Managing exploratory innovation

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ABSTRACT

Although the concept of exploration has been widely used in management research since James March's seminal article, the literature on exploration remains rather fuzzy. The question of exploration is dominated by the literature on ambidexterity but this research actually says little about concretely managing exploratory innovation itself, although this appears to be a central concern of most industrial firms today. Based on a material (twenty presentations made in a research seminar the authors have organized in the last two years) and a critical review of the literature, this paper provides new theoretical and managerial insights on the management of exploratory innovation. We first identify three complementary perspectives: 1. Managing knowledge for exploration, 2. Organizing for exploration, and 3. Creating new value spaces. Secondly, we recommend focusing the management of exploratory innovation on the following two processes: identifying an exploratory field, creating new opportunities via experimentation.

KEYWORDS: Exploration, management of innovation, knowledge, value spaces

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INTRODUCTION

From 2005 to 2009, we, the authors of this paper, organized a series of research seminars on innovation management. During this period, we welcomed more than 20 speakers and 40 panel members[1]. Each researcher invited was asked to give an hour's presentation based on a working paper or ongoing research illustrating new issues, both managerial and theoretical, in the field of innovation management. Each presentation was followed by two short comments from panel members and a discussion with the audience. We tried to cover a wide spectrum of perspectives by mixing speakers' origins (from the US, Japan and Europe) and by addressing various analysis levels: the individual, the project, the firm and the ecosystem. Seminar audiences comprised both social science researchers and company practitioners. We therefore asked our speakers to illustrate their talks with empirical examples and to derive from their research some principles and guidelines for the management of innovation in terms of "actionable" knowledge.

After about 20 seminar sessions, our aim is to provide a synthesis of the rich material covered in the papers and discussions and an overview of the state of ongoing research on innovation management – in other words, what have we learned, and how does this material contribute to a better understanding of current issues in the field of innovation management?

Although our sample cannot be considered representative of all research on innovation management, it is clear that our speakers mostly presented some work related to innovation

[1] To respect the principle of anonymity of the authors of this paper, we will not provide more information on this seminar at this stage.

that qualifies as exploratory. In fact, the situations and issues at stake mostly involved either a shift from a technological trajectory (or dominant design) to an emerging new one (Benner and Tushman, 2002) or product innovations aimed at creating new markets and sources of value (He and Wong, 2004). These situations are often referred to as "exploratory" rather than "exploitative" innovation (Gupta, Smith and Shalley, 2006).

Indeed, although the concept of exploration has been widely used in management research since James March's seminal article (March, 1991), the literature on exploration remains rather fuzzy, with a wide range of definitions (Gupta et al., 2006). The question of exploration is dominated by the literature on ambidexterity, which focuses on organizational structures that can support the coexistence of exploration and exploitation activities, but this research actually says little about how to concretely manage exploratory innovation itself, although this appears to be a central concern of most industrial firms today. It thus seemed that a synthesis of the material collected during the seminars might bring forth new theoretical and managerial insights on the management of exploratory innovation.

In this paper, we first try to better characterize exploratory innovation's dimensions. A study of the 20 presentations discussed in our innovation management seminars, and a review of the literature, led us to identify three complementary perspectives: 1. Managing knowledge for exploration, 2. Organizing for exploration, and 3. Creating new value spaces. Then, since our speakers were asked to provide managerial principles based on various empirical examples, our second concern is to organize these into a framework that could both synthesize previous contributions and guide future research on the management of exploratory innovation. We recommend focusing on the following three processes: identifying an

exploratory field, creating knowledge via experimentation, and articulating cognitive, organizational and strategic dimensions throughout the process.

1. CHARACTERIZING EXPLORATORY INNOVATION

In everyday language, exploration refers to a particular process of searching with the intent of discovering something that is unknown. This common view is based on a positivist assumption that the reality – or a new territory – is already there, waiting to be discovered (Garel and Rosier, 2008). However, linking exploration with innovation involves another, more constructivist view: in a sense, exploration is devoted not to *discovering* but to *creating* something new. Originally, exploration was associated with learning and qualifying the pursuit and acquisition of new knowledge (March, 1991). James March does not define "exploration" precisely, but rather associates this concept with "things" covered by such terms as search, variation, risk-taking, experimentation, play, flexibility, discovery and innovation.

Another research tradition addresses the question of balancing exploration and exploitation activities and elaborates upon the organizational structure adequate for allowing these two types of activity to coexist. The dynamic scientific debate on the issue of ambidexterity illustrates this shift toward organizational considerations in studying the tension between exploration and exploitation. Lastly, research in strategic management focuses on the notion of value and the importance of identifying new sources of value and creating new business models (Kim and Mauborgne, 2005; Christensen, 1997; Chesbrough and Rosenbloom, 2002).

