valid" at that time.

Liant (2007) analyzes intelligent CAS, capable of operating in environments rich in knowledge and requiring rapid reactions and learning. These organizations are also characterized by knowledge of how to co-evolve with their environment, hence a "smart survival" evolutionary model. For this, they must know how to renounce the bureaucratic fantasy of total control and allow the system to exist at the margins of self-organization (although with enough structure and rules that there is clarity around things such as purpose, values and operational learning). Complex thinkers understand that any attempt to force through vertical control will also lead to forms of self-organization, however these may be opposite to the desired direction, and in the less severe cases, will result in behaviors such as white

anting (tricky sabotage), obfuscation, creatively getting around the rules and shadow systems.

One result of a state of allowing guided self-organization is that it brings out unexpected ideas, often through a greater ability to read weak signals. The art of governing these intelligent CAS is summarized beautifully by Lichtenstein and Plowman (2009, p. 628): "Emergence can lead systems and leaders can foster emergence." For this, the design and implementation method of the organization's strategy cannot be linear; for beyond the linear informational categories of *known knowns* and *known unknowns* (classical strategic planning works on such variables and tries to quantify a degree of potential uncertainty), there is the *unknown unknowns* category that exists in complex systems, created by the process of emergence. This state of "we do not know what we do not know" cannot be brought back into a predictable, linear category, but instead should be listened to in order to learn what is changing, what novel conditions are emerging, and thus how the CAS may self-organize around them.

3.1.3.3. *The maturation preceding emergence*

Weak signals potentially have the ability to spread throughout the entire organization and to become "common knowledge", but initially they are hardly detectable to anyone other than those close to the source of such signals. They can only manifest themselves through complex interactive processes that are not apparent as at this early stage of emergent change as they remain informal. By the time the organization's management is able to detect these new signals, recognize their significance and act on them, they have already been identified and somehow captured by a select number of people who know they somehow matter. They have an underground life in various types of groups.

Such groups do not have to be in a specific unit or from a particular area. Sometimes there is a *shared neural network* of knowledge (Kerr 2017) that leads to a shared understanding of what to look for in the changing landscape. This typically occurs at the intersections and edges of the organization where people interact with each other and the outside world in different ways. Thus, it is vital to allow such

"boundary riders" to have a voice mechanism through which to communicate. In adaptive companies, these people are valued – they are the canaries in the coal mine and have invaluable insight.

Another group of people who are relevant here can be understood via the theory of communities of knowledge described particularly by Cohendet *et al.* (2006). Firms – particularly large ones – benefit from the cognitive contributions of informal groups built around a particular field of knowledge, practice or theory. These members of the organization voluntarily take part without official reference to the hierarchy in the construction and the exchange of a repertoire of resources in terms of information, knowledge and know-how surrounding a given profession or function; they construct a shared identity and behavioral norms particular to them. These communities greatly contribute to the maturation of new ideas. In a description of the firm as a cognitive system that is permanently learning, Amin and Cohendet (2012) define it as a *platform of communities*.

3.1.4. *Navigating in symbiosis*

Communities of knowledge are often organized around professions: computer programmers, machine repairmen, designers, scientists and so on, which can exist across different organizational silos or sections. Like people with a passion for an activity that is their hobby, these communities often spread through the "firm's frontiers", for people have exchanges among themselves with no particular respect for organizational perimeters and demonstrate greater solidarity between themselves than with their respective hierarchies.

This cross-connection is a rich source of adaptivity as it allows diverse ideas and information to be combined across hierarchical structures, and adaptive companies not only allow, but also encourage such cross-collaboration by rewarding the activities and outcomes that support it. However, in many of the past economic and hierarchical management models, this type of activity is not seen to meet the interest of firms because they do not recognize or reward the benefit they gain from the common construction of new ideas, practices and competencies.

From an economic viewpoint, the concept of creativity founded on externalities of knowledge was described for the first time by Alfred Marshall in the early 20th Century in his theory of *industrial districts*. Let us recall that for Marshall (1920), the ability of companies to innovate in the first industrial revolution is explained by external effects that belong within precise territories (like Manchester). The field of externalities of knowledge constituted by the first communities of entrepreneurs and workers was a creative factor shared by the entire sector-specific ecosystem. The history of Silicon Valley is also that of a Marshallian district, but in the age of globalization, as shown by Saxenian and Hsu (2001), the interpenetration of communities, which has led to an exceptional surge in major innovations, has spread to both sides of the Pacific, even though the location in California has played a key catalyzing role.

Such shared sources of value remain generally hidden, in the form of many weak signals, until the formal emergence of ideas. Explicit formulation is certainly an important stage for organizations' management, but the underground creative factors were already at work, both produced by and impacting the system in as yet unrecognized shifts. Historically, numerous large enterprises have recognized the importance of the communities of knowledge phenomenon – under a variety of names and noting a range of facets of the phenomenon such as communities of practice for Xerox technicians (as defined by Wenger 2000), learning groups at Hewlett-Packard and knowledge networks at IBM. These reflections have upset the conception of managing change in an organization (knowledge management). If *management by communities* is practiced, as suggested by Amin and Cohendet (2004), then there is a certain degree of refusal to introduce creativity through a hierarchical approach (*management by design*) with its emphasis on quantitative reward and measurement. Instead, a learning infrastructure is created that motivates and lends value to the communities' social dynamics. In this framework, work is done through intrinsic motivations (encouragement, symbolic compensation, nudges, etc.) rather than principally through extrinsic ones (hierarchical control, premiums, etc.), as we mentioned in Chapter 2.

The informal communities that exist in a CAS is one of the features that allow them to function as ecosystems (Attour and Burger-Helmchen 2014), maturing over the long-term by not only producing creative systemic modifications in their own ecosystem, but also co-evolving with the system within which they exist. Mittleton Kelly calls such organizations complex, co-evolving systems (CCS). Think of the image of underground roots shared by mushrooms (spreading synergies with other living creatures such as trees). The emergence phenomenon in an organization must often be understood as a self-organizing process within a larger system. In this highly interconnected world, all emergent behaviors are rewarded (whether positively or negatively) and interconnected via feedback loops, although not necessarily in a formal, official manner. The participants' intrinsic motivations suffice, generally, to maintain motion. Seijts *et al.* (2010) recall the small world of actors, sometimes physically distant from one another, who communicate thanks to a global society that is becoming increasingly interconnected. This is the paradox of "globalization", which causes certain local events to have much larger repercussions in a short time frame.

The smart leader's art lies in detecting these weak signals and partially hidden mechanisms to surf on the unpredictable ocean of emergent information instead of trying to impose plans elaborated over a long period of time to try and control the system. Complex systems are nonlinear, with multiple feedback loops, high levels of interconnectedness and a range of both dynamic and static states across the system, all of which produce emergent behavior. This makes linear thinking at best oversimplistic and inaccurate, and at worst dangerous with regard to strategy and governance.

3.2. *Managing interdependences and dancing with the system*

We have already pointed out that communities of knowledge go beyond the limits of organizations. Furthermore, the complexity of the economic interactions has extended yet further with globalization. The current overlapping of companies' value chains and their attempts to impose hierarchical organization (capitalistic ties, subcontracting

chains, etc.) create a context where peripheral events can easily trigger a series of impacts spreading throughout the global structure and climbing as far as multinationals' headquarters. This is the meaning of the small world proposed by Seijts *et al.* (2010). Here, the notion of a weak signal is described as the spreading of ideas and new representations that start at the periphery and not at the center. The signals are perceived as "weak" not only because governance did not plan them, but also because they are difficult to recognize by those who see change as a centrally controlled process, rather than as a possible result of peripheral events (sometimes happening at geographically and culturally very distant locations). Moreover, through various instances of translation on the journey through organizational channels, the initial message often arrives at the center in a very different form, especially where there is a lack of adequate measures and methods of identification and capture. All of this makes governance a delicate task, as the weak signals are both significant (they have already initiated change) and ambiguous. Interestingly, these signals are not ambiguous for those closest to their origin and hence these people recognize that something is changing. However, these people rarely have the agency to share their suspicions, and as there is not yet clarity as to what a subtle shift may mean, in a hierarchical organization that is commonly driven by quantifiable data, such intuitive insight is not seen as valid input.

Here we require a more precise analysis. What are weak signals and why are they weak? This concept is linked to the issue of sensitivity to initial conditions. The structure of the system and the general rules of the organization strongly condition the impact of such novel information.

Weak signals are small shifts that allow the new and novel ways in which a system may be adapting to be identified. They are weak because current practice rewards stability, and it contains strong connections and feedback loops to maintain that stable state, including processes and infrastructure that reinforces current methods, even in the face of mounting evidence that change is necessary. The weak signals, made up of what Aaltonen and Sanders calls *perking*

information, have not been strengthened or reinforced in any way, either in individual thought or action or in the organization as a whole.

Perking information is made up of the small ripples that are taking shape just below the surface in emerging conditions and changes, but are not yet visible. They are especially difficult to see in emergent rather than planned change, as they are a consequence of local interaction among people at a local level, and are not as easily identifiable or monitored as in planned change. Yet they are the norm in a CAS. As local interaction is based on local principles, rules and beliefs rather than via a plan imposed by a CEO or a director, this reinforces the need for the leader to have created a shared mental model of purpose, goals and values to align and guide rather than attempt to control activities at many levels.

The signals are also weak because at an individual or whole organization level, more effort is commonly put to maintaining present practice than to acting on evidence and shift, and this can be explained in CS terms. Complex systems have a natural resistance to absorbing and applying information and forces that show a need to alter the present path, as it requires the system to make more effort than it puts into maintaining the status quo. This can be a biological CAS trying to maintain homeostasis, the equilibrium of technical CAS or the entrenched patterns of behavior in human systems. The feedback loops that reward behavior already in the system are well established and on automatic pilot, so any shift requires energy to pattern break, taking apart the current ways of thinking and doing and building new ways in their place.

3.2.1. *The transmission of signals as a creative process: the example of composite materials*

When we speak of signals that spread in organizations and between them, such signals are not concepts such as standard signal (in electronics, in Shannon's sense). We can now see them as something more complex, emergent and qualitative. Weak signals are forms of knowledge that have evolved from one micro-context to another, like chains of translation from one language to another.

The adaptation of a message through translation is always an operation that modifies the meaning. *Traduttore, traditore*, as the Italians say. In reality, there is no "treason", but depending on the case, simplification, enrichment, extension to a broader semantic field or, on the contrary, a more specialized one, occurs. If there is spread, it is not identical, but according to a process of adoption-adaptation at each stage of transmission, further altered by the local micro-environment.

We find the same idea in the theory of *innovation diffusion* (Rogers 2003; Mercuri-Chapuis and de Bovis-Vlahovic 2016). The first works by technological historians built models of homogeneous innovation diffusion in a sector and/or country using simple models like a logistical S-curve. However, if models like this can be used to handle cases like the progressive mechanization of agriculture, in many recent technological fields, we can observe more of a creativity process throughout the diffusion. At each state, the adopter adapts the technological idea to his or her problem, which causes the idea to evolve. Finally, innovation is created through the very fact of its diffusion. This is what can typically be observed with the emergence of technical composite materials in the 1970s and the 1980s: "The developmental progression of this technology is very characteristic of the progressivity with which technologies are generally created using a chain of technical solutions" (Zuscovitch and Arrous 1984, p. 185).

In the technology diffusion chain of technical composite materials, each new adoption of the general principle was also a chance for the adaptation of solutions tested in a new situation. Creativity not only precedes diffusion but also manifests itself throughout the chain. These innovations that can be classified as incremental contribute to the reinforcement of the technological paradigm as well. It is only after an entire phase of diffusion with multiple adaptations that we can say: "the principle of composite materials is a major innovation".

The first composite materials

When the first high-performance composite materials (CM) were invented for spatial applications and/or in connection with national defense, no one expected the "composite principle" to become the rule a few decades later for designing parts in major production sectors like aeronautics and then automobiles and mass-marketed consumer goods (golf clubs). Let us recall that CM is an assembly of at least two distinct components that are not mixed, but which have a great ability to interact and whose properties complement one another. The CM has properties that its components do not have on their own. In retrospect, the first very expensive and very specific applications, e.g. ones based on Kevlar or carbon fibers, can be considered weak signals that were harbingers of the current methods for designing materials à la carte. Today, this "language" of technical design has become the standard. We can even use it to speak of products much older than the expression CM, like reinforced concrete (a macroscopic composite of concrete and steel) or natural products like wood (a microscopic composite of cellulose and lignin). The initial invention, being exceptional and specialized, became the paradigm for a new way of seeing things.

From an economic viewpoint, another characteristic of innovation through the accumulation of adaptations is that it places the dialogue between the providers and customers of technical solutions at the center of enterprise strategy. CM are functional materials in the sense that they are designed to meet a demand for precise user functions. Based on this fact, interaction between organizations is essential. The subject of innovation is not an individual economic actor, but a complex inter-organizational system. The conclusion we can arrive at upon analysis of the spread of CM in the concerned sectors is that "competition plays more on the ability of firms to manage customer-provider networks and industrial partnerships" (Willinger 1989, p. 65). Current discussions on the concept of open innovation cannot help but revisit this idea – but based more strongly on major technological developments of the moment, notably digital and the Internet.

In complex systems terms, CM development was driven by the emergence of novel thought, which occurs when actors in the system are interconnected and self-organizing enough that information can

flow as required along human networks, allowing them to apply diverse views and knowledge, learning and building layers of individual knowledge into the *bricolage of a new concept*. Open innovation incorporates many of these elements, but both outbound and inbound innovations need absorptive capacity. Cohen and Levinthal define this as "the ability to recognize, assimilate and apply relevant new external information" and they consider that the organization needs prior related knowledge to assimilate and use new knowledge. They call those who enable this to occur knowledge catalysts, who can bridge the organization and the external environment. An adaptive organization with minimal structure and the capacity for cross-connection also fosters such capacity.

Our conclusion in terms of signal transmission in complex systems is that the process cannot be planned or modeled linearly (expressed with diffusion curves for an unchanged object), but through creative interactions that modify, and sometimes amplify, the signal while spreading it.

3.2.2. *The nonlinear changes at the source of evolution*

A cybernetic metaphor is often used to speak of the cognitive evolutions observed in interconnection networks by suggesting nonlinear transformation operations. Gupta and Anish speak of "networks of nonlinear feedback loops" that connect people with one another and organizations with others of their type (Gupta and Anish 2011). The result is that the nonlinear properties produce qualitative modifications that cannot be predicted as they emerge over time, complicating the job of a manager who needs to maintain order and forecast results accurately. While the emergent path of change can be understood by looking back and seeing how the developments emerged, it is not possible to predict the path at the beginning of an emergent process. Thus, long-term strategic plans that describe the organization's journey through space and time are illusory.

Another characteristic of complex adaptive systems that makes strategy and long-term plans inaccurate is that in such environments, cause and effect are not proportional to each other, whereas in linear

systems, they are (a concept that shaped outdated "rational" management frameworks that saw organizations as both linear and controllable). A phenomenon that illustrates this lack of proportionality, and which is irritating for Cartesian minds, is the butterfly effect, where a small action in one place can have a disproportionate impact, even modifying the state of the whole system after a certain number of interactions. It also works the opposite way, with a large action having very little impact, again with little ability to predict beforehand. This is due to a phenomenon mentioned earlier, which describes the organization as containing multiple states of equilibrium (or flux). One of the consequences of the butterfly effect, which includes stability in some parts and metamorphoses in others, is that multiple states create the possibility for multiple solutions, rendering strategy and long-term plans precarious. Nor is it ever possible to expect a single, complete equilibrium in the system, as would be the case in a linear model.

Some managers or consultants still have a tendency to describe the system as linear, which is inadequate to say the least, even though they hope to do this "as a first approximation". This is not necessarily a sign of incompetence but of linear thinking, and a lack of understanding that while identifying what the parts of a system do, be it a car or an organization, it is the understanding of the connections between these parts that show *how* the system works. For some, it is a way of affirming their power by gaining hold through a simple and thus understandable and communicable schema. We find this temptation in the political world, for better or worse.

3.2.2.1. *The human characteristic*

The butterfly effect is a metaphor initially used to describe chaotic systems in atmospheric physics. Human complex systems also illustrate this coexistence of stable and evolving parts within the system. Indeed, individuals across the system have varying needs and preferences concerning stability or instability – a key element for a firm's innovation capabilities. Stability is preferred where security takes precedence. Innovation satisfies the need for adventure and excitement that is absolutely essential in the life of other individuals. The governance of organizations is complicated further by the need to

take this supplementary complexity of variable preferences into account, often made even more so by hierarchical position. To describe the manager's role, Meadows (2015) uses the metaphor of the orchestra conductor who "dances with the system".

The metaphor of the dancing conductor is interesting to express the idea that managing a complex system formed by a number of creative interacting individuals involves finding the right balance, avoiding two major pitfalls:

– excessive stability, which would restrict and even prevent system adaptation;

– an excessive push for change, which would render the system chaotic through a lack of capacity to embed change and learn.

