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Collectively exploring the potential of technology derived from university research: the NanoMem case

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Collectively exploring the potential of technology derived from university research: the NanoMem case

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Abstract:

The value creation of research activities is a fully fledged mission at university. This article examines the various issues arising from this requirement and the nature of the organizational mechanisms likely to be implemented to meet it. It describes the NanoMem case – based on a promising technology in the semi conductor sector-, the initial value creation project as well as its risks and limitations. It then attests to the collaborative arrangement set up during companion research in order to extend the perspectives for enhancing this technology as regards applications and markets. Our work demonstrates that this mechanism can be more generally extended and that this type of collaborative workshop makes it possible : 1) to guide the exploration of a concept both concerning the technical and value dimensions, 2) to better manage this upstream phase in innovation projects and 3) to identify the groups that must be mobilized.

Keywords: exploration, exploratory project, collaborative project, upstream innovation project phases.

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1. Introduction

The notably economic value creation of knowledge produced by academic research has become one of the missions at university. The objective assigned to entrepreneurial university (Etzkowitz et al., 2000) and to academic entrepreneurship (Grimaldi et al., 2011) is to contribute economically at regional or national levels and to generate revenues that can be ploughed back into research.

Despite the political will and the facilities that have been put into place, innovation is still a complex and uncertain activity; it is subject to many changes that are difficult to quantify and failure is common. In fact, gone are the days when innovation was considered a black-box where the complex processes at play were unknown. Although innovation is no longer a “journey inherently uncontrollable” (Van de Ven et al., 1999); the process still falls far short of optimization. Whether the project is steered within a university framework or not, not only must the scientific dimension be considered (production of knowledge) but also systemically speaking, the technologies (means of production, skills), the market (customers, means of distribution), the organization (project mode, partnerships) and the social and cultural context (favorable or not) in which innovation evolves (Kline et Rosenberg, 1986).

Our focus in this article is on situations where innovations are likely to come from inventions inside a scientific laboratory. In the case in point, the process of successful implementation and value creation continues to rely on the *Science push* model which links up activities in fundamental research, applied research, development, production followed by market placing. This linear model is subject to criticism due to its length and because the uncertainties or lack of knowledge about market and consumer often jeopardize the success of the innovation. The model is sometimes invalidated because it is not uncommon that the technology precedes the science, the latter thus not being a mere application of the former. Apart from questions surrounding the validity of research findings made outside the confined universe of the laboratory and the insufficient attention paid to the customers-value, certain organizational criticisms are also leveled at research (moreover, not just academic), namely in the organization of R&D activities and the use of project mode. Such criticism leads us to formulate new means to steer innovations (Le Masson et al., 2010).

Based on a case study retracing the first steps undertaken to enhance a property deriving from nanotechnologies – NanoMem – developed in a French university, this article seeks to answer the following question: **“What accompanying instrument is to be put in place to heighten the chances of success of a result derived from research?”**

The aim of this article is threefold: 1) empirical: to describe a promising case of technology derived from a university laboratory and report on the mechanisms set up to assess the potential and increase the chances of successful value creation; 2) theoretical: to question the theoretical settings which make it possible to set up the instrumentation of the managerial upstream phases of innovation, namely during exploratory partnerships and 3) methodological: to introduce a teaching-backed asymmetrical research approach.

The article is organized as follows. Firstly, we will describe NanoMem technology and notably the competition difficulties a start-up would face when created to enhance its value. Secondly, we will introduce the conceived and implemented companion research. In the third place, we will appraise the theoretical and empirical challenges pertaining to the function of economically enhancing the value of the academic results. We will demonstrate the utility of embedding it, as from the upstream phases, in collective mechanisms that go beyond university boundaries. Finally, we will explain why the tested collaborative workshop can be extended to wide range of innovation situations where it can guide the continuation of the investigations, the steering of projects and the identification of groups that must be mobilized.

2. From the discovery of a new physical property to the perspectives of value creation

This section retraces the progress made from the moment an opportunity for value creation is identified to the moment the organizational project is envisaged. It illustrates the fact that the success of a technology is not guaranteed just because it is promising. The conditions within the environment and the competitive context may actually impair its development. The vision of the project (initially the creation of a start-up) and the positions of the actors in the innovation process must equally be considered.

2.1. The promising prospects in NanoMem technology

In 2005, a team of 5 physicians and chemists from a French university discovered a new physical property in a nanomaterial.

This property was different from the principles listed in the literature and a first patent was filed, in 2007, to protect the invention. Previously, from 2006, fundamental research work had

provided better insight into the mechanisms at work. A new wave of studies led to a second patent in 2009, with very noteworthy performances being obtained by the new property observed on a material deposited in a thin layer on the nanometric scale. A third patent was filed in 2012, and triggered the prospect of manufacturing a new type of semi conductor. This technology features in the ITRS 2011: International Technology Roadmap for Semiconductors. It could replace the most currently used technology which has drawbacks and should shortly reach its limits of development (ITRS, 2011).

The international roadmap has already identified 9 technologies which include NanoMem technology. On prolonging the comparative analysis of future technologies, and their expected properties, the ITRS deduces the applications for which they might be of use (examples: multi core computing, cloud computing, mobile applications, etc.).

The question of value creation was keenly raised in 2011 and the team of researchers embarked on the groundwork. They filed a research project with the scientific objectives of producing a demonstration platform and undoing two technological locks.