In sum, the issue of exploration is related to three complementary perspectives that we develop in Part 1: managing knowledge for exploration, organizing for exploration and exploring new value spaces.

1.1. Managing knowledge for exploration

In general, exploration is described as a process that involves intended forms of collective learning (Gupta, Smith and Shalley, 2006). For some authors, what is at stake in such collective learning is the building of the strategic competences that must be acquired in order to change a firm's technological trajectory and address new markets (Danneels, 2002, Benner and Tushman, 2003). "Strategic" or "core" competences generally refer to a strategic management view of innovation where the unit of analysis is the firm. Based on analysis at the innovation process level, other authors focus on the type of knowledge that is involved in exploration activities. For example, Li et al. (2008) propose characterizing exploration according to the distance between the required knowledge and the knowledge already possessed by the firm, and develop a theoretical framework with two dimensions to characterize exploration activities: the first focuses on the type of function of the value chain concerned in the exploration activity (research, technological and product-market knowledge), while the second is the "knowledge-distance domain," which distinguishes exploration from exploitation based on the distance between the new knowledge that a firm seeks and its existing knowledge. For the latter, exploration would involve searching for distant knowledge while exploitation would involve searching for local knowledge. Distance is qualified by three variables: temporal distance, which involves the interesting and counterintuitive idea that historical knowledge may be qualified as distant, and, as such, nourish exploratory processes; cognitive distance; and spatial distance. Although they provide useful points of reference,

these variables do not tell us how to measure such distances, and bring us back to a relatively intuitive and contextual understanding of what "local" knowledge is and what comprises "distant" knowledge, considered specific to exploratory activities.

To a certain extent, the literature on exploration may be related to research on absorptive capacity (Cohen and Levinthal, 1990), a body of research in which a firm's innovative capacity is positively related to its capacity for seeking new external knowledge and connecting it to existing knowledge. A firm's existing knowledge is thus crucial to its ability to identify potentially valuable external knowledge and integrate it.

It appears that the criteria of "new" and "distant knowledge" are of limited use in understanding an exploratory process's complexity. First, an exploratory process can start with "existing" knowledge that was not used – in other words, "sleeping" knowledge. For example, in the early 1980s Sony bought a transistor-technology patent from RCA, which did not use it as it considered the sound quality inferior to that of its home equipment; Sony then used the patent (piece of knowledge) to successfully launch a portable radio. What is at stake is thus not the newness of the knowledge in itself but the way in which this knowledge is connected to new product concepts with use value.

On the other hand, a firm can renew its competences or seek new knowledge without producing exploratory innovation. This can be the case in strategic diversification where the body of knowledge can be expanded without any exploratory activity. Moreover, some activities like new market studies and technological research can bring new knowledge that will support rather exploitative innovation. As noted by Gupta et al. (2006), even when an organization is attempting to do nothing more than replicate past actions, it accumulates

experience, albeit in an incremental manner; they refer to March (1991), who says, "*The essence of exploitation is the refinement and extension of existing competences, technologies and paradigms… The essence of exploration is experimentation with new alternatives.*" As suggested in this quotation, exploratory innovation can be assumed to differ from exploitative innovation in two ways: it is always intentional, and it is based on experimentation, i.e. on a purposefully designed process of knowledge production and validation (Hatchuel, Le Masson and Weil, 2006).

Finally, the criteria for new market knowledge and competences do not differentiate between markets that are new ones for a firm, true emerging markets, and market that do not yet exist at all. In the latter case, the knowledge to be acquired is of a different nature, because it is inherently ambiguous and involves creating a representation of a potential future. It then appears that what is at stake in exploration management is not so much the newness of knowledge in itself, but rather the fact that this knowledge is fragmented, ambiguous and original. During one seminar session dedicated to the history of electric-vehicle development, Christophe Midler gave us the example of the vehicles' heating system, an issue that might appear trivial and already well understood. However, combustion engines provide heat naturally whereas electric cars do not. Thus designing heating systems for electric cars raise totally new problems, and new competences had to be developed that could be related to an exploratory process.

1.2. Organizing for exploration

The organizational dimension is in some ways the mirror image of the cognitive, as one cannot be studied without the other (Hatchuel and Weil, 1995, Brown and Duguid, 1991,

Blackler, 1995). Indeed, knowledge acquisition arises from exchanges organized between actors or groups of actors, and collective action takes on a twofold dimension.

Research on the organization of relations between innovation actors may be broken down into four currents in the literature: work on ambidextrous organizations; work dealing with the various ways of organizing exploration partnerships; work dealing with the coordination of actors according to product and industry architectures; and work concerning cooperative undertakings with stakeholders.