Good managers are able to think about complexity. This does not stop them from occasionally using linear discourse that, for the same reasons of political rhetoric mentioned above, can have a cohesion effect of creating a clear, simple vision around shared goals that should be able to be expressed simply. However, they must not allow their own rhetoric to lure them into a false sense of simplicity or premature success. This is minimized in complex thinkers who recognize and are comfortable with the emergent state that complexity creates, giving them a different view of how to handle common management challenges:

– The relative inefficiency of chains of command and classical motivational schemes is recognized, and instead such managers utilize and build in "soft" motivational tools like *nudges*. Dancing with the orchestra can then be interpreted as the preference for methods reinforcing intrinsic motivations through listening to the individual instruments and knowing the score.

– The ambiguity of multiple options and signals, which makes it difficult to control outcomes and define processes. This reinforces the importance of knowing how to interpret weak signals.

Vis-à-vis weak signals, managers in adaptive organizations not only gain the ability to use "radar" to watch and listen, but also understand the importance of creating organizational *permanent radar coverage* to capture and interpret such signals. A key attribute here is to not only resist the temptation to refute disconfirming information, but also actively look for it. Indeed, some messages that do not respect the linguistic rules of the organization's discourse may be important to consider. They may be the ones that will structure the common language of the future.

3.2.2.2. *Virtual stability*

One of the fundamental aspects of complex systems that we have not yet described is their virtual stability. Richard A. Voorhees provides the following definition: "The ability of a system to gain in flexibility and become more maneuverable while maintaining its self-control to remain in a state that is normally unstable" (Voorhees 2008, p. 133).

These are normal states in nature, and they go so far as to constitute the norm in human systems. A cyclist's virtual stability allows him or her to operate a technical object that is rather unstable to be on. A surfer, who seems to be a prodigy for common mortals, has developed a system of reflexes that permanently compensate for the countless destabilizing mechanisms of his or her paradoxical situation (staying upright on the sea with a slippery board). Managing an innovative enterprise and steering global finances are other examples of exercising virtual stability. As for weak signals, virtual stability involves taking potentially revolutionary phenomena into account while feigning that the system is working as usual.

Virtual stability has a price: the system must have enough resources to assume a high level of permanent reactivity, or in other words, it needs some slack built into the system – when the state of instability causes the cyclist to wobble, there must be enough time to correct the steering while traversing the road. Indeed, if this person is

going too fast, or holding on too tight, he or she will crash! Ashby's famous first law of cybernetics, that of requisite variety, states that the variety of possibilities for controlling a system must respond to the variety of outside disturbances. For Ashby, it is not necessary to provide more flexibility than is necessary to deal with all possible eventualities, or in the words of requisite variety – to control the spectrum of variety in terms of ordinary environmental fluctuations. However, some additional resources could be put aside for highly unlikely, but high-risk events with a very strong impact (we could call this the Fukushima clause).

Maintaining virtual stability requires finding a balance between expending too much and not enough energy to correct the small alterations currently in the system. The extreme situations that must be avoided are:

– a too high level of control (monitoring), which could monopolize attention on irrelevant signals and particularly limit the possibilities for innovation;

– a too low level of control, which could create instability through a lack of synchronization with external fluctuations.

We can draw the following lesson from the theory of virtual stability: "life is not about stability, it is about managing instability (so as to produce the illusion of stability)" (Voorhees 2008, p. 137).

This is a good intellectual model for the ideal "adaptive" leader who understands emergence, interacts with it, knows how to identify weak signals and can act on them.

3.2.2.3. *Organizational inertia*

The opposite of creative motion is inertia. This does not always have to be understood in a negative sense. The system's resilience requires both the ability to adapt and the inertia to stay on course. However, an organization's management constantly faces pernicious inertia that runs counter to its ability to adapt.

One example, somewhat paradoxical, is that of the *optimism bias* created by initial strategic success. Individuals, like organizations, are often blocked by hanging onto old ways of thinking about how things should be done due to them having worked in the past. This can occur to the extent that they do not recognize that the context has evolved and these ideas are now less pertinent. Fixed thinking minimizes the ability to see that tomorrow will probably be different from today. The cognitive bias caused by initial success prevents atypical signals from being perceived, those emergent peripheral weak signals of perking information that are important to recognize. What has not been understood in the case of an organization that remains overly proud of its initial success is that this only represents an example of a possible attractor for the system – to use the terminology of chaos theory, revisited by Irene Sanders. The system can perfectly swing towards another attractor, and it is best if the management is aware of this fact.

Another source of inertia lies in the games of internal actors, with coalitions that lead to rigid political equilibriums. Game theory has taught us that a game's equilibrium may not be optimal – even in the very limited sense of economic theory (Pareto-optimal). In fact, in complexity theory, optimization is not the goal, as when one part of a system is optimized, it de-optimizes the rest and skews the capacity for system-level adaptation. Instead, maximization is sought through intelligently combining and aligning sub-goals while ensuring that one part of the system does not succeed at the expense of another. Inertia in games theory presents a paradoxical but stable systemic situation, resulting from the actors' behavior, such that everyone would be better off changing states to move towards a new balance, although no one is interested in moving on their own (Umbhauer 2016). In this so-called *prisoner's dilemma*, we can clearly see the eminent role played by informed managers if they manage to force movement through their hierarchical weight.

It shows us the need for strong leadership, supported by minimal rules and structure against which people can steer. Self-managed complex systems still have such things – they are not *laissez-faire*, disorganized mobs with no structure or goals, but instead, one of their key features is a clear, shared goal that is only achievable through

each part of the system working with others to do so. As organizations, they are actively shaped from both the top down and the bottom up, with the leader clarifying and maintaining both the organizational purpose and the rules around the values used to achieve such purpose, thus setting the tone and creating trust (or not, in some cases). They then tend and nudge in order to ensure that things go in the right direction but they do not get in the way of innovative ways to get there. Only when people go against the clear, value-based boundaries will they step in and enforce their power. Thus, people in such a system have a clear idea of where they are going and what the boundaries are and can innovate within this space. With too much structure, or too little, however, inertia will occur for different reasons.

3.2.2.4. *Chaordic operations of evolving systems*

Regardless of its own cause, inertia is a cause of organizational collapse due to a lack of flexibility. It can even become quite schizophrenic where the dominant discourse is at odds with the reality of a system that has already begun to change. Interestingly, in these circumstances, it is common for the only ones who do not recognize this to be the leaders still pushing the dominant discourse!

"Chaordic" systems, presented at the onset of this chapter, provide a model for how organizations either avoid or fall into this kind of crisis. At certain moments in its history, the system moves from stability to instability along the path of change before stabilizing again in its new state. This is a necessary course for adaptation, provided that it does not remain in this state of ambiguity for too long. As emphasized by van Eijnatten (2004), complex systems have discontinuous, evolving trajectories, and the order/chaos duality manifests itself particularly in the phases of regime change where the system's ambiguity is at its maximum.

In the phases of regular growth, the system is in a state of relative stability and modifications are incremental (see the textbox and figure below). Approaching the end of growth, the system seems more unstable. We can speak of bifurcation in the sense of system theory or a catastrophe in René Thom's morphogenesis models (1979).

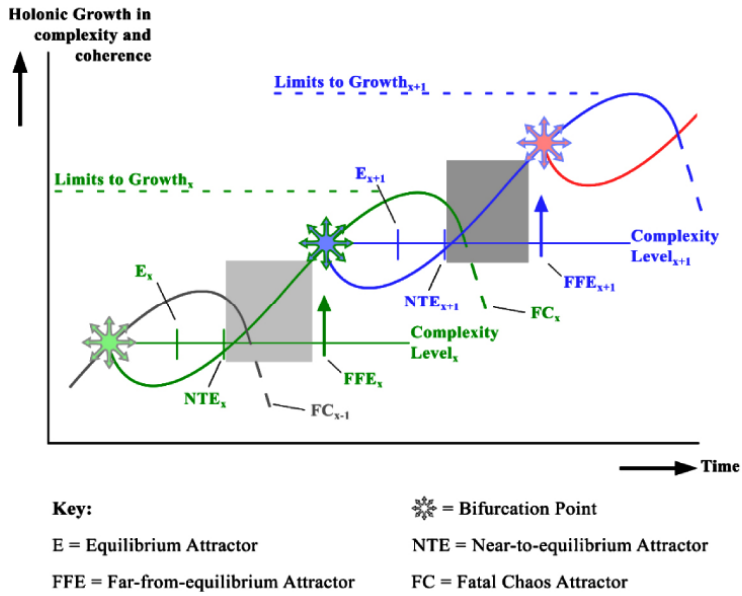

Figure 3.1. *The discontinuous growth of a chaordic system (source: van Eijnatten (2004, p. 431)). For a color version of the figure, see www.iste.co.uk/heraud/creative.zip*

Explanations: The trajectory of growing complexity and coherence moves from one attractor to the other (Ex, Ex + 1, etc.) via bifurcation points. The attractors are NTE (near to equilibrium), FFE (far from equilibrium) or FC (fatal chaos). In NTE, there is movement to a path of regular growth. In FFE, a crisis has begun that will lead to another possible state. In FC, the system drops to a chaotic situation that risks being fatal to it.

In the critical phases, the organization is in "the eye of chaos" with multiple possible paths. When the system moves to such a strongly nonlinear regime, it is also particularly sensitive to exogenous shocks. This can be a crisis situation in the etymological sense of the term: in Ancient Greek, "crisis" is the moment in the evolution of a disease where the patient is lingering between life and death. If equilibrium is reached by adopting new ways of thinking and doing, the organization will survive the crisis and grow through a qualitative leap towards a level of greater complexity. A new cycle begins.

3.3. Surfing on the wave

How can we manage to forget old dominant signals or move them to the background, especially in a period of crisis, to keep our ears open for new ones? Within an organization, it is not enough to change the boss's way of seeing things; everyone's mental representations need to be shifted, old practices changed, loyalty to old methods and processes questioned and the new behaviors that herald the way forward in the transition phase must be accepted.

The most successful way to reinforce changes in behavior involves initially tackling individuals' mental representations rather than dictating new actions to be taken. Unlike robots, humans must be mentally prepared for change. Contemporary psychology and experimental economics have taught us the importance of the phenomenon known as *cognitive dissonance*: a discomfort that occurs when a person's actions do not align with his/her beliefs. There is an internal drive that pushes the individual to change in a way that aligns the two again. Such alignment to doing something new is consistently more successful when people change the way they think rather than what they do – once they accept the need for the change, they change their actions accordingly. In a similar vein, the bias towards the status quo (a relative preference to that which does not change) is discarded more quickly if people know why there is change. They can then be more creative and positive about the question of how to bring the change about as they have an understanding of the underlying purpose.

3.3.1. *Preparing the actors means first listening to them*

The dominant signals are constantly reinforced by learning loops and infrastructures, which are set up to correspond to current methods. Even when faced with evidence of change, these routines produce powerful inertia against organizational adaptation. However, the weak signals are already at work. As described above, perking information (Aaltonen and Sanders 2006) are facts and representations that are just below the surface, often created by local interactions between agents. These barely observable phenomena, like wrinkles on the surface of

ordinary operations, bear witness to the existence of another barely perceived reality.

What management – truly wishing to observe weak signals to evaluate them can – do is establish a system that trusts and enables actors in a position to reveal them, knowing that most organizational system's rules rarely encourage this. The first step in preparing actors is thus giving them the right to express representations that do not reinforce the standard model, and even go against the mechanisms for aligning attitudes – mechanisms that, we must not forget, lie at the heart of the very concept of an organization.

Artigiani (2015) showed that the largest successes enjoyed during historical battles came from leaders who did not use overly formal and rigid plans of action (like the Royal Navy's permanent fighting instructions), but instead, allowed plans enabling dynamic changes in battle. This was possible because those who constructed the plans had spent many hours together building a set of alternative action plans based on common goals and values, and this shared knowledge of strategic alternatives allowed for easily broadcast changes in precise action. Building this type of flexible strategic skill involves largely renouncing fixed, comprehensive plans, as these are not adaptable when the environment changes faster than the strategy. It is much more a matter of building systems for reading the environment, observing local responses and understanding each other's agreed signals. This means knowing how to decentralize responsibilities, accepting the right to err, and above all else – the primary point we wish to emphasize – allowing on-site collectives to construct their mental representations of goals and tactical means based on what they see and not what the comprehensive plan foresaw.

3.3.2. *Choosing the right methods to design a strategy*

We saw above that preparing agents for change begins with the freedom to form their own representations based on local information at their disposal. These local interactions allow them not only to gather and synthesize local information (the "acquisition radar" to find weak signals), but also to share mental representations and the values

that will guide their action. This organizational method is more effective in complex situations than giving on-site teams formal missions. The objective is to establish a form of guided self-organization.

In practical terms, there are minimal tools available to organize the governance of organizations in a way that maintains ambiguity and identifies a future direction in a non-orderly environment. Aaltonen and Sanders (2006) proposed a classification of prospective methods based on categorizing them in a way compatible with the philosophy of complex adaptive systems. This is not the place to go into details on the nearly 30 methods found by the authors, but it is useful to look at some examples illustrating the typology proposed:

– The first category of methods corresponds to the engineers' approach and largely attempts to remove ambiguity. These apply to systems designed *ex ante* and managed using straightforward rules: science and technology roadmapping, genius forecasting, relevance trees and so on. These are useful for linear transactional problems, but they contribute little to complex issues or the emergence of new ideas within the organization and in dialogue with it.

– The second category of methods leaves room for heuristics by accepting ambiguity. The tool typically found in this category is the Delphi method. Let us recall that this method involves consulting the system actors during a number of stages and returning information aggregated at each stage to gather not only their information but also their future visions and their judgment of others' opinions, thus constructing a common representation. If this method does not manage to bring the actors together towards a common vision, it will at least have the interest of examining a set of contrasting visions from all sides and allowing the strategic debate to be organized on clear bases familiar to all concerned. Although Aaltonen and Sanders do not consider this tool to be typical of complex adaptive systems, we believe that it can help large organizations evolve in this direction. It is commonly implemented by an external designer and allows for some bottom-up control depending on how much the feedback is accepted and acted upon.

– The third category applies to an emergent system – through interactions between agents. Models exist to attempt to define rules for the future system. This is the domain of mathematic complexity (structural analysis, interactive scenarios, etc.). We believe that the drawback of this approach is not co-constructing the future system with the agents.

– The fourth category also applies to emergent systems, but working through heuristics. This is the domain of social complexity. It is a matter of participatory methods. Only in this last category can we find processes authorizing the emergence of truly new forms during operations by identifying future directions in an environment with no preconceived order.

The overview of known methods put forth by Aaltonen and Sanders shows that at the end of the day, there are only a few methods fully adapted to managing complex adaptive systems. Instead, the most common methods present a linear bias by imposing a consultation or calculation model. *Ethics of complexity*, on the contrary, would suggest seeking and preserving a wide variety of options for the future (without seeking perfection or working forever) by opening spaces where every actor can participate in a loyal and transparent spirit in order to collectively construct the future.

3.3.3. *Choosing a good steerer*

We can start with the principle that in order to steer a complex system, it is best to have a leader with the qualities of a *complex thinker*. How can we summarize these qualities? This chapter has strongly insisted upon the ability to detect weak signals – insofar as this atypical information is ambiguous and thus does not fit into quantitative analytical categories currently used by the organization. It is born of diverse input and diversity is critical for a healthy system. It is a condition of the system's adaptability (as defined by Loasby 2000). In many cases, weak signals are even harbingers of the system's future operations if its trajectory is recognized and supported, thus pushing it towards a new attractor (beyond the crisis) and creating a new path. From the standpoint of the organization's

structure and communication flow, it is best to reflect on whether there are current systems that can help the manager detect and evaluate these signals. However, if the head of the organization is neither capable nor inclined towards this kind of listening, it is an undeniable fact that they will not be acted upon! In any case, something will happen, but maybe not what the boss wants and what is in the interest of the organization.

The last part of this chapter poses the question of the ideal qualities of a complex adaptive system's manager. Some essential dimensions are explored: at an individual level, training and career profile is relevant, but also complex cognitive capacity and behavioral characteristics related to the cultural context in which the individual and his or her organization evolve. We will make some digressions concerning language as both a metaphor in which we think of management and imagine the future and as a fundamental context of managerial behavior. Linguistic context formats our understanding of the world and the relationships between human beings, and perhaps the habit of knowing a number of languages prepares managers to detect and interpret weak signals.

3.3.3.1. *Nonlinear thought as the foundation of an elaborate form of resilience*

Successful leaders' training should influence *both* their attitude and ability to deal with complex questions. Training that is strongly oriented towards classical problem-solving techniques risks creating a cognitive bias by reinforcing an analytical, quantitative approach only. Many professions (engineer, financial officer, lawyer, economist) feel comfortable with well-expressed problems for which an optimal solution can be found, and this often reflects their training and what is rewarded as an outcome. This skill is well adapted to simple and complicated situations, but not complex ones. CAS demand nonlinear thinkers, and for all but the most linear thinkers, regular exposure to complex problem solving; the agency to act in order to put their solutions into practice and learn from the outcomes increases the capacity for cognitive complexity (Kerr 2013).