2.2. A start-up project for the value creation of NanoMem technology

Despite there being many question marks and pitfalls, the advantages of NanoMem technology (Table 1) give the team of physicians and chemists good grounds for studying its value creation. The project was strengthened by the university incubator that proposed to accompany it so as to better weigh up the business opportunity provided by a start-up. The incentives for this type of value creation are considerable and perceived as dominant in the depictions of the researchers, all the more as such a project can also provide continuity to the research team and enable the recruitment of a research engineer.

Table 1. The strengths and weaknesses of NanoMem technology in 2012.

Strengths	Weaknesses
<ul style="list-style-type: none"> • A technology with distinctive and promising perspectives and features (new type of properties). • Three patents registered. • International recognition due to its registration in the ITRS 2011. • Partners in value creation. • Growing demand for semi conductors. • A global market worth several billion (10⁹) dollars. 	<ul style="list-style-type: none"> • A degree of technological maturity that is still insufficient (points 2 to 6 on the 9 point TRL scale¹) which excludes all short term value creation. • The interest for this technology by the industrialists remains unknown.

¹ Technology Readiness Level.

In order to obtain assistance in its reflection and accompany its value creation activities in the year 2012-2013 and further to the advice of the incubator, in July 2012, the scientific team requested the help of students among their training courses, in a Master 2 in Innovation and Entrepreneurship. These students would accompany project initiators through an analysis work related to the implementation of their innovation project. The requirement of the initiator related more significantly to an evaluation of the possibilities of NanoMem technology value creation as well as a strategic analysis and a market study enabling a selection of conditions. Two scenarios were envisaged from the outset: the creation of a start-up (with what business model?) and the value creation of a single industrial property (licensing for the patents?).

3. An asymmetrical university-backed research methodology

The authors embarked on this project *via* their student teaching and tutoring functions. From the outset, the students were invited to perform intelligibility study of the entrepreneurial situation created by NanoMem and its initiators. The aim was to clarify the assumptions implicit in the reasoning, the pre-conditions and the representations so as to better model the problems pertaining to the project. The approach described in this section consists of *a posteriori* rationalization of a work process conceived and implemented over a period of 10 months. Characterized by the traits of companion research, it equally receives the backing of theoretical work on exploration² and design activities (Hatchuel, 2001).

The approach which is going to be described was not originally meant to be research work. Initially, it was a study within a framework of project teaching, a study given to a group of students in Master 2. The feasibility study covering the creation of a start-up project, to create the value in NanoMem technology, was in line with activities usually given to students completing specialized training in the dynamics of innovation and entrepreneurship. Thus, reversing the usual procedure of “teaching supported by research”, this article describes research supported by teaching.

The approach we chose could be qualified as companion research (Bréchet et al., 2014). Over the months, and with the active commitment of the researchers behind the students, the work process was part of a companion research effort, aiming both to help the initiators in the anal-

² "Exploration concerns a poorly posed problem, a concept for which there is no fulfillment and for which available knowledge is very limited or is difficult to directly apply." It is an "approach aiming at investigating, scanning, experimenting and mapping the space potentially opened by such a concept." (Segrestin, 2006).

ysis and explorations of possibilities in the real world, on the one hand, and in understanding their achievements as well as the conception of their future, on the other hand.

The data which enriched the research comprise primary data provided by materials scientists (data on new technology, research project application files, etc.), scientific articles (Epicoco, 2013), studies or reports by consultants or professional bodies in the semi conductor sector, notes taken further to field exchanges and observations or reports from project reviews.

Given that action prompted entry into research, the field represented the melting pot, throwing up both new questions and knowledge, according to a process of abduction (Reichertz, 2004; Richardson and Kramer, 2006). The complexity and instability of the field emphasized the need to commence exploratory work, notably on non realized and even unimagined potentials. Companion research aims to collectively develop sterling insight into practices by confronting diverse points of view.

The demand for a companion research approach leads to three questions: what accompanying positions should one privilege? What exploratory and design mechanisms should one implement? What actors must be mobilized? These questions raise the following problems: 1) i.e., the scope of relevant study between, on the one hand, the initiator and their close scientific and economic partners for the value creation³ and on the other hand, the globalized sector of the semi conductor industry and 2) conditions for equipping oneself with collective, learning and organizational capacities likely to be used in a wide array of scenarios. Before describing the in-company activities and findings, it is worth recalling the theoretical debates and empirical challenges pertaining to value creation of research, the answers provided to date and their limitations.

4. From the knowledge producing researcher to the group creating its value

The value creation of research raises specific theoretical issues. Recent literature beckons us to consider it as a collective and interdisciplinary effort creating artifacts, techniques even social systems. As such, it is part and parcel of the design activities (Simon, 1969). Studies on C-K theory⁴ (Hatchuel and Weil, 2002, 2008) paved the way for problematizations comprising innovative design. Although often devoted to *Science-Based Products*, these studies generally

³ The ground shifting did not allow the investigation the other actors involved in the enhancement of the NanoMem technology or likely to be so in the short term, due to their power of initiative or financial power.

⁴ The C-K theory will be briefly described in Section 4.2.

involve R&D activities less upstream than NanoMem. In a value creation project, the actions that the actors generally come to consider are founded on mechanisms both novel and complying to needs. They are also driven by desires and constrained by contexts. The responses to these problems are increasingly made through collective arrangements.