From an organizational standpoint, exploration for innovation was first broached in the literature on ambidexterity, which stresses the need for coexistence between exploitation and exploration in order to maintain a simultaneous stream of incremental, radical and architectural innovations. Three main models of ambidexterity were highlighted.

The first model, structural ambidexterity, presupposes the creation of differentiated entities respectively in charge of the processes of exploration and exploitation (Tushman and O'Reilly, 1997; Benner and Tushman, 2002). These two types of entity are coordinated at top level management. The second model is network ambidexterity (McNamara and Baden-Fuller, 1999), in which exploration is conducted externally by small firms situated within a network comprising larger, established firms; the result of this exploration is then integrated (through capital interests, the acquisition of licences and so on) into the larger firms. Exploitation and exploration are thus conducted by different but complementary firms. The third model is contextual ambidexterity, which calls for individual employees to alternate between exploration and exploitation activities, according to the various situations that arise (Gibson &

Birkinshaw 2004). Context and the role of management ensure that the two types of activity are supported by the organization.

However, this literature remains incomplete. Aside from the fundamental distinction between structural and contextual ambidexterity, other possible intermediate organizational arrangements (BenMahmoud-Jouini, Charue-Duboc & Fourcade 2007) to be found in many companies are not taken into account, for example, situations where exploration and exploitation are carried out in the same organizational units (R&D departments), but not by the same individuals. In addition, the literature on ambidexterity says little on how to manage exploration processes concretely, regardless of the organizational structure adopted (Ben Mahmoud-Jouini, Charue-Duboc, Lenfle & Midler, 2009).

A second current in the literature deals with the inter-firm partnerships brought to the fore in the processes of exploratory innovation. Entering into an exploration partnership suppose to agree to the triggering of a learning process in which the modalities of cooperation and coordination, together with the sharing of risks and benefits, will come to light as the process advances (Segrestin, 2006). This is not contradictory, however, to the formalization of contractual frameworks. But these contracts should provide flexibility. Thus, in a seminar session, Christophe Midler presented the model of co-innovation that developed between Renault and Valeo wherein the objects and modalities of cooperation were invented gradually during the course of the relationship.

Indeed, inter-firm partnerships are different depending on whether the objective is to explore new concepts and new knowledge or to draw on complementary areas of expertise concerning specifically defined topics (i.e. solution-oriented or exploitation-oriented). In the

first case, the goal is to work together on learning projects that may lead to expansion and divergence (Segrestin, 2005), while in the second case the goal is to converge upon solutions to an identified problem by mobilizing appropriate areas of expertise.

A third current in the literature dwells upon models of collaborative innovation that do not necessarily involve the formulation of strong ties or special arrangements and are organized around collaborative platforms. Current work on open innovation (Chesbrough, 2003) thus stresses models of collaborative innovation that are extended to partners with which the firm maintains loose ties. In one seminar session, for example, Frank Piller described experiments undertaken by such firms as Adidas and Innocentive that involved building previously untried forms of cooperation with user communities. In another seminar session, Valérie Chanal showed how crowdsourcing services developed by new web intermediary platforms are brought to fruition by way of emerging user communities.

These collaborative innovation models are not limited to bilateral relationships; they may also require multilevel partnerships within sectors. The purpose is, on the one hand, to articulate new application projects sponsored by one or more firms and, on the other, to shape sectoral reorganization. Eisenhardt and Santos (2005) thus stress that, in situations involving the emergence of new markets ("nascent fields"), entrepreneurs operate in different arenas, defining borders for each, but rely on alliances and acquisitions to mesh them together.

Regardless of whether they are bilateral or multilevel, these forms of collaborative innovation are made possible by and implemented around technical objects (Ackrich, 1993) or platforms (Gawer, 2009).

These platforms are shaped by product and industry architecture choices. In one seminar session, Franck Aggeri showed that the development of new sustainable-transport services using electric vehicles (Better Place) is based on prior stabilization of product and industry architecture choices. To circumvent battery-charge constraints, the system's inventor, the Better Place company, concentrated its innovation efforts on the rapid battery-exchange concept. Three independent architectural levels – product architecture (the vehicle-battery interface), process architecture (the design of battery exchange and recharge stations) and industry architecture[2] – were entirely redesigned. Interest in the issue of new industry and product architectures has been growing with the development of innovations based on distributed capabilities and multilevel cooperation, the organization of which involves the definition of a minimum system of rules (design templates) concerning the division of labour, value distribution and the division of surplus (Jacobides et al., 2006). In one seminar session, Paul David showed that design templates go beyond these economic dimensions and also encompass the standardization of design languages. For example, open innovation plays a role in the software-development field thanks to common languages (codes) and through objects that shape exploratory approaches in design.