Unfortunately, even where such exposure is distributed throughout the organization and thus increases adaptive skill throughout, it is rare for agency to also be widely distributed, so much of this learning is only done at the top. Indeed, the greater distribution of appropriate permission to act is a key characteristic of truly adaptive organizations. They not only task people with complex problem-solving and give permission to act (at an appropriate level of authority), but their infrastructure and processes also reinforce such engagement throughout the organization. This is rare in hierarchical organizations as it is seen as "messy" – difficult to control, measure and direct – yet we see from our Artigiani example that it allows for nimble adaptative response at all levels of the organization in the face of change.

The nonlinearity of systems creates emergent outcomes, occasionally translated as brutal changes in the operational regime. As described previously, the person steering the organization must be able to deal with flux, allow systemic mutation and not seek to shut it down, control it or optimize current practice. He or she must not be thrown off by the ambiguity of information in transition and the inability to make clear choices in highly uncertain situations.

To characterize the qualities of successfully managing a complex system, let us revisit the analysis from the previous chapter concerning system resilience. The steerer must think of the organization's long-term future, shaping the path for the system's metamorphosis. The old concept of ecosystem resilience introduced by Holling (1973) describes their ability to remain in an original state subject to disturbances when a number of attractors are possible, something more akin to homeostasis. The literature moved over time (see Folke *et al.* 2010) to include the possibility of integrating resilience, adaptability and transformability, particularly for complex socio-ecological systems, i.e. by introducing human parameters – implying intentionality and thus requiring long-term strategies. In this broadened framework, where actors take the initiative and risk instigating profound transformation, the leader's visionary abilities involve understanding the pull of inertia to remain the same, and encouraging people to "step into the next adjacent", thus, over time,

allowing the system to change to another possible state. In this case, the primary quality of managers is not prudence, but a capacity to inspire trust in people in order for them to take such a step into the unknown. They have an ability to clearly frame their goals and ideas, and they take people with them through to the end by convincing them that the future will be different but safe. They believe in their vision and thus are able to convince others. The ability to inspire and convince is an essential skill of leadership.

Understood in its usual sense, resilience is sometimes used as a synonym for force of character. Resilient people know how to overcome life's challenges and more specifically, they engage with the potential risk of failure when they undertake individual or collective projects. Not letting themselves be thrown off balance, learning through their failures: these are *a priori* the characteristics of the resilient individual. However, complex systems theory adds to the concept of resilience with regard to steerage. One who steers well knows how to stay on track through the tempest, even when it means changing course. We have already seen that when they are faced with multiple attractors during a crisis period, systems are in a very strong state of instability and ambiguity. It is thus not simply a matter of sticking to a plan but also of adopting an open attitude *vis-à-vis* regime changes. As such, obstinacy is not a successful quality of leaders if not presented with the pursuit of bold ideas founded on visionary analyses (which may be revised). Indeed, interpreted as a bias towards the status quo, such a mindset is the opposite of the flexibility that is required. The resilience of complex adaptive systems allows them to remain viable precisely by adapting and transforming.

3.3.3.2. *Knowledge angels*

The central message of this chapter is that managers must know how to decode weak signals. We have specified the meaning of this expression by explaining that their "weakness" is not necessarily an intrinsic characteristic of the signal, but rather its reception by the system in its current form. As such, a highly sought after quality in those who steer is knowing how to decipher snippets of information in the form of a new and unusual code. For a sailor, deciphering fragments of nautical charts in new waters is such a challenge. The

more experienced the sailor, the more able they will be, as they will have built a robust body of knowledge that their brain can call on to compare and contrast patterns, and thus make informed predictions.

We have also discussed the adaptive value of people at different levels within the organization being able to tackle complex problems, identify weak signals as and when they recognize them and have mechanisms to feed them into tacit and/or explicit knowledge flow. As noted, such signals are often picked up at the intersections and borders of the organization, as this is where the system interacts with an external environment.

This leads us to considering the external environment as another source of such radar, as those outside the organization can compare and contrast what is occurring within and without. This may be the new employee who brings in different experiences and mindsets, although they often tend to be discouraged from such observations and encouraged to "adapt". Consultants are another source, and they are indeed a mixed bag. Many have cookie cutter approaches and either little capability or too little time to observe, dance with and understand the system. However, there are other external sources that are of value in deciphering weak signals and assisting adaptation.

We hope to illustrate this theory of deciphering with an example observed in a particular sector and a particular type of consultant who contributes to innovation at enterprises. The notion of KIBS (knowledge-based business services) was set forth by Ian Miles in the 1990s to characterize business service providers who impart elements of knowledge and lend advice regarding engineering, management, economic analysis, finances, law and so on (see Miles 2005). Muller, Zenker, and Héraud (2015) observed an international sample of companies in this B-to-B sector to detect the particularly creative individuals within them who contributed to each business's success – as well as to the success of clients who benefited from this advice to undertake and manage projects and innovate. The essential function of these people, known as *knowledge angels*, was knowing how to contribute the right information, idea or knowledge at the right time to bring about an innovative development or a change in the strategic course. Such people also tend to have enthusiastic and creative

temperaments, as well as having developed their activity in various contexts – successively or simultaneously. These are people who are well aware of how to decode weak strategic signals because these signals are only "weak" in the current context and with their current client, but not elsewhere. We note that knowledge angels are similar to the concept of knowledge catalysts described previously in the section on absorptive capacity.

Just like the experienced sailor described above, the message that goes unperceived in the enterprise they are evaluating is sometimes detectable by consultants who have seen similar signals elsewhere and thus have a cognitive map to refer to. They can also recognize the similarities across different environments, such as other clients, other organizations like basic research centers or various creative communities.

Here are the typical qualities of knowledge angels (KA) detected in a survey:

– ambitious character and will to fulfill themselves through projects;

– playful character;

– a wide variety of interest;

– ability and enjoyment in taking on multiple tasks;

– imaginative and potentially visionary character.

Because the survey was carried out in various corporate consulting sectors and in multiple countries, we can generalize the usual professional profile of KAs from the sample:

– they occupy a relatively high hierarchical position but are not necessarily the head of the organization, because they only moderately enjoy exercising power; they actually prefer influence to hierarchical power, and their personal satisfaction is connected to project management, not general management;

– they lend a great deal of importance to trust as a form of relationship. Teamwork (in small teams) is their preferred framework to act in;

– they evolve or have evolved in various professional and intellectual contexts, and their comparative individual advantage is being *idea ferrymen*.

We have also managed to observe differences between national (and therefore cultural) contexts for the perception KAs have of their role:

– in France, they tend to define themselves first and foremost as creative "idea givers" on behalf of their clients;

– in Germany, they see themselves more often as intermediaries on the idea market, "knowledge brokers";

– in Canada, they consider themselves to be "business pushers", emphasizing the entrepreneurial dimension of creativity;

– In Spain, they mention their role as a "facilitator", in the sense of an intermediary between actors, institutions, etc.

The few contacts made in Asia seem to indicate a certain difficulty in aligning the notion of KAs with their cultural and institutional reality. In China, respondents saw themselves more as solution providers, which does not completely respond to the idea of creativity (providing breakthrough responses). The ideological framework remains relatively linear: for each problem, there must be one solution *a priori* in a known repertoire.

In Japan, there is a different problem. Faced with the idea of KAs and the examples already seen, the reaction of Japanese respondents is as follows: the model is seen as very interesting, but unfortunately impossible to apply. KAs will be poorly received because they contradict the Japanese concept of collective identity. Although a sense of belonging to multiple communities or organizations is tolerated, even encouraged in the West, it is considered bad form in traditional Japan, where individual identity is meant to be strongly shaped by the group. This has not stopped Japan from becoming a

very innovative country, but the processes and methods of innovating are not the same as the ones observed in the other model countries. The concept of breakthrough thinking and radical innovations are difficult to accept, particularly when brought about by individuals, who should at least bring about advances in an anonymous way.

Although they are limited to the specific domain of the enterprise (KIBS), works by Emmanuel Muller and his partners to bring about the concept of knowledge angel are interesting to consider when considering individuals capable of steering complex inter-organizational projects. In particular, we can stop to conclude that the "steerer" of change is not always the head of the organization. Among the companies interviewed that belong to the KIBS category, only a portion of these mentioned their boss as the breakthrough/innovative thinker.

This means that there are many situations as described throughout this chapter, where the manager is better advised to listen to what a subordinate worker or partner has to say, as this person is filling the role as a visionary. Better still, they build infrastructure that not only allows but also encourages such information flow. In doing so, the boss demonstrates a form of meta-competence – wisdom.

3.3.3.3. *Navigating between languages*

We have used the metaphor of language to speak about the concept of weak signals, and we shall now take linguistic skills literally to illustrate the skills necessary to steer a complex system and render it adaptive in the long-term. Interestingly, many leaders are polyglots, so what can this skill contribute beyond its obvious concrete utility? Indeed, languages are simply useful operational skills in management, just like technology, law, accounting and so on. However, the mastery or simply the learning of foreign languages has cognitive similarities to an essential meta-competence for managing CAS.

Speaking a number of languages (two is already a good deal) means being able to interpret the world and express one's ideas in multiple cognitive contexts. This consequently increases the intellectual agility, considering multiple points of view. The habit of

getting by even in languages that speakers have not perfectly mastered like their native language is an asset insofar as the person is psychologically prepared for ambiguous situations typical of complexity. Polyglots tolerate fleeting uncertainty in information better *a priori*. They will tend not to suffer blockages as often, not to wait to understand everything before taking a somewhat new course. As such, they are patient and know how to take limited risks by trusting progressive learning of meaning.

Why? Let us turn to the brain for one aspect of the answer. If we look at the cognitive process of learning a language, there are many interesting aspects regarding the way in which it increases cognitive complexity. First, it makes the brain work harder, thus increasing the strength of our willpower to not just focus on a quick answer or habitual response. The brain has to actively suppress the dominant language with each word, so it gets better at working instead of being on autopilot. This "fitter" brain means the person can bring to bear more cognitive power and apply more thinking power to a problem. The reason why this is important is that our brains are both efficient and lazy, and they will not work if we are not excited or compelled enough to engage willpower to make such a cognitive effort. However, willpower is like a muscle – the more it is used, the stronger it gets, and the better we get at bringing more of our thought processes (cognitive resources) to bear a problem. This is not only true in the case of adults who are trying to deal with complex issues, but is shown in all sorts of situations, such as studies of first-grade children who are better at math when they take the bus than if they are driven to and from school. The reason is they have to use willpower to be where they need to be at the time required and work out the details necessary to catch the bus. That same capacity allows them to apply more cognitive effort to work out the mathematical problem and solve it.

Language acquisition is also the gift that keeps on giving, for each time we have to translate, the brain has to work. As such, learning one or multiple languages means building new real estate to hold the information (we increase cognitive density or "reserve"), increased perceptual judgment and more use of executive function, all reasons

why language acquisition in adults is a recommended method for minimizing dementia and has been measured to protect against symptoms for 4–5 years.

Another key advantage is that it is not only the effortful memory of learning words and symbols that occurs when learning a language. It is also the embrace of a new culture and a different way of seeing the world, as the words in a particular language represent how we frame it. This is also why people learn faster when stationed in the country where the language is spoken – it is not just that there is more opportunity to practice, but they are immersed in this novel culture of different behaviors, rules, food, relationships, esthetic preferences (art, music, dress, beauty) and so on. All of these things change the way our brains are programmed, expanding these areas of our own awareness and memory.

Embracing the culture and the language creates a more flexible concept of reality instead of the often quite rigid one we have built when only exposed to one language and one way of life. Such exposure and the added conceptual richness that comes with learning a language that captures new ways of seeing the world are obvious elements that build the polyglot's capacity for immersive adaption and indeed enjoyment. Now let us turn to the role of language itself.

The French language is pervaded by Cartesian culture, which wants every statement to be as clear as possible. The Japanese language does not make the same demands. It is common for sentences not to have subjects – each time the subject is logically superfluous because it can be deduced from the context. In some cases, this can pose problems; however, this is culturally expected. In French, the speaker's minimum courtesy is to be precise; in Japanese, the responsibility for clearing up ambiguity lies much more on the listener, hence an occasionally visible form of panic when a Japanese man or woman is not sure to have understood instructions correctly, whereas speakers of French or English do not hesitate to ask for clarification.

Everyday Japanese is also less precise for structural reasons. For example, there are no articles, making it more difficult to distinguish between the definite notion of "the" and the indefinite "a". Let us take, for example, the phrase [情報を見つける] (jôhô ho mitsukeru). This can be translated as "to find the solution" or "to find a solution". Of course, as in all languages, if Japanese speakers wish to be more precise, they will find a way to do so, but the language itself does not force them to do this systematically. The grammatical and syntactical possibility of remaining ambiguous is a characteristic of Japanese (in comparison with many European languages, anyway), and this necessarily has to do with Japan's cultural and social system. One potential advantage of this context is encouraging attentive listening and reflection on exactly what messages mean, which can also encourage the perception of weak signals.

We can also analyze the question of the subject and intentionality through languages. This is important with regard to complex systems, where matters of subject, causality and responsibility pose problems.

Let us imagine that the pilot of a ship asks a sailor to describe the state of their environment (the sea) at sunrise to him:

– The Japanese sailor could respond [天気はとても良い] (Tenki ha totemo yoi). The approximate meaning is, "regarding (は) weather (天気), completely (とても) beautiful (良い)". Renowned French grammarian Vaugelas (one of the first members of the Académie Française, † 1650) would not have appreciated our translation! He would have chosen to add at least a subject and a verb to the sentence. Most of European languages require the same. Nothing like in Japanese. The presence of a verb is not systematic (even a function as essential to the verb in European languages as expressing tense can be ensured in Japanese with an adjective). Since the subject is not necessary, either, we see that the subject–verb pair, so fundamental to our understanding of the world in the West, is much less structuring at the other end of the world. Logically, this cannot be neutral in the way people think about systems.

– The English sailor would say, "The weather is very good", which respects the European discipline of having a subject and a verb. It is clear and pragmatic. Let us simply note that, logically, "the" is useless, because the question of definite and indefinite is moot here,

yet the language demands the use of an article. The German sailor would say exactly the same thing: “Das Wetter ist sehr gut”.

– The French sailor’s statement is more surprising: “il fait très beau temps”. Literally, we are suggesting that someone “makes” the weather. In fact, there is a purely formal subject and a verb that clearly does not express an intentional action in this case. We are satisfied thinking that this is an idiomatic expression and that this does not change anything at the end of the day, but the question remains: how did the French language, throughout its evolution, end up with this formulation? Why not simply say, “The weather is very good” (which is, perfectly possible, but less common)? It is clear that language expresses and reinforces cognitive biases and that French, as well as English or German culture, through the ages, has pushed mental representations towards values of subjectivity and action. Speaking in terms of subject and action is maybe not the ideal mental representation of systemic phenomena.

As the preceding linguistic digressions have shown, learning to speak a number of languages broadens people’s horizons by making them aware of their own representational biases. For example, we will ask the question of knowing whether the mechanisms observed in an environment are more causal and relatively linear or, on the contrary, more systemic. What is true individually for an adaptive leader who speaks multiple languages is also true for the adaptive organization. Intentionally building a culture that contains and rewards diversity of thought and approach, and a tolerance of ambiguity and difference, is a key element of innovation and adaptation. Looking at the role of language in increasing such characteristics was indeed a digression, but it shows the complex nature and advantages of recruiting members with diverse cultural and/or linguistic backgrounds, or at least with exposure to different settings and ideas, to better carry out the function of seeking weak signals. We know that innovation is a bricolage of ideas that already exist, layered upon each other in new and novel ways, so the greater the diversity of thought and experience, the more creative and innovative scope the organization has.

3.4. Conclusion

The notion of a complex adaptive system has led us to question the classical approach of *rationality* and to consider the role and skills required of those who lead and manage complex organizations in a different way. One of our conclusions can be formulated as follows: a successful leader and manager cannot control but can only steer a system that is largely self-organizing. This does not take away from the role which is still vital in orienting and clarifying where people are going and why, and tending them on the journey of adaptation, but it changes the approach and the journey.

An essential task for those who steer is knowing how to correctly identify the challenges facing the organization. To tackle this in an adaptive way, instead of building a hierarchical, vertical management structure, they must establish an internal environment capable of intelligently evolving along with the external environment. Their objective will be to establish strategic intelligence distributed throughout the system, capable of perceiving and welcoming weak signals. These signals will be often be hard to identify, confirm and capture with methods and goals of the current system. The more static and quantitative the norms around such things as the organization's identity and its reference language, the more difficult it will be to escape embedded cognitive routines and to both identify and interpret weak signals. Yet if this rich information source is not only recognized, but encouraged and built in, then it does not endanger the organization, but quite the opposite.

This type of dynamic flexibility is also related to the building of resilience, whereas some organizations unfortunately build an ability to resist change. Organizational flexibility becomes crucial in periods of flux, change and crisis. These episodes, which are necessary for long-term survival, are highly unforeseeable situations that are often uncomfortable at the time due to the natural anxiety that change creates in people. During such periods, organizations on the whole have not built a cultural, cognitive system with adequate language that gives meaning to many of these situations. Most have also not yet embraced the challenge of building a structure and system that enables adequate self-organization, within the boundaries of simple structure

and rules to steer against and imbed learning, while still allowing sufficient cross-connectivity for creative curiosity.