4.1. The incentives and disincentives in research enhancement

Some of the objectives of the university involve the diffusion and value building of research results as well as the development of the innovation and its technological transfer (Bozeman, 2000; Cummings and Teng, 2003; Macho-Stadler and Pérez-Castillo, 2010). These objectives explain the creation, since the nineties, of Technological Transfer Offices (TTO) intended to facilitate the relationships with industry and to turn the exploratory activities of the researchers into marketable services or products (Debackere and Veugelers, 2005; Hewitt-Dundas, 2012). The literature often notes their current limitations and shortcomings (Cooke, 2004; Anderson et al., 2007; Landry et al., 2010; Bruneel et al., 2010). The entrepreneurial dimension of the new objective can actually be a source of tensions (conflicts between disciplines, paradoxical demands) (Philpott et al., 2011). What is more, various obstacles check the technological transfer. They can be related to difficulties in financing development within the time frame required to progress from research result to marketable product. The obstacles can equally be due to cultural differences and to problems of communication between university professors and industrialists, conflicts surrounding the sharing of industrial property or differing stances on the financial spinoffs (Decter et al., 2007; Bruneel et al., 2010). Once these obstacles are removed, there still remain various factors (what knowledge to use, if it can be protected, harnessing specific advantages, characteristic of the institutional environment) (Conceição et al., 2012; Lichtenthaler; 2011).

Still other parameters can weigh on the success of the value creation. The transfer and enhancement of knowledge or technologies might be, in certain cases, difficult or random in others. By definition, expertise is immediately available. The approach is more complex for fundamental research results with a lesser degree of technological maturity. Innovative albeit validated technology can be disconnected from potential uses and promising market niches. In addition, the novelty and performance of a technology does not guarantee its commercial success (Kline et Rosenberg, 1986).

A University will not enhance the same knowledge where it will privilege a contribution to economic development, financial gains, scientific standing or social utility. Although the creation of a start-up by researchers is one of the most encouraged forms of value creation (Cara-

yannis et al., 1998), it is not the only possible form. The procedures for value creation close to traditional academic activities (publications, research contracts) are already authentic vectors of value creation (Dasgupta and David, 1994; Bray and Lee, 2000; Philpott et al., 2011). Value creation may have a marked entrepreneurial character (patents, spin-offs) or a partnership dimension (collaborative research) (Landry et al., 2010; Grimaldi et al., 2011). In this case, who must the participants in the value creation be - the researchers themselves or a structure dedicated to this end? In addition, although the university is a large scale organization, the teams are often the size of VSEs with all the ensuing limitations. As a rule, they do not have, in-house, management, administrative, legal skills etc. to enhance the research. Value creating activity must be performed in addition to their usual activities.

All these factors weigh upon the decision to enhance or commercialize research work. To attenuate or even remedy these limitations, it may be useful to endow the value creation with a more collective dimension.

4.2. The collective exploration of the applications of results derived from research

Since the eighties, the innovation projects involving partnership relationships between organizations have significantly developed for several reasons: the re-focusing of firms on their core professions, causing a loss of internal specialists, the growing complexity of the products and the consequences on the resources to be mobilized, etc. The "interfirm" has taken pride of place in the innovation and development of strategies (Segrestin, 2006). Numerous concepts – co-design, co-development, and co-exploration – illustrate this phenomenon in the product design phase. The interest of the groups is, *inter alia*, to learn together, to access a missing resource or share costs and risks to develop a new product (Barringer and Harrison, 2000). Parallel to the growth in partnerships, greater attention has been directed to the management of the Fuzzy Front End process (Smith and Reinertsen, 1998; Khurana and Rosenthal, 1997). At this juncture, this means studying the relevance and the viability of the concepts, leaving aside any immediate commercial purpose and exploring the markets, the customers and potential uses in order to ascertain the relevant targets (Gautier and Lenfle, 2004). Faced with the difficulties in simultaneously the technical possibilities and the use value of the innovation specific management principles need to be formulated (Lenfle, 2004).

In the late nineties, the principles of innovative design were developed as a response to the significant changes which intensive and repeated innovation was causing the traditional organization of R&D activities and design (Hatchuel and Weil, 2002, 2008; Le Masson et al., 2010). The rationale behind cutting edge design aimed at organizing the exploration of possi-

bilities using available knowledge or creating it in the event that it was lacking. The C-K theory, which is associated with it models the new generation with a dual expansion: that of K (Knowledge), at the root of the design, and that of C (Concepts), innovative propositions albeit unknown to current scientific knowledge. The C-K theory makes it possible to describe the reasoning behind the conception and to specify the value of the concepts being explored. It assumes that it is possible to design in a controlled manner unknown objects which will manifest the truths that we desire (Hatchuel and Weil, 2008).

In the early 2000s, one could observe within the activities of R&D, a convergence of "partnership movement" and that of "upstream return" with questions relating to innovation (Heger and Rohrbeck, 2011). Segrestin (2006) termed as "exploratory partnerships" the groups meeting within the project initiation: badly defined problem, serious technological uncertainties, flawed or unusable knowledge, distance from final markets, etc. The objective of these partnerships is to collectively investigate fields of innovation⁵ or concepts⁶ to produce knowledge so as to map out their potential and their use value. As the object of the cooperation is not predefined, given that it is situated significantly upstream of the projects within an uncertain context, and because the area of possibilities is also unknown, the management steering skills become prone to failure. Devoid of predefined tasks, the division of work and delegation are problems that hamper coordination. In addition, identifying suitable actors, their interest in collaborating and their shared motives are also poorly distinguished. The exploration thus aims to equally devise the group that is to be formed then cement its interests. Although Segrestin aptly demonstrated that exploratory partnerships were "the place for the germination of future areas of action", it is Gillier et al. (2010) who, inter alia, engineered steering instruments suitable for collective exploration, notably with the approach named OPERA.