Finally, according to a fourth current in the literature, exploratory processes are conducive to the involvement of stakeholders positioned well downstream of the marketing stage: this is one of the challenges of stakeholder mobilization (Birkinshaw, Bessant and Delbridge, 2007). As regards innovation in treatments for chronic diseases, for instance,

[2] "Industry architecture" refers to the organisation of relationships within an industrial ecosystem (Jacobides et al., 2006). In the case of the electrically-powered vehicle, the development of an industrial ecosystem was supported by strong government incentives for the rapid creation of a station infrastructure, an appropriate range of electric vehicles and a renewable ("green") energy supply system that would legitimize the ecological dimension of the service-products system thus designed (Aggeri, Elmquist and Pohl, 2009).

innovative approaches involve a wide range of stakeholders, including patients, physicians, healthcare personnel, healthcare systems and social-security systems.

Through these various currents, it appears that exploration for innovation is associated with the establishment of new relationships within a firm, since the old relationships are out of step with those favoured by the organizational structure, as well as outside the firm, since the partners and partnership conditions differ from those usually found. In addition, these exploratory processes help configure the ecosystem in which the resulting innovations develop.

1.3. Exploring new value spaces

The dynamics of exploration for innovation are characterized not only by the accumulation of new knowledge and building of new relationships, but also by the identification of new opportunities for value creation or opportunities not satisfied by existing products. The link between value opportunity and exploration is less systematic in the literature than for the preceding dimensions; nevertheless, we consider that it needs to be stressed. First, ever since the publication of Schumpeter's work, innovation has been associated with value creation for firms, and value analysis of innovation's contributions has become commonplace. Traditional approaches involve analyzing customer needs and comparing them side-by-side with innovation's contributions and how the latter meet customer needs in order to specify and assess an innovation's value to customers (Achilladelis et al., 1971; Meyers and Marquis, 1969). Eppinger's work, which takes this approach, underscores the importance of comprehending unsatisfied needs and the value of products

already on the market, and situates this analysis of the market, customers and their needs in the upstream stages of the innovation process.

A second component in the analysis of innovation's value refers back to the organization of product-prototype user panel tests aimed primarily at confirming the value of products according to predefined criteria and with regard to predetermined target clients.

In the case of exploration, these approaches have four limitations that should be stressed and which highlight the specific nature of these value opportunities and call for specific approaches.

The identification of value on the basis of existing products rarely pinpoints radically new value opportunities. Furthermore, dimensions identified on the basis of positions acquired by a firm do not necessarily correspond to values that the new technologies or applications on which the exploration focuses might offer customers. Thus, in the case of radical innovation, T. Allen (1984) criticizes approaches based on customer needs, since users often fail to imagine the uses to which such an innovation might be put. R. Burgelman (1991) places the accent on the coupling processes involved between market needs and technical possibilities, as opposed to sequential approaches.

A second line of criticism has to do with identifying customer target groups; indeed, customer segmentation can be profoundly disrupted by exploratory innovation. This aspect is stressed by C. Christensen (1997), who shows that certain disruptive innovations have had a chance to develop by targeting an emerging low-end market or by redefining segments according to new criteria associated with new uses. In one seminar session, Gilles Garel

suggested that value potential ought to be explored while customers and demand are still lacking; special approaches need to be built in such cases. The emergence of new customer segments and user communities is also very significant in the construction of symbolic value associated with innovation. This dimension was brought out by marketing research concerning value as perceived by the customer, which stresses that expectations cannot be reduced to a quest for new functionalities. Indeed, as Davide Ravasi pointed out in one seminar session, "Consumers construct their personal and social identities through the purchase of new products. The symbolic value of the latter derives from the possibility of using them as identity markers." In fact, symbolic value is built through their adoption by user communities and the process by which a set of meanings is ascribed to an object.

A final perspective on the exploration-of-value issue involves the idea that one cannot speak of value without inscribing the use of a technology in a business model, since the technology has no value in and of itself (Chesbrough and Rosenbloom 2002). Chesbrough's view on business models relies on a distinction between value creation and value capture: *"A business model defines a series of activities that will yield a new product or service in such a way that there is net value created throughout the various activities. Secondly, it captures value from a portion of those activities for the firm developing the model"* (Chesbrough et al, 2006). Management literature provides many examples of firms that have developed a capacity to modify an industry's traditional business models such as low-cost airlines, Ikea and Apple's iTunes and iPhone, whose business models are based on the creation of an ecosystem to sustain an innovation (Iansiti and Levien 2004). This is related to with what some authors call "changing the rules of the game" (Hamel and Prahalad, 1994; Brandenburger and Nalebuff, 1996), a capacity that has been termed "value innovation" (Kim and Mauborgne, 2005) or business-model innovation (Comes and Berniker, 2008). This

business-model innovation perspective means that not only can value creation be modified, but also value capture. The positioning of a firm within its value network may also be impacted by innovation, and new entrants may appear; the Web 2.0 revolution, for example, gave birth to a range of new business models (Shuen, 2008). More generally, all types of product and service innovation that can somehow be digitized (information, music, books and movies) may lead to renewed value chains and the development of new approaches, like "long tail" strategies[3] (Anderson, 2006).