When we speak here about flexibility, this is not the static, planned contingent flexibility of having alternative plans for situations known in advance, but a more dynamic characteristic, which allows the system to reinvent itself while being tended adequately.

Steering a complex adaptive system requires both a great deal of ambition, insofar as leaders will occasionally bear the responsibility for major organizational changes, and a great deal of self-awareness and even modesty through the recognition of how much knowledge will at times be lacking when making decisions. When this is the case, complex thinking managers know how to embrace, harness and rely on the collective intelligence in their organization – which implies that they have cultivated this beforehand. Together, the organization and its management will know how to keep their eyes peeled for weak signals that emanate from the system itself and/or its environment.

4

Entrepreneurship, Market Creation and Imagination

Management science has naturally developed numerous reflections on the way in which we create and manage an enterprise in the dynamic sense of the word, i.e. undertaking something new. We speak of entrepreneurship for anything concerning the foundation and growth of an enterprise, with results in terms of value creation and therefore wealth and employment. This can also apply to non-profit organizations, in which case we speak of *social entrepreneurship*. It is important to emphasize that the entrepreneurial attitude also manifests itself within organizations. We then speak of *intrapreneurship*, which partially comprises the field of project management.

The economic sciences have dealt with the question of entrepreneurship from a number of angles: in terms of theory, as the foundation of innovation, but also through the range of macroeconomic consequences from the phenomenon and to clarify innovation and economic development policies. If entrepreneurship has taken on so much importance today, it is because innovation is systematically placed within economic and social evolution. It is worth mentioning that the notion of entrepreneurship owes a great deal to the founder of innovation economics, Joseph Schumpeter (Schumpeter 1934, 1942).

According to Schumpeter's definition, the entrepreneur is not the one who manages an enterprise, but the one who innovates in one way

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or another, particularly through enterprise creation. This is a person capable of transforming a new idea into an economic reality, which will in turn transform the system according to the *creative destruction* schema that Schumpeter subsequently endeavors to analyze in all of its consequences, particularly macroeconomic ones like business cycles (Schumpeter 1939).

The figure of the entrepreneur and, along with it, the analysis of the socioeconomic system's evolution are also developed in another school of economic thought, the so-called *Austrian* approach, with founding authors like Friedrich Hayek and Ludwig von Mises. This approach was extended by Israel Kirzner in particular, representative of a very lively neo-Austrian school that distinguishes itself from Schumpeterian analysis through its insistence on the portion of creativity provided by the *market*, in addition to individual initiative (Kirzner 1997).

In a general way, economic theory somewhat excessively reduces innovation to the creation of knowledge, but this notion is much more bountiful in the Austrian school than for Schumpeter because it is more subjective: knowledge is not absolute and universal; it is original and contextual (Witt 1995). Israel Kirzner constructs an interesting concept of *entrepreneurial discovery* on this basis, where innovation is actually a co-construction by the entrepreneur and the market. This vision is typically one of a complex system whose dynamics are articulated between the microeconomic (entrepreneur) and macroeconomic (market) levels.

The goal of this chapter is to deal with entrepreneurship not only in terms of managerial recommendations, but also through economic science, as the previous statements might suggest. Indeed, it would be artificial to separately consider economics and management science. Before proceeding to more in-depth analyses, we can advance a very simple initial argument to justify a joint approach through management and economics: the fact that innovation is anything but an isolated individual activity. No one innovates alone. The very notion of open innovation (Pénin *et al*. 2011), which is being mobilized more often to interpret contemporary technical and organizational evolutions, corresponds to the idea of network

creativity, including the designer and the user of the new goods or service. At the end of the day, it is the economic system as a whole that is in a systemic relationship with the entrepreneur-innovator, hence the particular pertinence of *Hayekian* analysis of the market's role in the economic system's operations and development.

Not taking this reality fully into account through an overly linear managerial attitude (technical bias) can lead to serious strategic errors in innovation management. Innovative entrepreneurs are not satisfied with designing a good that is adapted to the market; they create their own market. As for the market itself, it is not a theater stage prepared in advance for economic actors, but rather a living environment, where the supply–demand relationship is created and where the product is defined. There is, therefore, a form of osmosis between the managerial process of designing an innovative product and the economic process that compares a potential supply with a potential demand.

The complex creative process spread across time and characterizing all forms of innovation – a dynamic interaction process between the individual actor (or team) carrying out the project and the entire socioeconomic system – has actually been described in the economic literature for a long time now. We need to only re-read the great authors form the last three centuries to find food for thought. This detour through the history of thought is far from futile, for the dominant economic science of today tends to hide entire areas of reflection that are in fact vital to understanding the entrepreneur's central role. This is masterfully shown by Humberto Barreto's "The Entrepreneur in Microeconomic Theory. Disappearance and Explanation" (Barreto 1989).

We will dedicate section 4.2 of this chapter to reviewing literature on the entrepreneur as seen by economists, and this will enable us to demonstrate the primary theoretical functions that can be expected of entrepreneurship in society, particularly the relationship with the market. Section 4.3 will complete the idea of entrepreneurs' creative interaction with their environment by recalling the role of the communities they draw their identity from and which delimit the field of entrepreneurship. Section 4.4 will conclude with the function of the

imagination, which is indispensible in formulating projects in a complex system. Before this, we will introduce our goal in section 4.1, which gives a few examples of contemporary reflection on the question of entrepreneurship in order to show the renewed interest in the subject and its multiple facets.

4.1. Some current stakes of entrepreneurship

To provide some examples of the current stakes of entrepreneurship, we can refer to the special issue of the *European Economic Review* (No. 86, 2016), in which we find contributions to the following subjects:

– An observation of the recent decline in indicators of entrepreneurship in the United States. This is translated by a smaller portion of newly created enterprises in the total population of enterprises and a smaller proportion of high-tech firms among these young enterprises. This example shows us that nations and territories are not neutral contexts *vis-à-vis* entrepreneurship and that they are themselves evolving.

– A historic analysis of regional business cycles in the long term. Regions that were marked, at some point, by industrial innovation, with many enterprises being founded, demonstrate a less entrepreneurial population of large enterprises a number of decades later, which translates into low economic dynamism and a critical employment situation.

– An analysis of the growth of feminine entrepreneurship. This arises from numerous questions, starting with that of whether gender is *a priori* a characteristic of innovation or management. Can we speak of feminine creativity?

– A number of articles on the question of financing innovation – in particular, the question of a possible bias introduced by the nature of capital: is openness to the capital market (private equity and LBO) favorable to innovation and creativity or not? In the case of the United Kingdom, the statistics do not seem to confirm the intuition that access to financial markets leads to short-term management that is unfavorable to innovative risk-taking. However, this result would need

to be confirmed (or disproved) in other national contexts, for enterprise culture differs in this field, just as it does in many others.

– An analysis of the percentage of start-ups in overall job creation. In Denmark, we can see that the creation of "Schumpeterian jobs" is actually more significant in well-established enterprises. Here again, can this statement be generalized? Must we distinguish territories marked by the start-up phenomenon and others whether the large enterprises' contribution to innovation is determined through the *intrapreneurship* phenomenon?

One of the conclusions to be drawn from these works is that economic policies should pay more attention to the analysis of entrepreneurial management and the organizational abilities of firms. It seems to us that managers should also take inspiration from economic findings (and even from what the history and the history of thought can contribute) to understand the societal interweaving of complete innovation development. The professional training received by engineers, who are often in a position as potential innovators when they are inventors, does not always encourage this systemic awareness, hence the risk of thinking of innovation as a linear process brought about by science, then implemented by technology. This linear conception of the entrepreneur's role as the one who applies new knowledge to the economy is very limiting. It denies the existence of a complex system connecting innovators with their environment from the start of the creation process until the end.

The point of view that we are defending here is that not only microeconomic innovation has consequences for the overall system (Schumpeter's creative destruction), but is itself a co-creation by the entrepreneur and the system (Muller *et al*. 2017). Innovation transforms the economy and society, but it is largely conditioned by the socioeconomic environment in return. This takes nothing away from the figure of the entrepreneur, but rather emphasizes that the entrepreneur is necessarily embedded into a certain environment, in the sense that his or her creativity is supported by *communities of knowledge* (Cohendet *et al*. 2014) and conditioned by the market's reaction (Kirzner 1997). The territory is often a receptacle for all of these factors, which interact with the entrepreneur-innovator

(Porter 1990; Pecqueur and Zimmermann 2004; Boschma 2005; Levy and Ferru 2016).

Based on some above-mentioned examples, we can actually observe that:

– the enterprise is variable and situated both geographically and temporally;

– the available methods of financing and the financial culture of enterprises influence the nature and forms of innovation;

– the size and organization of firms condition the opportunities for innovation; let us add that the way in which they are organized into networks and milieus also plays a role;

– increased female participation in training and professions can be a cause or consequence of the forms of innovation that are being developed.

In the studies cited, we note that entrepreneurship has territorial, financial, organizational and gender characteristics. The list does not stop there, though. For example, the founders of enterprises often identify with communities, as we will see in section 4.3. As a conclusion of these preliminary reflections, we can confirm that innovation is the result of an entrepreneur (in the narrow sense provided by Schumpeter, i.e. a figure who is not a simple manager) influenced by his or her environment, by the context of his or her action.

The entrepreneur-innovator's context demonstrates the characteristics of a *complex system*. Individual action is inspired, constrained or amplified, modified by the circumstances and the actors involved: chosen partners, rivals who show themselves, a regulatory framework imposed upon them, first users who bring about the creation of useful information for refining the concept of the new product and so on. Interactions are often more dense than it seems at first sight, even with a single actor. For example, prior financers (risk capital) are not satisfied only providing money; they generally condition their involvement in rewriting the initial project. All in all,

we can say that if the entrepreneur is responsible for innovation, this does not mean that he or she is an isolated designer.

4.2. The entrepreneur in the history of economic thought

The great authors in economics have enlightened us concerning innovation: not only Schumpeter and Hayek, whom we have already mentioned, but also before them, Alfred Marshall. Economic tradition, however, subsequently interpreted the questions of innovation according to a vision of the economics of *knowledge* rather than entrepreneurship. This constitutes a limiting analysis by economists, e.g. the analysis of territorial development based on the creation of innovative enterprises, even though this was a significant starting point for Alfred Marshall's reflections one century ago. To develop a more realistic vision of innovative territories, we must start with a more general notion than the creation of knowledge, namely *creativity* (Héraud 2016).

The most *orthodox* economic research can hardly provide an account of the entrepreneur's figure. In an article published in 1968, "Entrepreneurship in Economic Theory", economist William Baumol concluded: "the entrepreneur virtually disappeared from the theoretical literature", as we are reminded by Humberto Barreto (1989).

Barreto's work shows that the entire construction of the microeconomy would lose in intellectual coherence what it would gain in realism if it introduced the entrepreneur as an agent distinct from the economic scene. As we will see later, in the early 19th Century, Jean-Baptiste Say, although considered as one of the fathers of classical economics, placed the entrepreneur at the center of economic analysis. In the meantime, the classical English school of thinking and then the currently dominant neoclassical school have turned many economists' attention from the reality of entrepreneurship to orchestrate the traditional factors of labor and capital. Yet, the entrepreneur is a distinct notion from those of the capitalist or the manager.

4.2.1. *The entrepreneur, harbinger of decentralized creativity*

What distinguishes the entrepreneur from the manager or the capitalist is the creativity of enterprise action. This functional difference can already be seen in their remuneration: managers receive a salary; capitalists benefit from interest and the entrepreneur earns an innovator's profit, which is highly random and dependent on the success of the enterprise. If the entrepreneur is first and foremost characterized by his or her creativity, the nature of this creativity must be closely analyzed and contextualized in the socioeconomic system that contributes to it – as well as the entrepreneur's individual qualities.

We believe that the dominant economic thought – which ends up influencing society, particularly through the culture of the economic and political elite – lends excessive importance to the forms of creativity via formal knowledge like scientific discovery or technical innovation. Entrepreneurial behavior itself largely depends on human qualities like an appetite for risk, the desire to change the world or the ability to coach others. It is more strongly characterized by meta-knowledge than technical knowledge or specialized professional skills. As for entrepreneurs' motivation, it is partially extra-economic.

4.2.1.1. *Information and knowledge cannot be fully centralized*

Friedrich Hayek's thought strongly agrees with this point of view. The author explains that the economic system's efficiency depends on the way in which knowledge is managed, not only to innovate (which implies the creation of new knowledge elements), but also in all economic activities, even the most mundane. The problem with knowledge is that it is largely decentralized. No one has all of the existing knowledge in the economic system: concerning methods of production, quantities produced, prices, offers or demands not satisfied at a given moment and in diverse locations and so on.

The dream of installing central planning was pursued by economics in the past, but we know the difficulties of implementing this and the drama brought by a society where the implementation of

such a utopia is forced. Planning, be it public or private, quickly reaches its limits. On the contrary, it is just as unrealistic to maintain, as some liberal economists do, at least implicitly, that markets carry out this function of integrating all information perfectly – and that it would suffice for the microeconomic agent to know the prices to know everything necessary for decision-making. Indeed, markets are not always perfect, as is assumed by the standard model of microeconomic manuals. Adam Smith himself never seriously thought that the "invisible hand" was a solution to all of humanity's problems; some of his writings even express the opposite. Friedrich Hayek, a great defender of liberal economics against the centralism of socialist utopias, is not so naïve, either, as to believe that real markets will work ideally once the State stops intervening. His position is to critique the relative inefficiency of most hierarchical organizational solutions, particularly public ones, as compared to market mechanisms: which is not the same as claiming that markets are complete and function perfectly!

In a renowned 1945 article, "The Use of Knowledge in Society," Friedrich Hayek analyzes the informational processes that support economic decision-making. Rather than seeking to concentrate economic information in a central decision maker, who will never know all the contextual details of applying this knowledge, Hayek maintains that we must encourage the transmission of as much knowledge as possible to decentralized actors, who, because they are on site, are most able to deduce adapted economic behavior from this. Of course, some of the knowledge necessary to the economic system can and even must be centralized: this is formal scientific and technical knowledge. However, a large part of the knowledge necessary for economic decision-making is not of this type and is only available and efficient on site, at the level of individual actors. The information likely to enrich the knowledge of the authorities and experts is destined to be centralized, but not necessarily the knowledge concerning management and entrepreneurs.

Unfortunately, the mental representation of managers, engineers and administrative or political executives is always polarized by

formal categories of knowledge. As Hayek states quite clearly (1945, p. 2):

"If it is today so widely assumed that an authority made up of suitable chosen experts will be in a better position, this is because one kind of knowledge, scientific knowledge, occupies now so prominent a place in public imagination that we tend to forget that it is not the only kind that is relevant."

In our opinion, this remark by Hayek not only applies to public decision-making, but also to all forms of hierarchical decision-making in private organizations.

4.2.1.2. *Being informed to decide in a world undergoing perpetual change*

The general debate on the efficiency of decentralized decision-making is even more significant in an evolving system, one that involves the figure of the entrepreneur. Hayek believes that the primary economic problems that are found in society are relative to adaptation to change, particularly circumstances of time and place. It is, therefore, important for decisions to be made as much as possible at a decentralized level:

"The ultimate decisions must be left to the people who are familiar with these circumstances, who know directly of the relevant changes and of the resources immediately available to meet them" (Hayek 1945, p. 4)

In a Hayekian world, the entrepreneur's function is decentralized. Entrepreneurship is the business of everyone in society. It is up to each person, in his or her position, to make the right decisions based on his or her on-site knowledge and circumstances. However, overall complementary information must be provided as best as possible by the system and/or the hierarchy to help individuals optimize their decisions. As we can see, the question of entrepreneurship is tied to that of knowledge for decision-making. Hayek's position is strongly influenced by the issue of the nature and place of knowledge.

Other standpoints are interesting to consider in order to understand the entrepreneur's specific creative function. Following this section, we will move onto a review of the four economic traditions distinguished by Humberto Barreto: in addition to the Hayekian and Schumpeterian traditions that we have already seen, the interest of Barreto's synthesis lies in bringing out the contribution of other schools of thought, starting with that of French economist (and entrepreneur) Jean-Baptiste Say, who was the first to speak of the entrepreneur as a central actor in economics.

4.2.2. *The entrepreneur according to Jean-Baptiste Say: the assembler of factors*

What is interesting about Jean-Baptiste Say is that he distinguishes three levels in the division of labor leading to production. At the bottom is the worker, who executes the production plan; at the top is the theoretician (scientist, "philosopher", etc.) and between the two, we can find the entrepreneur, who has the idea to assemble these elements and is involved in coordinating the process, as well as distributing the revenue generated by production. It is also the entrepreneur who takes it on the uncertainty concerning the enterprise's future success (or failure). Entrepreneurs partially wager with not only their own personal fortune but also the money they manage to borrow.

As for other production factors, there is an entrepreneur market. This factor has a high value because there are not many people with all the necessary qualities, namely a minimum of personal means to appear solvent, intelligence and reputation, integrity, prudence, "regularity" in his or her actions and a sense of organization.