Gillier et al. (2010) used C-K theory to understand the dynamics of cooperation within exploratory partnerships and to model the collective mechanisms generating new objects. In order to do so, they characterized each exploratory partner actor by her/his C-K profile, i.e., by her/his own areas of knowledge and skills likely to be used in the process of cooperation (K) and in relation to her/his own areas of purpose or problem areas that she/he would wish to address through the partnership (C). Comparing the C-K partner profiles *via* what they called a

⁵ An innovation field is an unfamiliar space which has a value potential but for which there is no customer specifications (because there is no market yet) and which lacks the professional skills required for achieving it (consequently, new knowledge has to be created) (Le Masson et al., 2010). An example of an innovation field, several years ago was the mobile internet.

⁶ Considered here in the understanding of the C-K theory: innovative proposition which will initiate a design study (Hatchuel and Weil, 2002, 2008). Example: the pen which "writes" in 3D.

Matching and *Building* process makes it possible to identify their common interests or observe an opportunity for cooperation that had not been foreseen.

5. From the risk of the initial demand stalling to the NanoMem collaborative workshop

The support of the NanoMem project has been steered by the theoretical studies described in the previous section and then enriched in view of four preoccupations: questioning the directions and initial choices, going back upstream to forestall identified risks, testing partnership exploratory work to open up less risky fields of innovation, preparing the next stages of exploration as well as their partnership conditions. Beyond the NanoMem case, the findings aim to produce knowledge beneficial to activity, during the collective accompanying of innovation projects and from a theoretical perspective, to complete and enrich the instruments steering the exploratory partnerships.

5.1. Creating a start-up to market NanoMem technology?

The first contact was made in mid October 2012 and enabled the five researchers and students from Master 2 to discuss the main questions which the researchers were asking: What industrial application(s) can be used for the technology? What can one do with the registered patents? What type of company should be set up? What niches does one position oneself on?

After a phase of immersion followed by documentary research, the students drew up a strategic note covering semi conductor and likely to inform the researchers about the value creating scenarios concerning NanoMem technology. The main items are as follows:

- For 20 years, there has been a market increase in technological breakthroughs, a reduction in product life cycles along with much faster distribution.
- The semi conductor sector is henceforth dominated by latecomers South Korea and Taiwan.
- 4 leaders corner almost 90 % of market share.
- In the 2000's, the sector reconfigured itself around three types of actor: 1) the "Fabless" are small companies without production facilities but specialized in the designing of electronic circuits, they are profitable activities and minimally capital intensive; 2) using computer software, EDAs (*Electronic Design Automation companies*), test and validate the functional performances of chips before manufacturing them and 3) the "Foundries" (silicon foundry) specialized in the production of semi conductors with a strategy of volume due to the spiraling of R&D costs and production costs linked to the miniaturization of components.

Investments amount to billions (10^9) of dollars and have led to a merging of actors with only a few foundries now operating.

This short introduction highlights the gap between the features of the sector, on the one hand, i.e., the rapidity of change, the high barriers to entry, the merging of the actors, the capital intensity, and, on the other hand, the limited means of action in a team of 5 university researchers. This doesn't mean shelving the NanoMem value creating project but it is better to begin by prospecting other markets and applications, obviously less significant in volume but easily accessible. And what might these be?

Kline et Rosenberg (1986) have shown that successful innovation hinges on a process linking technological and economic dimensions, to combine current knowledge with the wants and needs of future consumers so as to create an inexistent market which no one is expecting. In this case, how does one prepare a matching of shifting supply with an absence of market? What is more, how does one identify and motivate partners to work collectively which, for the time being, only has promise. In other words, how does one explore the new functionalities of NanoMem technology, identify new value attributes and what exploratory partnership does one set up to obtain this?

To address these questions, a team of lecturers-researchers in management studies suggested to the NanoMem project initiators that they take part in an inaugural platform aiming to test the new practices to support innovative projects associating challenges in research, training and collaboration with the regional socio-economic actors. This meant working on project exploratory problems situated upstream of the sectors without a market defined *ex ante*, without validated technologies and requiring the simultaneous exploration of technical potentials and use values. The proposal by three management lecturers-researchers and a strategy consultant to organize a collaborative workshop dedicated to the value creation of NanoMem technology was accepted by the researchers.

5.2. The inauguration of a platform of innovation with the NanoMem collaborative workshop

The aim of the collective workshop was to develop applications and uses other than the replacement of technology dominating the current market. As innovation processes can take place in situations where producers and consumers depend on each other's knowledge and skills, we focused on the interactions so as to diminish the uncertainty about the characteristics of a product and those of the demand (Nahuis et al., 2012). As regards NanoMem, the difficulty is to pinpoint the new needs to meet the new property of the nano material. As there is no known experience among prospective users, calling on lead-users (von Hippel, 1986), the representatives of the future users is impossible. The workshop organizers have therefore to

bring together actors heterogeneous in both status and their disciplinary knowledge in order to imagine new uses for the technology collectively and very much upstream. They decided to partially place their trust in chance as regards the makeup of the workshop group. In order to stimulate the production of new ideas, they were counting on the meeting both inevitable and random of volunteers within a flexible set up requiring neither contract nor obligation further to the workshop⁷. Only a signature of confidentiality was required.