2. MANAGEMENT PRINCIPLES FOR OVERSEEING EXPLORATION

Our concern here is to organize management principles into a framework that might synthesize previous work and guide future research on the management of exploratory innovation. From the seminar contributions, we have identified two phases that are recursively linked: the first involves defining an exploratory field; generally speaking, an exploratory process starts with either a key issue or a solution concept that delineates an exploratory field; the second involves creating something new by engaging in an experimentation process. For each phase, we will provide some management principles on the three dimensions – knowledge, organization, and value – presented above.

2.1. Defining exploratory fields

Starting with a problem or concept

[3] C. Anderson describes "long tail" strategies as a new business model that shifts from mass markets of standardized products to a mass of niche products that were once unprofitable to market.

When considering exploration management, it is important to define exploratory field. In fact, case studies presented during our seminars highlight the fact that exploration is delineated by a concept or field defined from the start: fuel-cell uses in the case of Air Liquide and cookware for casual meals among friends in the case of Tefal. To illustrate this section, we will draw on a case presented in the inset below, to which we will refer throughout our analysis of how to manage exploratory fields.

Delineating an exploration field: the case of Domauto

A top-ranked automakers' equipment supplier, Domauto[4], created an entity – the PWT innovation field – responsible for proposing radically new innovation products designed to improve power-train efficiency.

It is not surprising that the power train was identified as an area in which innovation is needed, in view of the objectives imposed on automakers concerning automotive carbon-dioxide emissions. Even so, it is a much more delicate matter to determine the components that should be included in this field: should they be limited to engine components, or should they encompass the entire power transmission line, including the wheels? To limit efforts to the engine would reduce the exploratory field to a subset on which the supplier under study has no differentiating competences; on the other hand, broadening the scope to include the wheels could lead to the consideration of an extremely heterogeneous set of innovations, requiring the development of knowledge in very different directions and thus raising capitalization problems. As a result, the exploration team's first job was to agree on the specific scope designated by the acronym PWT (power train). It was decided to include accessories directly driven by the engine, particularly the alternator-starter, cooling system, drive system, turbocharger, air-intake systems,

[4] The real name of the company has been modified

and the engine and its computer-controlled management system. The scope thus covers components on which the firm has differentiating competences, as well as other components that are either geographically close or functionally related.

This scope is much broader than existing product lines (i.e. the alternator, cooling system and other comfort-related accessories, for the most part), meaning that innovations involving components other than those marketed by the firm may be considered, such as electric turbochargers, for example, or architectural innovations, such as optimal accessory coupling, as well as completely new solutions that do not follow pre-existing divisions between product lines, such as braking energy-recovery systems.

This definition of an exploratory field's scope presupposes a process of reflection involving the functionalities and main sources of new value to which customers are sensitive, and the identification of those components, subsystems and products that might provide these new functionalities along with their related technologies. This prospective analysis is combined with a strategic analysis, since the goal is to make choices that take a firm's competences into account as well as those of competitors as regards these new objects.

An exploratory field to generate exploratory projects

The exploratory field embraces a varied set of exploration and innovation projects targeting various markets and relying on different technical components. Although delineated, the field allows room for heterogeneity and divergence with regard to the areas of innovation considered and pre-developed. Indeed, among the various exploratory projects, a significant number will not result in end products due to the uncertainty inherent in exploration. This divergence is thus both essential and in need of management.

In the case of Tefal, the development of a new product – a waffle maker – and its commercial success led the firm to identify value-creation opportunities relating to products intended for casual entertaining and meals among friends. The firm's formulation of this "casual dining product" concept led to the exploration of a much wider range of products (i.e. raclette grills, fondue machines, crêpe griddles and so on) that share the same concept of a meal that does not require much cooking and to which one can invite friends.

Impact on the organization

One characteristic of this exploratory field is that it transcends existing product-line structures: it can focus on either a technology that might impact the firm's various product families, or a set of components that might be reconfigured, or a value axis that might lead to solutions that do not fit within established product-line boundaries.