Jean-Baptiste Say is the first economist to distinguish entrepreneur from the capitalist. He is followed by Schumpeter. For Say, the entrepreneur does not belong to a particular social class. Being rich and knowledgeable is not sufficient to become an entrepreneur. The entrepreneur's remuneration may partially come in the form of interest on the capital he or she has contributed, but the true remuneration for an entrepreneur's actions is rather what Schumpeter called "the

innovator's rent". This is a profit insofar as it is a residual remuneration, only positive in the case of success, and not a salary (manager's remuneration) or interests (capitalist's remuneration, profit). We must point out that this vision, very ahead of Say's contemporary English school of thought, is not unrelated to the author's professional life as an enterprise manager.

4.2.3. *The Austrian approach: a form of serendipity within the economic process*

From Ludwig von Mises and Friedrich Hayek to Israel Kirzner, it is *human action* that lies at the heart of the economic process and not the equilibrating market mechanisms described by the standard model of economics. The Austrian approach is implicitly a theory of creativity when it attributes a central role in socioeconomic development to certain individuals, but it does this through a particular conception of the market – which is a living terrain, subject to constant discoveries by the actors who know how to explore it.

The market is not a single location for arbitrating between supply and demand with perfect information, but much more a perpetual process where actors meet in a somewhat random way and generally confirm the imperfection of their information and the faults in their action plans (which leads them to review these information elements before the next time). The heart of the actual economy cannot be resumed with the optimization of the use of rare resources to achieve determined goals (to revisit the definition made famous by Lionel Robbins). On the contrary, typical economic activity is the *discovery of opportunities* people had not yet thought of. As such, what characterizes the entrepreneur, a paradigm of *human action*, is more the ability to discover market opportunities than the ability to calculate an optimal action plan. The first quality of entrepreneurs is to be "alert" to the opportunities they perceive by exploring the market – which is neither definitively given nor completely known to anyone.

The question that asks itself, then, is knowing why and how certain people perceive market opportunities better than others. Kirzner's position on this stance involves explaining that it is not a question of

information *per se*. Being alert is not the same as knowing (having information). The entrepreneur often has less information than an *expert*. Instead, he has an important quality, superior *foresight*. It is somewhat difficult to construct a precise idea around this notion, but what is certain is that the essential quality in an entrepreneur is alertness, i.e. attention turned towards opportunities.

We would like to bring the *Austrian* concept of attention towards opportunities closer to the contemporary idea of *serendipity*, which is often used in works on creativity. Here, serendipity corresponds to the discovery of opportunities to arbitrate by exploring the market. The most trivial example of arbitrage involves finding goods offered somewhere at a lower price than the reserve price of another agent (who has not discovered this). The double transaction will allow a profit to be made, constituting the "arbitrageur's"[1] compensation. Let us not forget that in a neoclassical world made up of markets in equilibrium, or tending towards equilibrium, this case scenario is exceptional and transitory. For the *Austrian* school, on the contrary, it is because the prices are "wrong" or because there are multiple prices that entrepreneurs make money.

A more complex example of arbitrage is the discovery of production means that cost less than those usually required to produce an existing good. This example corresponds to a *process innovation*. In this case, entrepreneurs are Schumpeterian in the sense that their creativity and the added value they create are linked to innovation. However, the *Austrian* concept is more general and belongs to a theoretical framework, where *the market is seen as a constant process of discovering business opportunities*.

4.2.4. *The Schumpeterian approach: from serendipity to creativity*

Serendipity lies at the heart of the Schumpeterian analysis of economic development: the serendipity of the entrepreneur-innovator. This is a person who seems more creative than a simple "arbitrageur"

1 In the "Austrian" literature, an arbitrageur is an investor who profits from price inefficiencies in a market by making two simultaneous off-setting trades.

in Kirzner's sense of the term. We could say that we are moving from serendipity to creativity in the broadest sense of the term. For Schumpeter, as well as the *Austrian* authors, entrepreneurship is the basis for change in (unplanned) market economies, but this change is particularly qualitative. Schumpeter proposes a theory of development and not a simple theory of (proportional) growth. Entrepreneurs are truly creative people, because they qualitatively modify the economic and social system. This takes place through the development of new goods or processes that the entrepreneurs introduce into the system. They invent new productive combinations and implement them (here, we can see Jean-Baptiste's ideas). Another qualitative dimension: entrepreneurs can also show their influence on the system through structural changes like opening a new market for an existing product or creating/tearing down a monopoly. These are also examples of innovation in the Schumpeterian sense.

For Schumpeter, as in the *Austrian* theory, entrepreneurs benefit from a situation of imbalance to develop new business. Therein lies the heart of Schumpeter's analysis of economic cycles (1939). In a period of crisis, where production factors go particularly unused (unemployment, uninvested capital, depreciated land assets, etc.), many entrepreneurs undertake experimentation with new products or production process or even create new market structures. This phenomenon lies at the foundation of the economic revival that follows the crisis. Inversely, the growth phase will tend to fizzle out when the economic context becomes less favorable to innovation and thus the spirit of enterprise.

The alternation between phases of growth and crisis corresponds to a sequence of periods that are favorable or unfavorable to radical innovation and thus to entrepreneurship. When the economic system has reached a point of technological maturity, it evolves more in terms of (quantitative) growth than (qualitative) development and the role of entrepreneurs moves to the background. In a period of growth, the economy stages managers in particular. During the crisis and at the start of the subsequent revival, on the contrary, entrepreneurs win

back their place: phases of intense imbalance bring out leaders and creativity.

The Schumpeterian entrepreneur often benefits from macroeconomic imbalance – and thus from the imperfection of markets – to create new economic forms. However, creative activity often contributes to producing imbalance such as, for example, the failures of enterprises based on old technologies. This is Schumpeter's *creative destruction*.

The great difficulty facing entrepreneurs (in the strongest sense of the term: those implementing radical innovations) is that they cannot find an action model in ordinary circular economics. They are thus, by definition, creative, but they must also have the ability to impose "new productive combinations of factors" upon the system, which many actors will seek to combat because this undermines their established situation. Potential innovation will take away their business prospects and/or steal their production factors (human, natural, financial, etc.). Moreover, entrepreneurs will have not only the actors who are threatened by their innovation against them, but possibly competing actors who have a similar idea as well, not to forget the large majority of people who, in any case, do not want the world to change. In the end, all of this creates a great deal of resistance to the change the entrepreneur wishes to introduce into the system.

Schumpeterian entrepreneurs are far from having ensured success, regardless of the absolute quality of their new idea. In this, the entrepreneur is not a rational economic agent in the orthodox economic sense. The essential motivation for such people is the potential to realize their own dreams, the joy of creating, the pleasure of the fight and so on, and certainly not a future profit coldly calculated with probability functions. This point is important to consider. For Schumpeter, entrepreneurs are certainly first and foremost concerned by uncertainty, but their function in the system is not risk management. They are not insurers. They are actors who know how to make decisions by seizing opportunities, like the Hayekian entrepreneur, but they do this by establishing a new combination of production factors. They are truly creative.

4.2.5. *The entrepreneur as a decision-maker in uncertain situations*

In the notion of entrepreneurship, Jean-Baptiste Say mostly saw the function of coordinating, Kirzner arbitrage on markets and Schumpeter the creative act of innovation. Humberto Barreto (1989) completes the series of the types of entrepreneurs imagined by economic thought by bringing out a fourth function: that of managing uncertainty. He emphasizes (op. cit. p. 33) that in the economic literature concerning the entrepreneur, one of the most often cited roles is that of the "uncertainty bearer". However, he distinguishes three approaches, which we will list below with comments.

– **The entrepreneur as a *speculator***. This is the position held by Richard Cantillon, an 18th-Century Irish-French economist (*Essay on the Nature of Trade in General, 1734*), who believes that entrepreneurs are intermediaries between manufacturers and consumers, whose function goes beyond that of Kirzner's arbitrator, for they support uncertainty. They buy objects at a certain price and resell them at an uncertain price, hence the expression "speculator". In doing this, they fill an essential function for market operations.

In contemporary economic language, we could say that they support transaction costs as defined by Ronald Coase. These are largely due to uncertainties: concerning prices given quality, concerning the partner's reliability, concerning the practical methods of exchange and so on. We can therefore interpret Cantillon by considering that every economic actor who accepts to assume a transaction cost is an entrepreneur. Let us note that this is indeed a function and not a professional category or a social class.

– The entrepreneur as an *owner*. In the early 20th Century, American Frederick B. Hawley published articles in which he defines a function of a person he refers to as the *enterpriser*. This actor ensures more than the coordination of production. In fact, *enterprisers* are the owners of products, which are the final cause of production, whereas other factors like capital, labor and natural resources are

simply means. This notion of the entrepreneur describes a decision-maker whose decision-making power stems from his or her ownership rights. Ownership ensures control of benefits, as well as the responsibility for possible losses. The benefit here is not a profit in the neoclassical economic sense, for it is random residual revenue once all other factors have been paid. It has the nature of a rent (in Ricardo's definition) and is not the regular payment of coordination work. Entrepreneurs, in the sense of an *enterpriser*, are essential actors in the socioeconomic system because they bear a great deal of responsibility for activities (and thus the risks, which are generally difficult to evaluate).

– The entrepreneur as a last resort *decision-maker*. Here, we are referring to an analysis by Frank Knight, who distinguishes risk and uncertainty. Risk can be calculated (this is the insurers' job), whereas we do not have laws of probability for uncertainty. Taking on uncertainty is the entrepreneur's function, for the act of creating a business always includes things that cannot be rationally decided. In the economic system, the actors must regularly take responsibility for their decisions, even though they do not have all the necessary elements to decide according to the canons of economic rationality. Action is then founded on an *opinion* and not *knowledge*.

In an organization, the true entrepreneur is the person responsible for making decisions. The problem, once the organization has reached a certain size, is that the boss is responsible for all decisions, even those that he or she has not personally made. In fact, many decisions are made within the scope of a delegation of power within the hierarchy. An essential point for the entrepreneur is, therefore, knowing how to choose his or her collaborators. This is where we can see that the entrepreneur's function goes beyond the simple coordination of production. It is a function of *meta-organization*: the entrepreneur outlines the system that will have to be organized, and rather largely make its own decisions. In our language, we would say that entrepreneurs take on the function of a self-organized system in advance, which they know they will not be able to control completely (see the concept of self-organization presented in Chapter 2).

4.2.6. *Towards a taxonomy of the entrepreneurial function*

Having reached the end of this section dedicated to the notion of the entrepreneur in the history of economic thought, what can we take away? For Humberto Barreto, at least four large functions can be distinguished:

– coordinating economic activities, particularly production;

– arbitrating on markets and, in doing this, discover business opportunities;

– introducing innovations that will change the socioeconomic system;

– assuming all non-calculable risks of the act of opening a business.

Each of these responses to the question of entrepreneurship's economic role summarizes a complex and systemic thought in a few words, that of great authors from the last two or three centuries. It seems interesting to us, as a conclusion, to pose the question of the possible perception of the following four statements by an ordinary observer of contemporary economic life.

– The function of coordinating will be, it seems to us, relatively well perceived by any reasonable person who questions the direction of an enterprise's management. However, this immediate perception would need to be completed by analyzing the idea of coordination in a complex world that is not always foreseeable. From this standpoint, entrepreneurship is faced with a more complex task than planning (which could be too quickly seen as a synonym for coordination in Jean-Baptiste Say's sense of the term).

– The second definition is natural for defenders of free enterprise and will please those who wish to throw themselves into business, dreaming of becoming rich thanks to a godsend. Discovering opportunities along the way is the dream of every person whose ambition it is to make a fortune through the thought of having sufficient serendipity (the *alertness* emphasized by the Austrian theory). The fact remains that this definition does not imply a

particular method. This characterizes a state of mind, but the question fully remains of knowing where, when and how to go about discovering these opportunities.

– Schumpeter's definition of the entrepreneur as an innovator is common and even trendy. It is a completely creative notion of the entrepreneurial function: having new ideas; verifying their pertinence and convincing as many actors as possible to become partners in the venture. In our opinion, the theoretical question that remains partially unanswered here is the hinge between the individual and society. This is a point that must be investigated in greater depth, for we have increasingly more evidence these days that innovation is a co-creation between the innovator and his or her environment.

– Taking on absolute uncertainty is a very pertinent and profound definition of entrepreneurship. Concretely speaking, this refers to the managerial profession; due to their function, they must accept responsibility for collective action. This is what leads to the splendor, but also sometimes the losses of individuals who accept this role. A French expression dating back to the 1980s throws light on this issue: "*responsable mais pas coupable*", responsible but not guilty.

4.3. Motivations, responsibility and identity of the entrepreneur

It appears from all the preceding analyses that the act of starting a business is both inseparable from the macroeconomic mechanism of economic and social development and profoundly individual. Can these dimensions be connected? If the microeconomic decision is, to some extent, the foundation of macroeconomic (and social) evolution, isn't there also a relationship in the opposite direction? As we will see, if the motivations of entrepreneurs – those who innovate by founding an enterprise – are analyzed, social determinants will be found. The expression of an individual identity in the act of starting a business is often the reflection of a social identity.

4.3.1. *The entrepreneur's responsibility*

One of the most important individual dimensions is the notion of responsibility, as we emphasized above. If there is a difference between the role of an individual and that of a robot or an administrative procedure, then the individual is the one who decides, "in all good conscience", in other words, to take on the responsibility of decision-making, by weighing the positive and negative consequences of strategic options (affected, moreover, by different uncertainty factors that are difficult to measure objectively).

To illustrate our point, let us cite the representative case of the two French ministers who had to answer for their actions in court, following a scandal involving the transfusion of blood contaminated by the AIDS virus in the 1980s. It would possibly be an option to accuse the administration of that era of not having foreseen the extent of the risks connected to this disease (knowledge of which was still quite limited at the time) and to believe that there was a lack of discernment or foresight and that, at the end of the day, a precautionary principle should have been applied by the Ministry of Health – it is always easy to say this in hindsight. However, the *Court de Justice de la République*, which gave its ruling in 1999, did not agree with the accusation of involuntary homicide. As for the expression "*responsable mais pas coupable*", which gained a great deal of popularity during this time, it is best to refer to the precise declaration made by minister Georgina Dufoix:

> "I feel deeply responsible; however, I do not feel guilty, because at the time, we truly made decisions in a certain context that seemed, for us, to be the right decisions."[2]

For better or worse, anyone who assumes responsibility for a collective action in a situation of uncertainty in the strong sense provided by Knight is potentially in a situation to be *responsable mais pas coupable* if things do not go as well as planned. This is part of the

2 "Je me sens profondément responsable; pour autant, je ne me sens pas coupable, parce que vraiment, à l'époque, on a pris des décisions dans un certain contexte, qui étaient pour nous des décisions qui nous paraissaient justes".

entrepreneur's function as well as that of a political or administrative head.

In terms of managing complex systems, we can conclude that entrepreneurs undertake a new collective action knowing that they cannot completely control the system they are establishing. In particular, they must delegate decisional functions. It is thus a matter of designing a partially autonomous (and thus non-deterministic) system and accepting responsibility while knowing that it is hard to plan and not perfectly controllable.

4.3.2. *The entrepreneur's identity*

To understand the individual act of starting a business, we must turn to the human and social sciences. This is what an entire field of literature does in order to provide more than banal analyses like "the founder of an enterprise poses successive questions concerning the target market, consumer needs, and internal resources that must be given added value". The fundamental psychological reasons that push entrepreneurs to start businesses are never a search for opportunities according to this kind of disincarnated procedure.

It is more interesting to return to the issue with the notion of identity. Studies in the field of corporate identity show the interest of a managerial approach that showcases collective identities. What interests us here is the individual identity of the enterprise's founder, but we will see that this is often linked to a collective identity. Cardon *et al*. (2009, 2017) examined the kind of passion that is an impetus for deciding to start a business and perform an analysis in terms of identity. This is how they distinguish:

– the identity of the inventor: passion for activities exploring new opportunities;

– the identity of the founder: passion for activities exploiting new opportunities;

– the identity of the developer: passion for activities making the company grow.

By studying a sample of the founders of enterprises (in the sporting gear industry), Fauchart and Gruber (2011) proposed a three-category classification: *Darwinians*, *communitarians* and *missionaries*. They base this on a psychosociological analysis that introduces the integration of individuals into communities where individual identities are defined based on the environment according to a mental schema as follows: Who am I?/What is my role? The enterprising act is then interpreted as a way to fulfill oneself regarding this issue – particularly for the last two categories.

Type	Characteristics
Darwinians	*Reference to the classical economic model:* Seeking personal interest; concentrating on the firm's competitive advantages
Communitarians	*Reference to a community:* Supporting the community and benefitting in return from its support
Missionaries	*Reference to a general mission :* Filling a general social role

Table 4.1. *Characteristics of the three types of entrepreneurs*

The approach guided by Emmanuelle Fauchard and Marc Gruber in their field survey with founders of enterprises is a theory of *social identity* that they developed from the literature on social cognition – a field of social psychology as described by Moscovici's collection (1972).

This approach allows us to expend the classical understanding of the entrepreneurship phenomenon, particularly through consideration motivations other than a search for long-term personal monetary gain – which is still the theoretical hypothesis of evolutionist authors or at least the founding father, Schumpeter.

The idea developed, based on the theory of social identity, is that individuals who found a new enterprise act in order to remain coherent with their identities:

> "(...) founders perceive as opportunities only those situations that are consistent with their self-concepts as they strive for identity-relevant actions in creating their new firms" (Fauchart and Gruber 2011, p. 952).