The decision to not just get experts together may come as a surprise but, in the early phases, one source of success might be the interactions between a diversity of actors who form alliances, galvanize their creative potential, share tacit knowledge and recognize the diversity of their interests and expectancies (Nahuis et al., 2012). Whenever there is paucity in predictive knowledge, recourse to a slower empiricism is imposed (Kline and Rosenberg, 1986). As Garel and Midler (1995) underlined, at the start of the projects one can do everything but one knows nothing, and it is thus pointless to want to go quickly. An absence of decision does not cause any harm if it does not interrupt the exploratory process. All the same, the risk of deviation would either come from not seizing opportunities or being overtaken by competitive technologies.

The collaborative workshop was organized into three stages: 1) introduction of the aims of the workshop, 2) a brief presentation on the technology to share a minimum amount of knowledge on it and 3) the exploration of its potential. In the light of the stumbling blocks mentioned in Section 5.1, the third stage consisted in finding applications and uses other than the replacement of currently dominant technology.

To explore this new applications-markets duo, two creative approaches were implemented. Firstly, the words, the images and the ideas that the concept inspired among the participants were pooled together in themes representing market challenges on a mind map (Buzan and Buzan, 1993) posted on a board. The game of discovering the mystery object made it possible to discover the material properties by asking the material researchers questions (is NanoMem material durable? Colored?...). Non experts and experts played complementary roles: the former tending to distance themselves from the subject, the latter to focus on the heart of the subject. The experts were recalling existing or targeted applications, which Gillier and Piat (2011) coined as "assumed identity". The collaborative workshop made it possible to deconstruct in order to develop a new "technological identity" using properties overlooked or un-

⁷ The free enrolment of interested and voluntary participants avoided the costs and the hazards both in the prospection as well as the enrolment and mobilization of a group.

suspected. Around 15 properties and ten or so market challenges were updated. The construction of a segmentation matrix (Table 2) facilitated the useful group discussions on properties – market challenges duos. For confidentiality reasons, only one duo is featured on the matrix.

Table 2. Partial properties – market challenges matrix following collaborative workshop.

		Properties			
		Insulator / conductor	Durable	...	Colored
Market challenges	Microelectronic	<i>Memories</i>			
	Aeronautic				
	...				
	Neurology				

As the collaborative workshop was only a half day, there was no means of turning the investigations into an in depth knowledge of the promising duos. On the other hand, the intermediary result, i.e., the properties-market challenges matrix provides an appreciable tool to continue the work and the identifications of new actors to mobilize.

5.3. From the collaborative workshop to the exploratory and/or design partnerships

Given that the Region was the right level to innovate due to the proximity of the actors and the systemic dimension provided by the interconnectedness of economic, political, educational and social processes (Cooke et al., 1998; Sternberg, 2000; Vickers and North, 2000; Asheim, 2007), it appears relevant that one uses this territorial echelon for further explorations. In the Region where the research was conducted, the innovation development scheme is structured around nine sectors upon which are aligned the structures of research and value creation of the university and the Chamber of Commerce and Industry. By crossing these sectors, for example, with the ten or so applications of emerging semi conductor technology, identified by the ITRS (2011), a new matrix is obtained (Table 3).

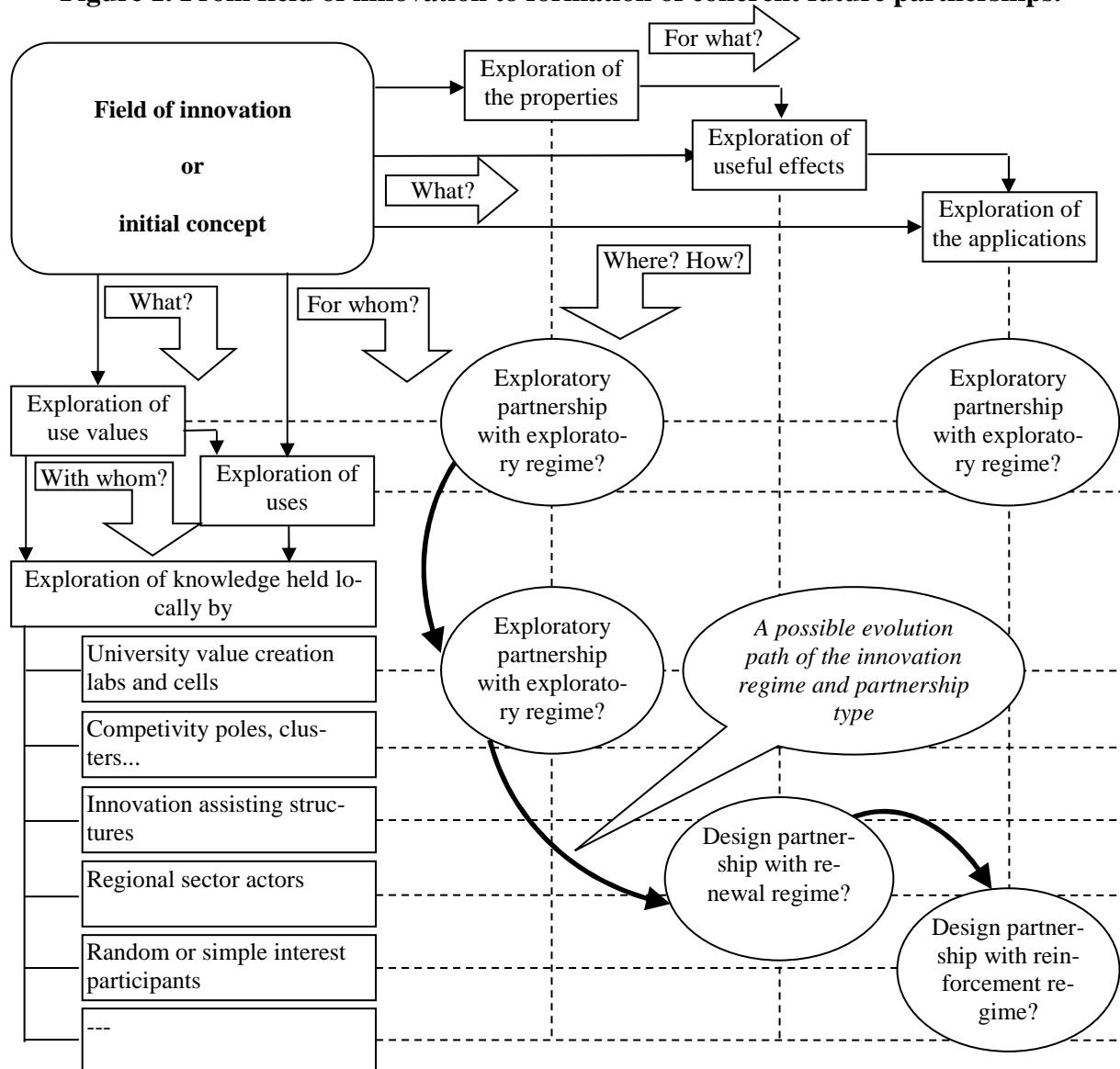
If the participants in the workshop find a segment that they consider to be promising, for example, at the intersection of the “mobile applications” column and the “Fishing, sea, sea coast” line, it will subsequently be easier to establish a new partnership or explore its potential with geographically nearby actors who are likely to possess knowledge of the markets in the sector and have access into them. In principle, these professionals know who uses their products and can identify their new needs. In the event that there is no demand to which the explored field of innovation may be linked, these professionals may act as intermediate consumers *a minima*, and this will already help in the development of knowledge.