The consideration and development of innovative solutions relies on a certain level of existing knowledge within a firm, which is often distributed over various entities. Exploration does not start from a blank page. Hatchuel et al., (2006) note that *"radically new products were designed using, in large part, well-established competences"*. They also lead to the development of new knowledge, which sometimes leads to new partnerships created for the purpose. Knowledge developed on an exploratory project can also be reused in other projects. Such repeated cross-learning interactions lead to manage them in "innovation lineages".

An example of the coupling of two knowledge fields

In Domauto's case, for example, exploration into an electric-turbocharger technical solution led to a first exploratory project involving new partnerships, the reliance on the

competences of a company division dealing with electrical systems, and the development of special competences to deal with this type of solution. This first approach did not result in an end product that would satisfy customers. Another exploratory project concerned solutions for the recovery of braking energy. A solution that provided real fuel-consumption savings was finally achieved by combining these two new fields of competence.

Managing a portfolio of exploratory projects

Managing this exploratory field presupposes the creation of a portfolio of exploratory projects, which makes it possible to combine knowledge in different key areas to arrive at a product offering in a new field. The various projects within the portfolio must be analyzed in view of the new knowledge they will make it possible to develop. The dynamics of the project portfolio take into account the knowledge constituted and its reutilization in new projects, particularly where initial exploration failed to arrive at a product, in order to promote accumulation. The goal is to build a tool capable of representing and tracing this exploration path (i.e. the projects chosen as well as the knowledge acquired or made available for reuse).

In Domauto's case for example, a certain number of themes were defined for the powertrain exploratory field:

- Reduction of accessories' fuel consumption (e.g. through the drive system, by optimizing their operation, through centralization and by disengaging the accessory).
- The air injection and supply system.
- Recovery and temporary storage of energy.

Several projects underway on each of these themes are developing different technological approaches in order to pinpoint their contributions and limitations, and a balance between these various themes is achieved via management of the project portfolio.

Capitalizing on knowledge

Another aspect of management concerns the "place" of capitalization. The newly derived competences are embodied by various actors; in order to capitalize on this knowledge, these actors must be identified and redeployed from one exploratory project to the next (Lenfle and Midler 2009). Two types of organizational design can be distinguished: the first involves capitalization within an entity dedicated to exploration, while the second involves the accumulation of expertise in a business line with concomitant management of the development and reuse of this competence, particularly in consolidation stages, by the exploratory-field manager.

All in all, exploratory fields are defined by an initial analysis of opportunities in terms of value and technology. Based on this first delineation of the field, exploratory projects are generated (development of initial prototypes, creation of additional competences and formation of partnerships to develop an innovative solution). Bringing them to a successful conclusion involves building special organizations that cut across established organizational boundaries. Once this initial structuring phase is completed, managing an exploratory field involves repeatedly readjusting the exploration-project portfolio in order both to take into account new opportunities identified as obstacles and to capitalize on the knowledge created among projects along the way.

2.2. Creating knowledge via experimentation

The second aspect of managing exploratory innovation involves conducting experiments. In the literature, however, the term "experimentation" refers to the development

of new products at stages of validation that occur throughout the design process and lead to a marketed product. In the case of exploratory innovation, on the other hand, experiments allow us to identify and build new, varied opportunities based on interactions with the partners and/or potential users they create. We will use two situations to illustrate this role of exploratory experimentation: one involves identifying solution concepts and value, based on experiments with potential users of a radically new technology that is made available to them in prototypes that can be manipulated, while the other entails experimenting with new relationships involving partners with whom the firm had little connection up until then. Experimentation then involves either these new methods of cooperation, made possible by collaborative tools, or the joint development of prototypes for innovative solutions. It therefore makes it possible to define each party's scope of action and to alter cooperation methods.

Experimentation in traditional development processes

In traditional work on NPD and prototyping, experimentation phases involving future users are validation "cut-offs" in a funnel development process (Ulrich and Eppinger, 2004; Clark and Wheelwright, 1992); we will call this type of experimentation "**experimentation for evaluation / validation.** Prototypes and experiments are used to validate previously developed or co-developed solutions and functions; experimentation thus involves "actual size" testing under conditions that represent a previously imagined situation. The aim is to protect against the risk of late discoveries that would result in costly changes. Knowledge of the customer is used to model relationships between product attributes (or those of a range of products) and their market value. The purpose of such experimentation is to minimize risk (decrease design costs and reduce market uncertainty), maximize value (protect the value attributes or preserve spaces for improving value in a targeted manner) and accelerate

development processes (Thomke, 1998). This approach has been developed in particular through the marketing of new-product development, which imposes a traditional idea of market research (Hauser, Tellis and Griffin, 2006) whereby one begins by understanding customers' needs through the use of prototypes and then commits to a project.