This is particularly true in the case of "missionary" and "communitarian" entrepreneurs. The "Darwinians" seem more neutral in terms of identity – except for considering themselves representatives of the liberal norm and playing the role of the habile businessman meant to grow rich. Insofar as there are potentially infinite occasions to start a new business, it is important to understand the logical foundations of restricting the field of opportunities for starting one. In a classical economic vision, we will believe that the only restricting logic is the probable long-term monetary yield, which is concretely unrealistic as a criterion for choosing, given the immensity of all imaginable opportunities. This type of economic rationalization is actually of no help in understanding the concrete phenomenon of entrepreneurship. *The social identity approach*, on the contrary, allows the field of imaginable projects to be limited, making the explanation for founding the enterprise more realistic. The best example is that of the "communitarians". In fact, they spontaneously focus on opportunities that allow them to support the community they belong to and be supported by it. Here, we find a much more credible principle of explaining the motives for founding the enterprise than the hypothesis of maximizing future revenues.

Let us take the example of the innovative winemaker who develops a new idea for growing vines, organic wine-making or selling wine. This is done through a passion for the profession, a love of the land and a will to serve the cause of the local community. In the case of success, the *ex post* rationalization that involves calculating the long-term yield from productive investments is, we can see, completely artificial. Hayekian reasoning on market opportunities is hardly more convincing. It is, however, adapted to describing the behavior of the Darwinian category.

4.3.3. *Conclusion on the entrepreneur's motivations*

What motivates people to start a business can, as we have just seen, significantly vary. The social identity explanation of the entrepreneurial phenomenon is a relevant start. It considerably differs from the classical explanations:

– previous knowledge belonging only to the inventor;

– exclusive access to information;

– particular cognitive abilities.

If we revisit the example of the "communitarian" entrepreneur, we will see that what motivates the head of the project is not cold, rational reasoning on the cognitive opportunities mentioned above, but the will to defend the values of his or her community and to benefit from the help this community provides in return. The community's forms of contribution are themselves diverse. Some fall under the three categories indicated, e.g. when they are connected to skills specific to a region (inhabitants' knowledge and skills, specialized local ecosystem, adapted infrastructure, institutional support through cluster policies, etc.), but this may also concern other fields, such as community funding, the image of the registered designation of origin or a captive market to release the product.

What is reductive in classical explanations is the approach exclusively through knowledge. The entrepreneur's creative dimension is not limited to cognitive aspects in the strict sense of the term. Innovation is never just a matter of new knowledge (unlike scientific discovery). It implies a desire to change the world and requires particular qualities involving risk-taking (for unforeseeable risks) and the pursuit of a dream that is both individual and collective. This does not stop the entrepreneur from hoping to earn money along the way, but without the dimension of a dream and imagination, the enterprise is not possible. In addition to some knowledge elements, the entrepreneur has a vision. Moreover, his or her motivation is often linked to a desire to play a certain role: *vis-à-vis* a community or in relation to general stakes (ethical, esthetic, political, etc.). Incidentally, in a Weberian interpretation, earning money is also the choice of a

particular role in society and the manifestation of adherence to a collective ethic – in a historic analysis by Max Weber, Protestant ethics with various Lutheran or Calvinist inspirations.

4.4. Entrepreneurship and complexity: the role of the imagination

In this chapter, we reviewed numerous definitions of the entrepreneur's role in the economy (and society), finishing with an analysis of the motivations behind starting a business. We also considered the context in which an enterprise's project is selected – among an infinite number of imaginable opportunities. Now it is time to revisit the central question of this work, namely that of *complexity*. What is the emergent function from this standpoint? Can we possibly propose a new characterization of entrepreneurship?

When making decisions, entrepreneurs face a complex world. Let us recall that they do not know their market perfectly (decision-making with incomplete information) and they sometimes foresee creating one, an action that is at least as complex and uncertain. The project notion implies a decision in the present with effects on the future, yet these effects can only be partially anticipated since the project is acting on a complex system. What, then, will guide the entrepreneur to assume such responsibility? The response lies in the *imagination*.

In fact, since reality cannot really be deciphered, the entrepreneur's work is based on a mental representation of the world. Entrepreneurs do not have objective information on the present and future environment. The information they have is partial, and the choice of their project as well as the decision to take part in a venture will be guided by a particular perception that resembles the construction of an image (a vision).

The notion of *perception*, the mental construction concerning reality, deserves some explanation. The term, in French or in English, harks back to the idea of deciphering a meaningful form in a complex exterior message, mixing a great deal of information and various

sources of noise. Implicitly, the message sought after is present in the environment, but difficult to discern. The German translation of "perception" is *Wahrnehmung*: "that which is taken to be true". This belies a slightly different notion, one related to the philosophical idea of truth. In German, perception is a constructed truth. This definition seems better adapted to the entrepreneur's approach. The choice of a project and the decision to carry it out are based on a structure of the current and future world imagined, then assumed to be representative of reality.

The imagination is essential to act in a complex world, for this is by definition impossible to fully decipher. From this standpoint, the entrepreneur's fundamental role is to imagine – an activity that partially substitutes that of knowing and understanding.

We can find interesting analytical elements in Peter Earl's book *The Economic Imagination* (Earl 1983). In the real world of economic decision-making, it is not a question of knowing how decision-makers optimize their decision, but "how decision makers cope with ignorance and complexity" (op. cit. p. 81). The author revisits a wonderful expression by Kenneth Boulding: "Any decision is a choice among alternative perceived images of the future" (op. cit. p. 28).

In fact, all individuals – not only entrepreneurs – seek to perceive or impose order upon the complex world they are immersed in. The imagination allows the formation of a representation of reality, knowing that we cannot reason about reality, which is itself unthinkable. Reality, on the contrary, will end up manifesting itself as the project is carried out: it is a source of potential surprises for the entrepreneur. What must be understood when observing entrepreneurs is what creates their representation of the world and what motivates their action. Peter Earl provides leads to understand the individual's choice of a project. In particular, he mentions the following attitudes:

– satisfying their aspirations and controlling the world in a way that is coherent with their representational system (their imagination);

– avoiding situations where they risk facing their inability to understand reality;

– promoting a certain self-image;

– escaping a negative vision of the world; breaking away from the present situation, which is seen as being non-satisfactory.

We have already seen the contribution of social psychology, which explains the choice of entrepreneurial project through the desire to play a role in a particular community, to personally express a collective identity. In this case, the entrepreneur's imagination is largely explained by his or her community belonging. Other patterns exist to explain the project's nature and genesis, possibly more individual ones, but we always return to an inescapable pattern: the entrepreneur's project is rooted in his or her imagination. This is itself the product of long-term interaction between the individual and the complex system he or she is immersed in.

5

Managerial Approaches and Theories of the Firm

Over the last two decades, complex systems have drawn the attention of numerous researchers from different disciplines. Allen *et al*. (2011, p. 2) remind us precisely that complexity cannot be studied in a monodisciplinary framework. Each discipline offers its own methods, approaches and measures, and all converge towards common definitions. Rarely can one find fields of transdisciplinary research where the advances in one domain (e.g. cybernetics) are considered by another discipline (e.g. philosophy) to then inspire the practices of a third (e.g. management) with considerable transparency and respect between the various disciplines. It is true that no discipline can claim to have an answer to every question related to complexity, which obligates a rather rare sort of mutual respect upon authors.

A complex system is made up of interacting parts forming a "whole". Each of these parts is governed by a set of rules, routines or forces that determine their behavior at a given moment based on the state and behavior of other parts. The interactions between the parts are generally numerous, dense and not necessarily limited in terms of location. These interactions may be formal, informal, virtual or suffused with materiality. Each part reacts according to its own stimuli on local or global emergent phenomena, even in the absence of coordination between the parts. However, the results of these

Creative Management of Complex Systems,
First Edition. Jean-Alain Héraud, Fiona Kerr and Thierry Burger-Helmchen.

interactions are difficult to foresee, even if abundant knowledge on the parts and the interaction rules is available, for there are many independent causal links. The system's "complexity" manifests itself through the issue of phenomena that affect all or part of the system with a regularity that is neither static nor random, but difficult to describe precisely and exhaustively.

Works on complexity in economics and management aim to study complex systems, their appearance and their evolution. These works are sometimes highly quantitative (use of mathematical modeling or computer tools) and sometimes qualitative (case studies, analogies, longitudinal studies).

The hierarchic view of economic systems as complex adaptive systems in a state of constant evolution owes a great deal to the precursory works of Nelson and Winter (1982). At their instigation, management of a firm and economics have shifted from a situation with absolute, quasi-Newtonian rules on steering organizations to situations where decision makers' knowledge is limited in an ever evolving environment with rules that are themselves undergoing change.

No manager faces an environment where the rules never change. We are able to describe the organizational dynamics of numerous economic and social systems primarily based on our own experience, and it is highly likely that another person's perception of these dynamics and its interpretation would be different. These differences in perception paired with other goals and constraints lead to divergent behavior that will either reinforce one another or come into conflict, and thus influence the overall dynamics of the system.

Although it is possible to predict the evolution of the system to some extent, under a given set of conditions, small-range and *a priori* inconsequential local events disturb and modify the system as a whole in the long-run. The science of complexity offers a framework for accepting two situations, i.e. individuals are neither omnipotent nor significant. They are certainly not capable of modifying a system

as they please, but their role is not insignificant either. They can change the system through their actions if they take on the system's complexity readily rather than rejecting or fighting it. Based on this fact, studies on complexity as well as those on creativity use dynamic approaches rather than visions of static equilibrium. Dynamics do not follow fixed rules or new qualitative elements; random variations show up as other elements fade away. In fact, complexity is a science for any organization, and research on creativity studies the indications of (sometimes weak) signals causing the system's evolution. Creativity thus is an aspect that exists both in entities (individual creativity) and the system as a whole (organizational creativity).

In section 5.1, we will provide a non-exhaustive list of works in management, grouped conforming to broader functions (strategy, information system, etc.), explicitly referring to complex systems, chaos theory, etc. In section 5.2, we will return to a conceptual model that enables us to distinguish between concrete actions and different positions to be assumed by a manager when faced with a complex system. The following sections will focus on two specific managerial functions: marketing (and its strong connection with strategy) and human resource management.

Indeed, the place of marketing in a complex adaptive system is less apparent initially. Wollin and Perry (2004) have a rather clever approach to this relationship, recalling that the theory of complexity enables marketers to understand a market's function. Complexity provides global and local explanations for markets and complements other theories such as relational marketing. By employing the Honda case, Wollin and Perry illustrate the extent to which complex systems can be employed in strategic marketing. Colbert uses an approach, connected with theories of the firm, to indicate through an example of human resource management how a conceptual approach far from the field can enlighten managers.

5.1. Complexity and management: the first steps

The use of complexity science to represent and create economic models sharply contrasts with classical approaches. Nevertheless, attempts have been made previously to describe the operations of organizations under different names such as the systems approach, the holistic approach and the systemic approach. Systems theoreticians dominated the study of organizations during the first half of the last century. Since 1938, organizations have been represented as multiple units of cooperation thanks to Bamard. These cooperations are then the engine of creation for new properties both between and internal to organizations. These properties are qualitatively different from previous ones and distinct from the qualities of the organization's members (Reed 1985). This work has progressed from the study of the internal organization of systems to the study of open systems (Scott and Davis 2007) and more recently open strategies (Hautz *et al*. 2017).

Following Bamard's works, numerous authors have contributed to the development of a generalized systems theory. In particular, we can cite Boulding (1956) and von Bertalanffy (1968), who presented the framework for the study of systems, to which many subsequent authors made a significant contribution. Among these was Ashby (1956) and his law of requisite variety, or Simon (1982) who described complexity science based on his work on decision-making in specific organizations, a study that he conducted notably through the use of digital tools to represent interactions and decision-making. At that time, Thompson (1967), as one of the founding fathers of contingency theory, also contributed to the emerging study of systems. Indeed, contingency and complexity both share the need to describe structures and relationships with the environment (Anderson 1999).

Table 5.1 provides an overview of these works. Even if all of the references emphasize the implications of complex systems for managerial issues, there are few references that explain the behavior that managers must adopt.

Implication for…	Introduction of…	References
Management of natural resources	Modeling evolutionary systems	Allen and McGlade (1987); van Mil *et al*. (2014)
Public administration	Absence of equilibrium, Chaos theory	Kiel (1989); Gerrits and Marks (2015); Daneke (1990); Overman (1996)
Social sciences, Social science research methods	Nonlinearity, Chaos theory	Kiel (1991); Smith (1995); Gregersen and Sailer (1993); Reed and Harvey (1992)
Management	Complexity theory	March (1991); Lissack (1997); Johnson and Burton (1994); Glass (1996)
R&D management and information systems	Chaos theory	Hung and Tu (2011); McBride (2005)
Strategy	Chaos theory, Complexity theory	Levy (1994); Stacey (1993); McMillan and Carlisle (2007)
Quality management	Complexity theory	Dooley *et al*. (1995)
Leadership	Complexity theory	Stumpf (1995); Wheatley (2006); McDaniel (1997)
Organization theory	Self-organization of systems, Chaos theory, Complexity theory	Thiétart and Forgues (1995, 2006); Drazin and Sandelands (1992); Niang and Yong (2014); Anderson (1999); Morel and Ramanujam (1999); Burnes (2005); Begun (1994); Cottam *et al*. (2015); Zuijderhoudt (1990)
Healthcare service management	Complexity theory	Resnicow and Page (2008); Arndt and Bigelow (2000)
Human resource management	Complexity theory	Colbert (2004)
Marketing	Complexity theory	Smith (2002); Wollin and Perry (2004); Hibbert and Wilkinson (1994); Nilson (1995)
Entrepreneurship	Chaos theory	Han and McKelvey (2016); Smilor and Feeser (1991); Mason (2006)
Project management	Chaos theory	Simard *et al*. (2018); Priesmeyer and Baik (1989)
Internationalization	Nonlinear phenomena, Complexity theory	Mendenhall *et al*. (1998); Chandra and Wilkinson (2017)

Table 5.1. *The first research on management in connection with complexity (source: Maguire et al. 2011, document updated by the authors)*

5.2. Manager's role versus complex systems

The manager's role is to analyze and characterize the organization's environment and its situation, and then provide a suitable response. In this regard Snowden and Boone (2007) perfected an analysis tool to improve decision-making: the Cynefin model, which helps in decision-making based on the environment. It is the manager's job to adapt his or her behavior to the present environment. The authors have identified four distinct environments (Figure 5.1):

1) If the environment is simple, the relationships between causes (A) and effects (B) are clear; and if the manager decides A, B will always take place. The organization responds to the situation through routine behaviors at its disposal in its process repertoire. This environment is not necessarily the most comfortable, for even if the manager's involvement is minimal in this situation and limited to a control mission, this can be a source of lost vigilance for him or her and all collaborators. The standard responses provided can lose their effectiveness without this necessarily being noticed and the firm can get stuck in a simple learning loop.

2) If the environment is complicated, the manager identifies what is unknown. Cause-effect relationships are acceptable and the manager's role is "simply" to pinpoint the usual system response that is best suited to the situation. The work put upon him or her is similar to that of surgeons or engineers. It is meaningless to invent new procedures, solutions or treatments; it is enough just to collect elements from the environment to determine the right behavior by lifting the veil off the unknowns.

3) In a complex environment, the manager must adopt the given solution or even devise a new one. This is the case in many economic situations, whether this involves competing markets or competition within an organization for a promotion. There are many unknowns and a real need arises to adapt a solution. For an example a firm must adapt its products to the customers' desires while setting itself apart from the competition, i.e. the solution must then be unique.

4) In a chaotic environment, cause-effect relationships quite differ and are often vague. The manager must test the environment anyway

before adapting a response. This represents the only method one can adopt for obtaining new information that is somewhat reliable. Without seeking to establish causal relationships or a battery of organizational responses, it is the manager's job to find out promptly what works least. Next, corrective actions can be taken to improve the situation.

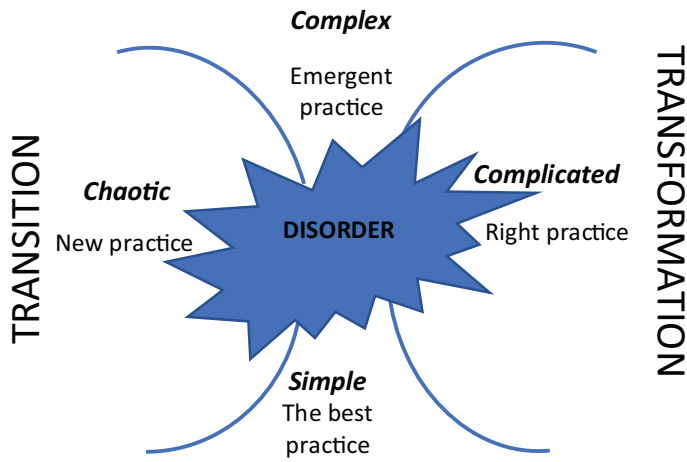

Figure 5.1. *The four situations from the Cynefin model (source: Burger-Helmchen and Raedersdorf 2018). For a color version of this figure, see www.iste.co.uk/heraud/creative.zip*

To illustrate this representation, let us take the case of a supervisor managing two lines of products. The first product is at the final stage of its life cycle, where its market has already reached the peak of maturity, and competitors are gradually withdrawing from this market. The environment is simple. The collaborators provide standard responses to the day-to-day problems and the supervisor must spend most of their time managing the lessening activity. For the second line, a future flagship product, an equivalent inverse problem exists. Even if the supervisor has already launched multiple products onto the market, things are different, particularly if the product is launched into several (developed and emergent) markets at one time and unexpected competitors appear at the last moment. Moreover, some collaborators associated with the product are new and the supervisor is

unaware of their reactions. In this chaotic environment, it is preferable to test the reactions of the collaborators and the competitors on the new markets before deciding on a definitive strategy.