Table 3. Applications of emerging technologies – Regional industries matrix

Regional industries	Applications of emerging technologies (ITRS, 2011)				
	Multicore data processing	Cloud computing	Mobile applications	...	Morphic systems
Mechanics and materials					
Materials, Molecules, Chemistry					
Data processing, Mathematics					
Energies, Process engineering					
Sustainable Construction, Civil engineering					
Fishing, Sea, Sea coast			<i>Growing segment?</i>		
Health care, Biotechnologies					
Specialized plant Agrifoodstuffs					
Human and social science					

Experience has shown that in a short period like a half day and with an uncertain and temporary group, it is possible to engage in an exploratory approach which, by means of a field of innovation, makes it possible to rapidly identify properties and/or new application as well as finding market challenges. Apart from the preliminary interest in the collaborative workshop, the procedure developed for a particular case can be generally extended and enriched (Figure 1). It can even facilitate the ulterior work in three ways: 1) by steering the next stage of the explorations, 2) by adjusting the extreme nature of these explorations and 3) by identifying the next groups to be mobilized (Heger and Rohrbeck, 2011; Nahuis et al., 2012).

Figure 1. From field of innovation to formation of coherent future partnerships.



If the distance between the properties and the applications likely to result from them proves difficult to narrow down, an intermediary stage describing the “useful effect” can be beneficially implemented (Figure 1). The “useful effects” (Zarifian cited by Garel and Rosier, 2008) are the effects that the transformations of a highly potential supply produce upon the activity conditions of the recipients⁸. Likewise, if it is difficult to directly project market challenges on homogeneous customer/consumer segments, the procedure may go through intermediary stages. These update the use values in the field of innovation then the characterization of po-

⁸ As regards, the concept of "intermodality energy", for example, the relevance of a fuel cell might be in supporting the displacement of objects without loss of electricity supply (incubators, organs containing cool boxes, work in confined spaces...) (Garel and Rosier, 2008).

tential consumers prior to observing market knowledge likely to be held locally by various actors (Figure 1). With this gradual exploration, the path taken in the course of a collaborative workshop highlights the areas that remain to be cleared and directs the next part of the project and the configuration of the collective possibilities. Diagrammatically, if one remains close to the field of innovation or initial concept (top left of Figure 1), the exploratory partnership is required. Inversely, if the past explorations have revealed most of the potentials (bottom right of the figure) one finds oneself in a situation approaching a conventional design activity. Several “regimes” are then possible (Segrestin et al., 2002; Bonaccorsi, 2008). In the course of this journey, three “innovation regimes” (Garel and Rosier, 2008) can be used: 1) the regime of reinforcing existing supplies to customers whose needs are known, 2) the regime of renewing supplies for present customers or those identified as future consumers and 3) the exploratory regime of undetermined application potentials and intended for unknown consumers. In the first two regimes, the group can be a design partnership made up of domain experts and, for the renewal regime, completed by potential users. In the exploratory regime it is better to form a heterogeneous group of actors but doubtlessly more targeted and less precarious than in the collaborative workshop described in Section 5.2. As the remaining explorations are better targeted, it is slightly easier to make up a relevant or promising partnership. One can even imagine several partnerships with different functions and/or innovation regimes being launched in parallel or subsequently one by one (Figure 1).