Experimentation for exploration

In exploratory situations, experimentation has a broader aim than that of merely validating preconceived functions and solutions. The aim is not to validate a pre-written development scenario by testing it, but to generate several tracks of exploration by identifying solution concepts, value objectives and the knowledge that will need to be developed. In this case, it is difficult to interact with potential users without reference to existing applications and uses when designers have only incomplete knowledge of their technologies' performance. In what we call **experimentation for exploration**, the desired objective is not the proper targeting of a product or technology (even an innovative one) or the roll-out of a family of products, but rather the addition of more variety to the fields explored and the proposal of original and even unexpected fields by incorporating value criteria and robust functionality. From this perspective, the process of involving the innovation's end users does not seek representativeness in relation to the market. What is even surprising at times is the fact that the users chosen are neither particularly representative nor competent.

When market research cannot provide usable information about future users and usage, the creation of experimentation processes is a solution. Some authors even suggest that a direct market launch without research is more efficient,[5] and recommend putting out large

[5] The Promise of In-market Innovation**;** *Alexander Kandybin, Surbhee Grover and Nami Soejima; strategy+business, 23 June 2009. http://www.strategy-business.com/li/leadingideas/li00127.*

volumes of new products and letting the marketplace – not focus groups – separate winners from losers. They also assert that their product launch strategy, which they call in-market innovation, is potentially more effective and less costly than traditional market-research approaches, and "often provides a quicker path to enhanced revenue."

Experimenting to learn about value

It might be said that the aim of value exploration is to transform the activity conditions of users in order to "produce useful new effects for these users" (Gadrey and Zarifian, 2002). By "useful effects," we mean the effects of an innovative product's transformations on the activity conditions of users. Here, experimentation involves various usage situations that are prototyped. Formulating these useful effects and having future users evaluate them involves a change in perspective (Garel and Rosier, 2008): it is not so much about suggesting new "turnkey" uses (i.e. validating the designer's hypotheses) as it is about demonstrating a potential to transform activities (i.e. to enhance or extend the designers' knowledge). In the case of the fuel cell, for example, an exploration of the benefits offered by this technology leads us to contemplate a large number of markets that might leverage various properties (emergency response, filmmaking, managing large shipments and so on).

Identifying useful effects: the case of Axane's fuel-cell exploration

Axane's first fuel-cell prototypes had little power and were essentially non-polluting generators powered by bottles of gaseous hydrogen. The first professional generator-users surveyed included firefighters and construction workers (Rosier, 2007). At first, they viewed the new generator only relative to their normal activities, considering it more fragile and seeing no necessity (no "need" according to market research) for a non-polluting generator. Worksites were outdoors most of

the time, and users felt that it was more important to reduce generator noise levels than to make them non-polluting. During the course of experimentation, however, two main useful effects were noted:

1) The fuel cell made it possible to work without risk of asphyxiation in confined spaces (tunnels, caves, grottoes and confined buildings), where long cables that restricted workers' movements were previously needed; the new generator could therefore be seen as a way of increasing mobility and making it possible to work in places that until then had been very restrictive.

2) The generator was also perceived as a source of "intermodal" energy, i.e. an energy source capable of supporting mixed activities involving outside areas and confined spaces; for example, certain equipment like incubators and ice chests for organ transport must have continuous electrical power regardless of the environments through which they pass. The generator responsible for powering this critical equipment could therefore be a dedicated, intermodal energy source for ambulance transportation, outdoor transport, hospital-corridor waits and more.

In other words, the Axane team offered fresh potential for activities in places where firefighters and construction workers had definitively wrapped up a problem, by its nature unsolvable, by using established technologies.

Giving potential users prototypes that can be manipulated allows for the emergence of values associated with innovative solutions based on a radically new technology, which could not have been identified via traditional marketing processes.

Experimenting to create new relationships

An organization that explores by experimenting will create or mobilize a network that prompts it to build new and unlikely relationships. Experimentation makes it possible to identify possible partners and to adapt relevant methods of cooperation. In the case of Axane, for example, a new relationship based on experimentation was formed with another exploring company, Airstar (see insert).

Experimentation involving new relationships: the case of Airstar-Axane collaboration

Axane approached a company that was geographically close, Airstar, which had been developing lighting balloons since the mid-1990s. Together, Axane and Airstar were able to offer services that combined fuel-cell energy and balloon lighting systems. The first prospecting efforts in the events sector led Airstar's teams to the film sector, where, it turned out, cameramen filming outdoor shoots greatly appreciated the shadow-free natural light quality projected from the balloons, but producers were reluctant due to the high price of the service. It was through experimentation that Airstar was able to convince them. The Airstar teams who monitored shoots featuring car chases highlighted the fact that these chases needed extraordinary equipment in order to be filmed: projector scaffoldings, helicopters, etc. One of the advantages that the lighting balloons could offer on mobile sets was the elimination of the numerous projector scaffoldings by replacing the cost of installation and equipment with the use of a few balloons. The concept of "infrastructure-free lighting" was born. It was tested in an experiment that allowed Airstar to convince the producers and led the company to form a business relationship in the film sector, which was a totally new market. By working together with Airstar, Axane was able to explore the quiet factor of fuel cells for film shoots and combine its product with that of Airstar.