As noted by Burger-Helmchen and Raedersdorf (2018), complicated and chaotic environments do not maintain historic cause-effect relationships and new logical sequences are not immediately apparent. In these environments, the manager's role is to test the waters if the environment is complex or act if the environment is chaotic before formulating an adequate response. Not taking any steps for providing better solution does quite the opposite. Likewise, when the organization has to innovate in a chaotic environment, it is better to accept provisional situations and imperfect solutions, even if it means having to improve them later.

Based on this generic framework for managers, we will now see how researchers have adapted the logic of complex systems to their field of specialization, turning our sights first on marketing and then on human resources.

5.3. Marketing and complex systems

Marketing, as we are reminded by Kotler and Keller (2015), is a planning and execution process that includes product design, price, promotion and the distribution of goods, ideas and services, all with an aim to create satisfactory exchanges for the consumer and to meet the organization's goals. These processes are often represented by 4P or 4C models in their modern vision (Burger-Helmchen and Raedersdorf 2018).

Due to consideration of communities and the development of social networks, numerous marketing authors over the past 20 years have turned their attention to the repetition of exchanges rather than a single transaction. Marketing offers a renewed sense of belonging to a community. This "belonging" makes relationships less fleeting, creates interaction dynamics between different agents forming a system with timeless properties: the transactions of yesterday establish the conditions for the transactions today, which will in turn define the

exchange rules of tomorrow. This temporal contingency lies at the heart of complex systems and chaos theory.

Very few works in marketing explore this type of contingency (see Table 5.1). Following strategic management, the dominating model is that of punctuated equilibrium. This model presents the normal evolution of an organization as a series of incremental improvements whose impact is marginal and do not affect the large equilibriums in place. The breakthroughs – major changes – that affect an organization and influence the system as a whole are rather infrequent (and, depending on the model, may or may not be foreseeable). Among the notable exceptions are Hibbert and Wilkinson (1994), who use a specific case to illustrate the evolution of a system in connection with marketing. Nilson (1995) identifies nonlinear marketing relationships between the product and consumers' opinions.

Wollin and Perry (2004, p. 557) explain this low number of works concerning "marketing and complex systems" as a result of the difficulty faced by authors in exploring the generalist previsions of complex models in their enterprises. Followers of complex systems have formulated few convincing responses to the question, "If you are globally smart, why aren't you locally rich?" In reality, the difficulty faced by certain researchers in management science, who use complex models to justify the relevance of their works, precisely lies in their scarcity. Indeed, success of complex systems lies in the field of life sciences, physics and meteorology because there are many works that accumulate to reinforce and complement one another, yet the social sciences face more intense problems in contingencies – ones that are more difficult to model – which makes the progression of knowledge slower. Particularly in complex systems in the social sciences, individuals learn, anticipate and modify their behavior. In complex systems applied to meteorology, for example, this is, however, not the case (Lorenz 1963). It is not possible to express this with equations containing constants. Throughout this section, which is dedicated to marketing, we try to show how the representation of a market in the form of a complex system is elucidating for a marketer. In general, four types of representations of complex adaptive systems can be used in management science. The complex adaptive systems model is

probably the most appropriate to represent the interactions between the market and the marketing process. We then use the example of Honda developed by Wollin and Perry (2004) to show how consideration of contingencies, feedback loops and path dependence makes projection and control difficult (and crucial) for marketers.

5.3.1. *Hypotheses and theories of complex systems*

Gleick's image (2008) of a butterfly flapping its wings on one continent and hurricanes appearing on another has become the symbol of chaos theory. The identification of regularities in an apparently random whole is the objective of those who observe complex systems. Such regularities (and contingencies) have been grouped into four sets of hypotheses in management science.

1) Entreprises (and marketers) have different forms of micro-diversity, i.e. they differ from others in certain aspects but are similar in others. All of the similarities (e.g. mastery of a certain technology or recourse to the same supplier) is called macro-uniformity. Differences can be found in the micro-foundations of each firm.

2) The behavior of each firm (or each head of marketing) is subject to different degrees of path dependence, i.e. each will be more or less influenced by its own personal history. The dynamics of decisions on the market, in a system, depend on this history, which constitutes the starting conditions.

3) The distribution of behavior can change drastically in a short time. Thus, if usual behavior respects the distribution of a normal law most of the time, "creative" or unusual behavior sometime appears. This behavior is likely to modify the systems' properties. The smaller the number of firms or heads of marketing is within a system, the greater the impact of creative behavior may be.

4) Not all rules evolve at the same rate. Some behavior rules only change slowly, for they correspond to the profound culture of an organization, or they exist as a function of the interactions with other actors in the system (a sort of common code). Others are likely to be modified much more quickly by the effect of learning and exogenous

shocks, or more likely in the case of marketing by the desire of an actor to change the code in place.

Of these four points, the first two being micro-diversity and path dependence characterize the local context (the firm) in which the marketer must act. The following two enable us to define a space to represent four types of complex systems corresponding to the (in)consistency of interaction rules and the normality/creativity of behavior.

5.3.2. *Four types of complex systems*

The first type of complex system corresponds to deterministic chaos. "Deterministic chaos" is an oxymoron that reflects the paradox of coexisting order and disorder within a single system. Meteorological phenomena or earthquakes typically belong to this category. Stabilizing forces and disturbances come into conflict, the system sometimes swinging to the extremes. These antagonistic forces make the system more difficult to predict. However, such systems can be modeled, mathematically described, provided that they are rather simple and only include a few variables. Nevertheless, most social systems include a large number of interacting variables. The hypothesis that interaction rules are constant does not apply to marketing. Managers learn from their interactions with clients, suppliers and competitors. The model created by Argyris and Schön (1978) lines up with this situation where consideration of new elements leads to an adaptation/evolution of the rules. As a result, the markets are more complex than deterministic chaotic systems.

This framework has been used in management to metaphorically describe the cycling phases of stability and instability in social systems, firms or project management (Brown and Eisenhardt 1998; Wheatley 2006). Another application in management lies in the creation of data for comparison (Hibbert and Wilkinson 1994; Cheng and Van de Ven 1996; Glée-Vermande 2016).

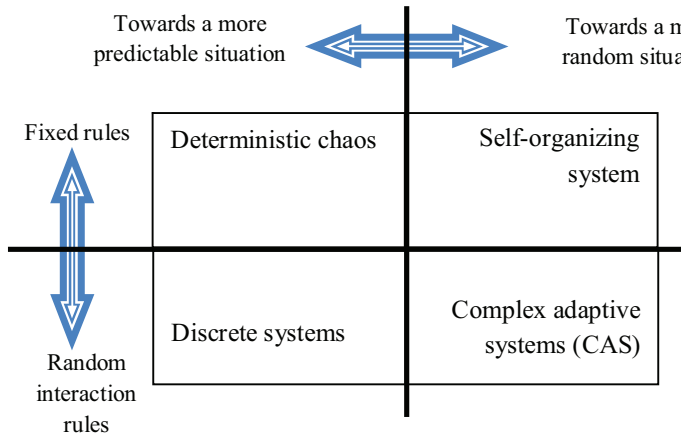

Figure 5.2. *Four types of complex systems in marketing (source: Wollin and Perry 2004). For a color version of this figure, see www.iste.co.uk/heraud/creative.zip*

The second type is a self-organizing system where order emerges from apparent disorder. A process involved in these systems leads elements to cooperate, coordinate and demonstrate united behavior, *a priori* spontaneously (Stacey 2010). These systems have micro-behaviors that do not dissipate into general behavior; on the contrary, it is a harbinger of change. The result is not predictable, for not all the interaction rules are known and many are emergent. Social systems do not have a limited number of convergence points, and self-organization models are not countable. Thus, a marketing situation is only partially represented by this type of complex system.

Another type of such system is based on hypotheses that are more appropriate for marketing (the fourth type is a version with discrete and thus less realistic states).

This third type, complex adaptive systems (CAS), found in the bottom right corner of Figure 5.2, is characterized by the ability of actors to profoundly change the system in which they evolve and interact. Complex adaptive systems take shape in markets where adaptation is possible (Simon 1945). This kind of market is made up of a large number of consumers and interdependent firms. Each of

these actors interacts with many other actors as well as the environment in general. The fact that the market is made up of a large number of actors must not lead us to a view that this situation is comparable to that of a pure competition market and is an attempt to perfect the neoclassical model. Indeed, it is notable that this final model formulates hypotheses of perfect information and agent homogeneity; however, in the present case, we are far removed from this theoretical account, because firms and consumers each have their own history. Moreover, the products and services are not homogeneous (hence the interest in marketing campaigns) and nothing guarantees individuality in pricing. The order that will be established within the system is not determined *ex ante*.

If there is balance, which is not guaranteed, it can be modified by interactions within the system according to the mechanism described by Adam Smith (1776). Mechanisms for adapting to each external or internal shock act as an "invisible hand". This adaptation affects the behavior of the actors and even the rules that are in effect within the system. In fact, these systems are potentially robust and sustainable because they are both capable of changing their environment and adapting to environmental change.

According to Simon (1982), these models are particularly relevant for the study of markets, for they use an architecture of multi-level rules; in other words, there are rules on a higher level (e.g. the system level) and a set of rules at other lower levels (for a firm, a project, a transaction, etc.). For Simon, a change to a higher-level rule leads to chain adaptations in the lower-level rules. However, evolutions in micro-level rules do not lead to modifications in higher-level rules (or do so in a less automatic way). This one-directional interaction between the levels broadly contributes to its stability. This structuring of the rules owes itself to the organizations' beliefs, values, culture and routines (Gersick 1991; Cohendet and Llerena 2003). For a firm, this structuring stems from its history, experience gathered through past interactions with consumers and competing firms. Higher-level variations come about less frequently, whereas those at a lower level appear at a higher rate.

These models, as we emphasized in Chapter 1, hold positions similar to evolutionary models of the firm. The evolution of the rules takes place through processes of variation, selection and retention (Nelson and Winter 1982; Carroll 1984). This succession of stages, the source of positive feedback loops (the source of new change) or negative ones that freeze the system for a certain period of time, allows innovations and imitations to take place (Stacey 1991).

Thus, for Spender (1989, 2015), the study of a market from the perspective of complex adaptive systems implies i) the search for specific rules and the ordering of these rules; ii) the examination of causes leading to the evolution of rules and iii) the identification of structures and behavior common to the primary actors in the system.

The last situation described in Figure 5.2 is a discrete vision of markets. The actors all line up with a median behavior. However, the model can swing towards another state, a new equilibrium, where the actors all act once again in a standard way based on the new state of the system. This situation is often described as a – discrete – subset of the complex adaptive systems, which offer broader behavior spectrums (Gersick 1991).

5.3.3. *Honda and the global automobile market*

To illustrate the marketing approach to complex systems, auto manufacturer Honda serves as a good example. Wollin and Perry (2004) analyzed this case that, in their opinion, illustrates how a firm adapts to complex systems. Indeed, the automobile market is a relatively open global market with a large number of interacting agents (large purchaser firms, manufacturers of numerous parts, consumers and multiple commercial intermediaries). This industry regularly undergoes cycles of profound transformation: the introduction of mass production (1920), the development of European manufacturing (1950), the growth of Japanese manufacturers (1970), intensified collaboration (1990) and the development of electric vehicles (2010), to name a few. This reinforces industry's internationalization at each step (Jones 1985; Amatucci and Mariotto 2012).

Honda played a special role in building the ties between the United States and Japan in the late 1970s and 1980s. This firm also has witnessed marked growth and strategic variation since the 1990s.

5.3.3.1. *Micro-diversity within the firm and the sector*

The global automobile market is characterized by macro-uniformity. There are in fact many characteristics common to all manufacturers; and vehicles around the world have too many points in common (number of wheels, seats, etc.). Consumers expect vehicles to be equipped with more options in pricing terms. However, we observe great micro-diversity. Thus, the distribution of parts on the market varies from one country to another; the same brands are to some extent not available elsewhere. Firms choose to produce a complete or partial range of products, to offer a variety of options and complementary services. Not all management methods are identical, nor are the choices for the geographic distribution of factories.

Not all firms have the same *micro-foundations*, either (Augier and Teece 2008). We can therefore conclude that this market proves the hypothesis of micro-diversity in complex systems.

5.3.3.2. *Irreversibility and path dependence*

The second characteristic that we can attribute to this sector matching the description of a complex system is path dependence. Future behavior is influenced by the actors' history (Arthur 2014). This path dependence can be more or less pronounced depending on the systems and actors (Cowan and Hultén 1996).

Honda started manufacturing cars in the mid-1960s, after establishing their leadership on the motorcycle market. This late entry onto the automobile market was initially a disadvantage for Honda, which had held a very modest position in Japan for nearly 20 years. Honda long held fifth place in terms of market share in its country of origin, partly because of its adverse location in Japan. However, Honda was the first Asian manufacturer to build a factory in the United States.

In the United States, Honda was less constrained by path dependence, as there was a lesser degree of social and cultural rigidity

there. The primary competitors in the United States suffered the same problems that Honda has experienced in Japan. Unlike large American manufacturers, Honda, with its new factory in Ohio, had no long-term agreements with unions or suppliers. Honda also had not made irreversible investments in production goods. American manufacturers had problems shifting production to bring out more compact vehicles as they hoped to first make profits on the investments made on existing production lines which otherwise seemed to be irrecuperable costs to them (Besanko *et al*. 2017). Thanks to this favorable strategic position, Honda began manufacturing and commercializing the Accord in the United States where it remained the most sold vehicle in its category for more than 20 years.

The automobile market belongs to a set of industries in which the weight of investments to innovate and commercialize innovations is so great that it imposes a timeframe on global system evolution. Firms in this sector have long succeeded in developing thanks to their massive investment in productive capital rather than in R&D. This phenomenon was particularly pronounced in the United States after World War II, when technological innovation in manufacturing processes and vehicles present were comparatively much less than economies of scale linked to modifications in manufacturing.

Honda, unlike American manufacturers, established multi-product production lines very early to enable the production of vehicles such as the Accord or the Civic. It demonstrates that the complex system of auto manufacturers, in which Honda finds itself, is sensitive to initial conditions of operation and presents a certain degree of path dependence.

5.3.3.3. *Variety of results*

A third characteristic of complex adaptive systems is the variety of results obtained by different actors. There is simultaneously a group presenting average results including actors performing at a higher or lower level.

These variations in performance within a complex system, such as the automobile sector, are caused by several elements. First, the

market in question is not in a state of pure, perfect competition, but in a state of oligopoly. Thus, it is possible for the actions of a small number of firms to noticeably change the median result. This play between the results of average and median creates particular industrial dynamics.

Next, there are positive and negative feedback loops within this market. Thus, the fact that Honda established itself in the United States initially had a positive effect leading the entire group to evolve, to change certain practices and to some extent its culture. However, the great success experienced by Honda thereupon generated a negative feedback loop too. Actually, considering the size of the market in North America, Honda began focusing its vehicle design on the tastes of North American consumers, yet the specificities of the vehicles desired by these consumers differ greatly from those of Japanese consumers. For a while, Honda established the design including some of its rules primarily for the American market but failed to develop satisfactorily on the Japanese market.

Finally, different results produced imply no occurrence of coevolution between the general system and all the firms. Indeed, some firms will evolve faster than others. For Stacey (1993), this situation of partial coevolution is a supplemental factor that makes the system's global evolution harder to predict. This is also the case of differential in coevolutions that supports heterogeneity within the system.

Honda won shares on the American market because the firm rapidly evolved towards the production of compact vehicles. Many manufacturers took time to enter this market segment, long considered to be a small niche of little interest to the giant industries in Detroit. However, successful coevolution does not indicate capability to repeat the operation and always perfectly stick to the market. Thus, Honda was ahead in certain aspects, but took longer to begin manufacturing four-wheel drive vehicles. Other Japanese competitors such as Toyota and Mitsubishi were able to take advantage of this market segment's growth.

5.3.3.4. *Evolution of interaction rules*

In a complex system, firms do not have constant interaction rules with one another nor with other elements in their environment. It is therefore necessary to question the factors bringing change to these rules and the factors that are likely to create resistance to change.