To sum up, the collaborative workshop which was tested not only makes it possible to initiate an exploratory partnership but equally helps organize the subsequent work: 1) by directing the progression of the dual expansion (technological and value), 2) by advocating a suitable innovation system and 3) by guiding the nature of the partnership required. As such, Figure 1, a real map for use by the “explorers” is a real aid in marking the exploratory path by replying to the usual questions in a Quintilian hexameter (Who? What? Where?...).

6. Conclusion

This article has traced the background to conceiving and testing a mechanism intended to collaboratively create value in NanoMem technology derived from nanomaterials. To our knowledge, the companion research described is the first restitution relating to an explanatory partnership that concerns the value creation of the work achieved by a university research laboratory. By going beyond the initial brief (studying the feasibility of creating a start-up), the investigational approach has avoided a hasty journey on a path which would have come up

against extremely serious economic and technological obstacles and then probably come to a dead end. Our research procedure has taken cross paths. Contrary to custom, the research was backed by teaching and was performed in parallel, and slightly deferred, to the supervisory activities of a student project. Taking liberties with dominant best practices during its journey, the research abductively brought in an element of chance by mixing experts and non experts, granting itself time and a slow commencement, at the outset of the upstream phase, in contradiction with current recommendations for speeding up technological transfers.

Theoretically speaking, our work extended those on modeling innovation group processes by organizing the exploration around a dual dimension (Properties – Useful effects - Applications) / (Use values - Uses - Markets). The steering instrument which we have described, the collaborative workshop has a threefold purpose: 1) directing the progression of the dual expansion of the concept or field of innovation, 2) specifying the regimes(s) of innovation suitable for continuing the investigations and 3) guiding the establishment of the partnership(s) to perform them.

This enlightening companion research is part of the research agenda of the innovation platform inaugurated with NanoMem. The next step will be a comparative study between collaborative workshop and exploratory partnership. A meticulous study of their similarities and differences could cast light on their distinctive vocations. Beyond the longitudinal study of the NanoMem case that we wish to continue in order to grasp the dynamics of the paths envisaged, we will test other cases and other partnerships in order to ascertain the transportability of our method, particularly in three areas: public and private clusters, university research laboratories and the supposedly innovation-lacking SMEs and VSEs.

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References

- Anderson, T. R., Daim, T. U., Lavoie, F. F., 2007. Measuring the efficiency of university technology transfer. *Technovation* 27 (5), 306-318.
- Asheim, B., 2007. Differentiated knowledge bases and varieties of regional innovation systems. *Innovation* 20 (3), 223-241.
- Barringer, B.R., Harrison, J.S., 2000. Walking a Tightrope: Creating Value Through Interorganizational Relationships. *Journal of Management* 26 (3), 367-403.
- Bonaccorsi, A., 2008. Search regimes and the industrial dynamics of science. *Minerva* 46 (3), 285-315.
- Bozeman, B., 2000. Technology transfer and public policy: a review of research and theory. *Research policy* 29 (4), 627-655.

- Bray, M.J., Lee, J.N., 2000. University revenues from Technology transfer: Licensing fees vs equity positions. *Journal of Business Venturing* 15 (5-6), 385-392.
- Bréchet, J.-P., Emin, S., Schieb-Bienfait, N., 2014. La recherche-accompagnement : une pratique légitime. *Finance Contrôle Stratégie* 17 (2), 2-20.
- Bruneel, J., d'Este, P., Salter, A., 2010. Investigating the factors that diminish the barriers to university-industry collaboration. *Research Policy* 39 (7), 858-868.
- Buzan, T., Buzan, B., 1993. *The Mind Map Book. How to Use Radiant Thinking to Maximise Your Brain's Untapped Potential*, New York, Plume.
- Carayannis, E.G., Rogers, E.M., Kurihara, K., Allbriton, M.M., 1998. High-Technology spin-offs from government R-D Laboratories and research Universities. *Technovation* 18 (1), 1-11.
- Conceição, O., Fontes, M., Calapez, T., 2012. The commercialisation decisions of research-based spin-off: Targeting the market for technologies. *Technovation* 32 (1), 43-56.
- Cooke, P., Uranga, M. G., Etxebarria G., 1998. Regional systems of innovation: an evolutionary perspective. *Environment and Planning A* 30 (9), 1563-1584.
- Cooke, P., 2004. The role of research in regional innovation systems: new models meeting knowledge economy demands. *International Journal of Technology Management* 28 (3), 507-533.
- Cummings, J. L., Teng, B. S., 2003. Transferring R&D knowledge: the key factors affecting knowledge transfer success. *Journal of Engineering and technology management* 20 (1), 39-68.
- Dasgupta, P., David, P.A., 1994. Toward a new economics of science, *Research Policy* 23 (5), 487-521.
- Decter, M., Benett, D., Leseure, M., 2007. University to business transfer - UK and USA comparisons. *Technovation* 27 (3), 145-155.
- Debackere, K., Veugelers, R., 2005. The role of academic technology transfer organizations in improving industry science links. *Research Policy* 34 (3), 321-342.
- Epicoco, M., 2013. Knowledge patterns and sources of leadership: mapping the semiconductor miniaturization trajectory. *Research Policy* 42 (1), 180-195.
- Etzkowitz, H., Webster, A., Gebhardt, C., Terra, B., 2000. The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy* 29 (2), 313-330.
- Garel, G., Midler, C., 1995. Conception et transversalité : concurrence, processus cognitifs et régulation économique. *Revue française de gestion* 104, 86-101.
- Garel, G., Rosier, R., 2008. Régimes d'innovation et exploration. *Revue française de gestion* 7 (187), 127-144.
- Gautier, F., Lenfle, S., 2004. L'avant-projet : définition et enjeux, in: Garel, G., Giard, V., Midler, C., *Faire de la recherche en management de projet*, Paris, Vuibert, pp. 11-34.
- Gillier, T., Piat, G., 2011. Exploring Over: The Presumed Identity of Emerging Technology. *Creativity and Innovation Management* 20 (4), 238-252.
- Gillier, T., Piat, G., Roussel, B., Truchot, P., 2010. Managing Innovation Fields in a Cross-Industry Exploratory Partnership with C-K Design Theory. *Journal of Product Innovation Management* 27 (6), 883-896.
- Grimaldi, R., Kenney, M., Siegel, D. S., Wright, M., 2011. 30 years after Bayh-Dole: Reassessing academic entrepreneurship. *Research Policy* 40 (8), 1045-1057.