This type of experimentation and fresh collaboration make it possible to explore the elements of a system into which the innovative technology is integrated and to offer it to the end user as a complete solution.

More open approaches aimed at identifying new partners and allowing them to contribute to the innovation's development have also become apparent. Thus, the possibilities offered by the development of open-source platforms provide a means of increasing opportunities among a multitude of communities to exchange and produce knowledge. Frank Piller, who focuses on new models of open collaborative innovation, has studied various types of platforms that allow new forms of network experimentation (see insert)(Piller and Walcher, 2006).

Experimentation of patterns of collaboration: "open search" and "open call"

Open search refers to an experimentation mechanism where there are just a few presumptions about where to find a concrete solution and how it might be composed, and where is no direct interaction between manufacturers and external actors. InnovationMachine, based on an "open search" web platform, is an example of this type of service provider: a website where users (companies) can configure a production system online and build virtual prototypes suited to their product.

Open call refers to a mechanism wherein a player (company or individual) can post a challenge to an undefined group of experts. Potential "solvers" select themselves and solve the problem independently of each other. Innocentive, based on an "open call" web platform, is an example of this type of service provider: a website where companies can post open questions to networks of researchers. For researchers, the high cash rewards associated with solving each question are a strong

incentive for high-level research teams to participate in such expert networks. For companies, access to an international network of top-notch experts allows them to solve problems for which their research and development teams have not identified a solution.

The aim is experimenting with new collaborative methods with various partners. This type of collaborative tool also paves the way for more active involvement in exploration on the part of such stakeholders as lead users or "customers". At times, entire communities can be involved in the exploration process.

In exploratory situations, experimentation has broader aims than merely validating preconceived functions and solutions; it also seeks to create new areas of knowledge concerning technology, value and relationships.

CONCLUSION

Our paper investigates the issue of exploratory innovation, an issue of particular interest for managers and scholars. We have provided arguments involving issues on which, according to our view, the literature falls short in order to provide a clear understanding of the processes at stake and derive from them managerial and theoretical recommendations. We have defined three levels that must be "managed" in an exploratory process: a cognitive level (managing knowledge), an organizational level (organizing to explore, both inside and outside the firm) and a strategic level (creating new value spaces). In concrete terms, managing an exploratory process means defining an exploratory field and leading various experiments within this field, closely linking market knowledge and technological knowledge.

This approach leads us, in our view, to go beyond debate on adequate organizational structures and the type of ambidexterity required to manage exploration. Another important issue involves, in a given organizational context and with a certain body of knowledge, how exploratory activities – conducted through purposefully designed experimentation – can both regenerate knowledge and organization relationships and eventually create new strategic options for future business models.[6] In the above examples, we have shown that – from concept phase to management of a exploratory-project portfolio – technology and value are mutually built through the process of experimentation. We might then consider a major output of an exploratory process to be the generation of strategic options or plausible business models for undertaking a new activity. Such a view opens up promising directions for future research. In particular, as long as an exploratory process's output is better defined, it becomes meaningful to speak of the process's performance: how can we assess the quality of the strategic options generated? What would the criteria be for evaluating the various options for supporting strategic decision-making processes? To what extent are these criteria contingent upon a firm's overall strategy?

This article also opens up a pragmatic view of the question of exploration. The literature presents and discusses very few concrete principles of action in terms of exploration. The primary aim of our paper is to contribute to a research agenda that might develop a practical view of exploration, i.e. exploration "in the process of creating itself." The questions are known: What is the reasoning behind the formulation of concepts? What is the underlying knowledge? Who are the players? How do they organize their relationships? How can the

[6] In other words, this is what Chesbrough and Rosenbloom (2002) call "business-model prototyping," i.e. the process of building new links between an emerging technology and its potential economic value on the market.

value of what is explored be defined? What are the exploratory fields? How should experimentation be conducted, and what results are aimed for (in terms of knowledge, organization and value)? What strategic options are ultimately created? And where are the obstacles to implementation at each step (definition of the field, experimentation and strategic options)? All these questions suggest that this research is only a first step in a larger research program on managing exploratory innovation that must be developed further.

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