The points that we highlighted in the preceding sections illustrate the evolution of interaction rules. Indeed, actor micro-diversity leads to a need to adapt the interaction rules of the actors on the same level. Thus, introducing a radically new vehicle, that creates a previously unseen market sector, forces competitors to become followers, imitating the predecessor. This was the case in France with the release of the Twingo, which changed consumer and manufacturer interest in small vehicles (interest that had been lost since the end of models such as the R4, R5, 2CV, 104, etc.). The interaction rules also change based on external shocks. Thus, in the late 1990s, when the Japanese market suffered its first significant slowdown, manufacturers felt threatened. This was notably true for Mazda and Nissan. Nissan underwent a clear change in its interaction rules within the scope of its alliance with Renault.

Finally, the firm may determine the evolution of interaction rules with the environment. This was the case when Honda decided to deliberately enter the North Korean market, drastically changing the actors with which it interacted.

In the early 2000s, Honda faced many challenges. The new manager saw no need to change some of the lower-level rules but to modify the higher-level rules that would themselves lead to changes at the micro level. In particular, the company was reproached for following its founder's logic. Engineers were in charge of everything and little room was made for marketing and interaction with clients. The release of the Accord was less to satisfy clearly identified customer needs and more to show off the engineers' technical exploits: attempting to bring together all the options in a smaller vehicle while controlling costs and making manufacturing tools more flexible. This profound cultural change allowed different firm

operations to work together better, as the hierarchy between them was no longer dominated by the engineers. This change in one higher-level rule led to modifications at the micro level throughout the firm.

5.3.4. *Implications for the marketing manager*

Managers specializing in marketing must embrace the micro-diversity that reigns in complex systems. This position is almost natural for them, for they know that they must develop positions that distinguish them from others. However, the managers of other functional units within a firm are not aware of this. It rests with the head of marketing to raise awareness among them. Thus, heads of R&D know that they must come up with better products than their competitors, yet without perfectly knowing consumers' preferences for one function or another. Must quality be improved? Does an option need to be added? A service? Which of two competing design options should be chosen? The marketer who is sensitive to micro-diversity must be ready to guide this decision-making.

It is marketing's job to ensure that the firm is exposed to the variety around it and to find all sources of commercial uncertainty. The firm thus prepares for change if necessary (here, we see a reproduction of Ashby's law of variety, 1956).

Marketing takes path dependence into consideration, including developing the story of a brand and creating meaning. However, a decision like the one made by Honda to take on a new market allows a firm to create a tabula rasa of the codes and prior marketing guidelines. The marketing challenge is to come up with a new campaign in a complex system with new rules.

Managers specializing in marketing must also develop the employer margin. Indeed, every firm needs to attract talent in order to develop new products and services and face system evolution. Complex adaptive systems are generally robust, but a firm may see a wide range of results or suffer an accident. In this case, the marketer is responsible for communicating the crisis to avoid the system rules evolving and making the firm's position – its survival – impossible. In

a less critical way, marketers must identify negative (and positive) feedback loops. They can thereby accompany and encourage change or help relax some positions.

As noted by Nilson (1995, p. 24), a marketer's difficulty in a complex system lies in the timely prediction of system evolution (and thus the detection of weak signals). The marketer's job, however, involves elaborating a message with no room for doubt, while knowing that he or she may be forced to change this discourse in a considerable way in the future.

5.4. Complex systems and human resource management

Strategic human resource management (SHRM) is based on two fundamental ideas:

– human resource management has major strategic significance for the firm. Knowledge, skills and employee interactions can form the firm's strategy and its implementation;

– human resource practices are instruments to develop a firm's strategic capacities through proper management of personnel.

Expressed in these terms, SHRM demonstrates many similarities with the vision of the firm based on RBV – resource-based view – resources (Wernerfelt 1984; Grant 1991). Those trained in RBV think that the competitive advantages of firms stem from the resources at their disposal. As a result, it is the role of the managers to select, develop, combine and redistribute these resources. Not surprisingly, many authors have attempted to develop a connection between human resource management and the theory of the firm based on resources (Wright *et al*. 2001). However, a number of these authors recognize that beyond the analogy involving the notion of resources, SHRM lacks a theoretical framework comprising every aspect and strategic implication (Delery 1998). Backed by this logic, researchers and particularly Colbert (2004), whose ideas we will focus on later, attempt to incorporate human resource management, the strategic vision based on resources and complex systems.

Next, we will use Colbert's results (2004) to show the connections between complex systems and the RBV approach within the scope of human resource management. We will then discuss the implications of complex systems on research and human resource management practices.

5.4.1. *RBV and complex systems*

Several authors note that RBV establishes an interesting framework to justify the importance of human resources in developing firm's competitiveness. It provides rather little information on the implementation and the way an organization must develop their human resources to attain and maintain a competitive advantage (Delery 1998). This situation is not surprising insofar as the strategic value of RBV resources stem from the complexity of combinations and the inimitable character of the resources. Furthermore, this complexity is difficult to resolve. This difficulty arises from the causal ambiguity connected to resource combinations, the inability to observe certain interactions and path dependence in their accumulation. It is difficult in this case to find a level of direction that maintains the strategic aspect of RBV while making it sufficiently operational.

As Colbert points out (2004, p. 346), the difficulties connected to the use of RBV and potentially echoing in the sphere of complexity are: i) the importance of creativity and adaptability; ii) causal ambiguity; iii) the notions of imbalance and path dependence; and iv) the global representation as a system. This represents a set of characteristics that is particularly important when it comes to describing and analyzing complex systems, as shown in the previous chapters.

Works on SHRM are particularly attentive to the concept of slack, the free time left to individuals. In this – unsupervised – time, employee creativity can be freely expressed. This point was underlined by Penrose (1959, p. 85) in particular: "The availability of unused productive services within it creates the productive opportunity of a given firm. Unused productive services are, for the

enterprising firm, at the same time a challenge to innovate, an incentive to expand, and a source of competitive advantage".

The use of the creative resources employed has given rise to many debates, notably on the duality between control and creativity. For many SHRM authors, the late 1990s and the 2000s were marked primarily by the control of productive resources and little by creative resource management. This is highlighted, for example, by Snell *et al*. (1996, p. 65): "In the context of achieving sustained competitive advantage, we need less research on the control attributes of SHRM and more research on how participative systems can increase the potential value of and impact of employees on firm performance. If human capital is valuable, we have to learn how to unleash that value".

Causal ambiguity and path dependence make it difficult to precisely understand the interaction mechanisms through which human resources and the policies that support them create value. To imitate a complex system, we must know how the elements interact. Researchers have shown that hiring human resource (HR) managers to imitate their previous organizational system and methods does not lead to high performative results (Becker and Gerhart 1996).

In the previous chapters, we have specifically insisted on the importance of interactions between the actors within complex systems. These interactions are many of the social links that make some employees valuable. Black and Boal (1994) put forth the notion of "system-level resources" to refer to the strategic organizational abilities that only exist within certain interactions and that are limited to certain relationships. Many works have shown the importance of these strategic connections by using the notions of complementarity or co-specialization (Brumagim 1994).

For Peteraf (1993), the resources particular to the system (and thus to the firm) are quite immobile. This fixedness of certain resources is the source of some firms' lasting competitive advantage. It is a source of value and profits for the firm (Burger-Helmchen and Frank 2011).

Table 5.2 summarizes and compares the characteristics of the firm's vision based on resources and complex systems. This table, inspired by Colbert (2004), has been updated with remarks by Stacey and Mowles (2015). The different dimensions highlighted show that the two approaches, RBV and complex systems, have the potential to enrich one another. Since SHRM is supported by firm's theory based on resources, the potential connections between human resource management and complex systems are possible. They are the subject of discussion in the next section.

Characteristics	RBV	Complexity
Creativity/adaptability	The source of competitive advantage lies in latent creative potential, encapsulated in the firm's resources	CAS create new responses to environmental modifications
Complexity and ambiguity	Inimitability stems from social complexity and causal ambiguity	CAS are made up of complex, nonlinear, non-deterministic interactions
Imbalance, dynamism, and path dependence	Complex relationships are inherited from firms' history; imbalance is habitual	The system evolves regularly; imbalance is synonymous with stagnation; history and the timeline are pronounced
Resources at the system level	Some resources only exist at the system level through construction	Some characteristics only exist at the system level thanks to agent intervention

Table 5.2. *Connects and complementarity between RBV and complex systems (source: Colbert 2004, p. 350)*

5.4.2. *Strategic human resource management*

Figure 5.3 illustrates the integration of SHRM into firm's theory as a complex system. Conceptual approaches and levels of analyses have been represented in this figure. The oval shapes indicate the range of each conceptual approach. As readers turn their attention to the right,

the degree of interaction between the system elements becomes greater.

This human resources approach specifically emphasizes that HR systems are very difficult to transfer from one firm to another. Path dependence makes it so rigid that a firm's HR practices only apply in a very specific framework. By definition, though, the employees in each firm, the organizational culture and the routines in place are specific to each firm. In addition, an optimal SHRM practice for one firm may be ill adapted to another's needs. This approach also is a large part of self-organization. The implications for HR managers lie at the level of specifying the rules to be put in place. In this approach, their role is to set some basic principles that will be available locally within each unit of the firm. Each unit will self-organize, where the HR managers' role is to avoid unacceptable drifting and fixing better practices once local actors are self-organized, if necessary.

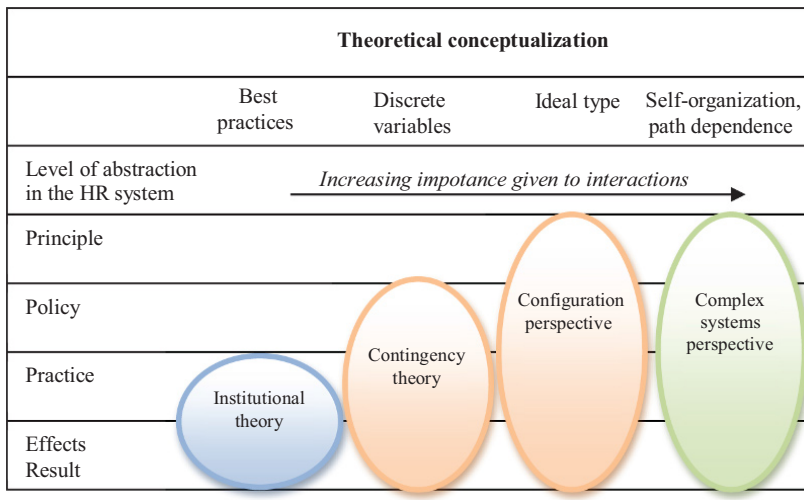

Figure 5.3. *Theoretical conceptualization of the firm and complexity (source: Colbert 2004). For a color version of this figure, see www.iste.co.uk/heraud/creative.zip*

The system approach implies that HR managers make it a priority to develop resources at the system level, for these are useful in large

quantities, which gives them greater value. Likewise, greater attention must be paid to interfunctional activities. To encourage these, HR managers can encourage personnel to move between different departments and functions in the firm or offer a training period when a new employee arrives. This could involve spending several months in different firm functions to improve knowledge of the system as a whole.

The information system must enable each employee to be quickly and correctly informed of important changes that affect the system as a whole. The formal methods of informing employees must be completed with informal practices (particularly at the unit level), recourse to forums and also a solution to ensure this information exchange, even if numerous works show that these forums are used very little by employees in the end.

One of the missions of HR managers is all the more difficult within the scope of complex systems: establishing performance measures and incitation mechanisms. Usual practices actually focus on local effects and immediate employee performance, yet a complex systems approach must look at long-term impacts and the value created by an employee at different levels. Designing performance measures and remuneration patterns in this case requires considering a large number of factors, often beyond the classical mapping criteria such as a balanced scorecard (Kaplan and Norton 2004). These kinds of works in SHRM are still few and far between, and those that exist could be largely amended. However, the school of thought concerning the micro-foundations of strategy offers new possibilities to echo complex systems within the scope of human resource management and strategic management by focusing on the smaller elements in a complex system (Foss and Pedersen 2014; Felin *et al*. 2015).

5.5. Conclusion: managers' creative responses

The situations we have described in this chapter have many points in common, such as strategy, marketing or human resources. Although section 5.2 describes what managers must implement to find a solution vis-à-vis the current environment, we have not yet offered a

framework for studying creativity in these situations. However, Fisher and Amabile (2011) have contributed considerably towards this analysis. For these authors, managers are never alone and it is not only their creativity, but organizational creativity that is important. This organizational creativity can take different forms, which must be represented and studied on two axes: the higher or lower degree of novelty (regarding solutions, practices and previous routines) and the speed at which the organization must react (which is the time before operational implementation can really take place).

Figure 5.4 represents the four forms of organizational responses that the firm can formulate. The most creative actions are in the top row. Improvisation and composition create new products or results. It is the reaction timelines that distinguishes them. In the case of composition, there is a delay between the moment of creation and its execution. To draw from a musical example, we distinguish here the situation where the composer creates a new melody and the moment when it is played. Inversely, improvisation corresponds to the simultaneity of these actions. To stick to the musical metaphor, this is an improvising jazz group: the group composes and plays at the same time.

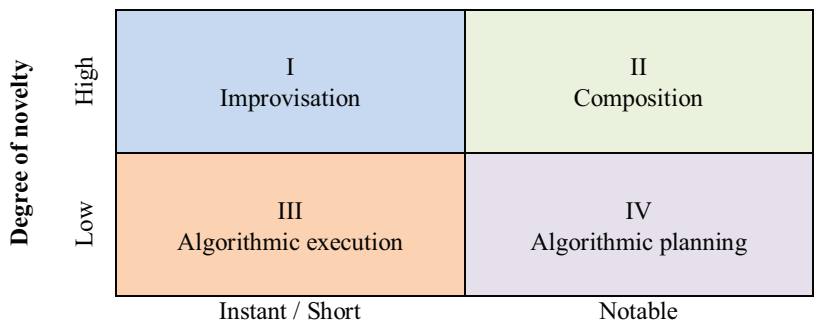

Figure 5.4. *Creative organizational reactions (source: Fisher and Amabile 2011, p. 17). For a color version of this figure, see www.iste.co.uk/heraud/creative.zip*

Improvisation is the intuition that guides the action spontaneously (Crossan *et al*. 1999). For Vera and Crossan (2005), improvisation has a lower chance of succeeding than composition because the temporal pressure is much greater and not all of the necessary resources may be available (see HR approach, section 5.4). However, the manager and the organization do not always have a choice; they often must organize.

The bottom row of Figure 5.4 refers to algorithms (this term is used by Fisher and Amabile, but the usual term would also be appropriate). Quadrant III refers to an immediate need for a response, but the necessary degree of novelty is low; it is more a matter of adapting an existing solution marginally and hoping for the best. This is the case, for example, during incidents at nuclear plants. The operators have the lists of procedures that they must execute and adapt based on circumstances, but in the end, the degree of freedom to break from these procedures is limited. Inversely, when the possible response time is greater, the algorithm may be optimally designed; the operators create the best possible response.

Managers will understand that they cannot expect the same performance level based on the quadrant the organization is in. Economic laws imply different results when creative actions are executed in different environments (Burger-Helmchen 2013). This is notably what is shown by Wagner *et al*. (2016) as they explore a set of managerial contexts complementary to those that we have employed in this chapter. Accepting that systems are complex is accepting the idea of possible temporary underperformance, a lower yield and time to adapt structures and allow the actors to self-organize.

Conclusion

Readers of this work will not have found standard formulas for managing complex systems, as such an ambition would be unrealistic. The very essence of complex systems is their uniqueness and emergent nature. There are, however, some common rules that apply to all these systems, which is exactly what we have attempted to describe.

Managers are required to be creative to successfully steer an organization that is, itself, creative. Large or small, technological start-up or well-established enterprise, every organization can be associated with one or more complex systems that managers must know how to decipher. Managers are not expected to know everything; they are expected to demonstrate an ability to observe and listen, reflect and then communicate. Such observation and nuanced understanding is more common in complex thinkers as they are comfortable dealing with ambiguity. This stops them from stepping in to control the adaptation process too early, and instead enables them to steer the system by watching, waiting and better understanding the "dance". An attentive ear to weak signals is indispensable, as is imagination, which helps formulate visions. Vision is sometimes more important than knowledge when a course needs to be set and communicated to others within the organization.

A leader's creativity must be distinguished from that of the organization. These are not the same thing; however, without a

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First Edition. Jean-Alain Héraud, Fiona Kerr and Thierry Burger-Helmchen.

creative leader, neither the organization nor those within it will be free to create. The creativity of autonomous systems is what constitutes the fundamental source of potential surprises – alongside unforeseeable outside events – for all of us, whether we are at the level of being a member of the complex system, or the manager who is steering it. Surprises can be good or bad. Moreover, their nature is to confirm the dominant discourse of the organization or, to the contrary, to test it and show changes over the horizon. In the face of such opportunities, threats and various emergent challenges, the organization must respond intelligently, i.e. by engaging creatively with such emergence. We are not speaking solely of managers' creativity, for its presence allows such a capacity to become a property fostered and distributed among the members of the organization and in the collectives that they form. We are saying that creativity must be seen by the organization's management as a potential resource (part of distributed intelligence) and not as a source of problems. To do this, managers must know how to demonstrate cognitive flexibility and avoid linear thinking by drawing on other registers than the hierarchical formulas of classical management. They must instead engage with ambiguity, create (minimal) organizational rules and structures that give people something to steer against, and align with, while at the same time allowing the "dance" of emergence to flourish.

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