- Hatchuel, A., 2001. Linking organization theory and design theory: towards collective action theory and design oriented organizations. Plenary Conference EGOS, Lyon (France).
- Hatchuel, A., Weil, B., 2002. C-K theory, notions and applications of a unified design theory. Proceedings of the Herbert Simon International Conference on "Design Sciences", Lyon (France), March 15-16.
- Hatchuel, A., Weil, B., 2008. Entre concepts et connaissances : éléments d'une théorie de la conception, in: Hatchuel, A., Weil, B., Les nouveaux régimes de la conception. Langages, théories, métiers, Paris, Vuibert, pp. 115-131.
- Heger, T., Rohrbeck, R., 2011. Strategic foresight for collaborative exploration of new business fields. *Technological Forecasting and Social Change* 79 (5), 819-831.
- Hewitt-Dundas, N., 2012. Research intensity and knowledge transfer activity in UK universities. *Research Policy* 41 (2), 262-275.
- I.T.R.S., 2011. Emerging Research Devices, Available on: <http://www.itrs.net/Links/2011ITRS/2011Chapters/2011ERD.pdf> [dated on 09/09/2013].
- Khurana, A., Rosenthal, S.R., 1997. Integrating the Fuzzy Front End of New Product Development. *Sloan Management Review* 38 (2), 103-120.
- Kline, S.J., Rosenberg, N., 1986. An overview of innovation, in: Landau, R., Rosenberg, N., (Eds), *The Positive Sum Strategy. Harnessing Technology for Economic Growth*, Washington D. C., Academy of Engineering Press, pp. 275-305.
- Landry, R., Saïhi, M., Amara, N., Ouimet, M., 2010. Evidence on how academics manage their portfolio of knowledge transfer activities. *Research Policy* 39 (10), 1387-1403.
- Le Masson, P., Weil, B., Hatchuel, A., 2010. *Strategic management of innovation and design*, Cambridge (NY), Cambridge University Press.
- Lenfle, S., 2004. Peut-on gérer l'innovation par projet ?, in: Garel, G., Giard, V., Midler, C., *Faire de la recherche en management de projet*, Paris, Vuibert, pp. 35-54.
- Lichtenthaler, U., 2011. Implementation steps for successful out-licensing. *Research-Technology Management*, 54 (5), 47-53.
- Macho-Stadler, I., Pérez-Castrillo, D., 2010. Incentives in university technology transfers. *International Journal of Industrial Organization* 28 (4), 362-367.
- Nahuis, R., Moors, E., Smits, R., 2012. User producer interaction in context. *Technological Forecast & Social Change*, 79 (6), 1121-1134.
- Philpott, K., Dooley, L., O'Reilly, C., Lupton, G., 2011. The entrepreneurial university: Examining the underlying academic tensions. *Technovation* 31 (4), 161-170.
- Reichertz, J., 2004. Abduction, Deduction and Induction in Qualitative Research, in: Flick, U. von Kardoff, E., Steine, I., *A companion to qualitative research*, London, Sage Publications, pp. 159-164.
- Richardson, R., Kramer, E.H., 2006. Abduction as the type of inference that characterizes the development of a grounded theory. *Qualitative Research* 6 (4), 497-513.
- Segrestin, B., Lefebvre, P., Weil, B., 2002. The role of design regimes in the coordination of competencies and the conditions for inter-firm cooperation. *International Journal of Automotive Technology and Management* 2 (1), 63-83.
- Segrestin, B., 2006. *Innovation et coopération interentreprises : comment gérer les partenariats d'exploration ?*, Paris, CNRS Ed.
- Simon, H. A., 1969. *The Sciences of the Artificial*, Cambridge, Massachusetts, MIT Press.

- Smith, P. G., Reinertsen, D. G., 1998. *Developing Products in Half the Time: New rules, new tools*, New York: John Wileys & Sons.
- Sternberg, R., 2000. Innovation networks and regional development - evidence from the European Regional Innovation Survey (ERIS): theoretical concepts, methodological approach, empirical basis and introduction to the theme issue. *European Planning Studies* 8 (4), 389-407.
- Van de Ven, A. H., Polley, D. E., Garud, R., Venkataraman, S., 1999. *The Innovation journey*, New York, N.Y., Oxford University Press.
- Vickers, I., North, D., 2000. Regional technology initiatives: Some insights from the English regions. *European Planning Studies* 8 (3), 301-318.
- Von Hippel, E., 1986. Lead users: a source of novel product concepts. *Management Science* 32 (7), 791-805.