The Boomerang complex: iterations and knowledge transfer in joint R&D projects

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Subtheme:

S5 Government and public policy in the Triple Helix era

S5.5 Innovation space organization, including industrial clusters, high-tech development zones, science parks, incubators, etc.

Abstract

In this paper, we explore knowledge exchanges between academic laboratories and their industrial partners as the R&D activities in their joint project vary between prospect, exploration and exploitation. We propose a qualitative, longitudinal approach to investigate how the nature of a joint R&D project influences knowledge transfer between partners. First of all, we contribute to a dynamic perspective on inter-organizational knowledge transfer. We show that exploitation, exploration and prospect R&D contribute in different ways to organizational strategies and inter-organizational complementarities. Secondly, we underline the alignment between the nature of the project (exploitative, explorative or prospective) and the expected flows of knowledge as an important stake for the conduct of University-Industry R&D projects. If such an alignment should ideally be built from the design phase, we show that a lack of alignment can be corrected as the collaborative research experiences iterations. Those iterations can be experienced as highly emotional events, influencing the rest of the collaborative work, which we call the "boomerang complex".

Keywords: R&D, alliances, knowledge transfer, exploration, exploitation

INTRODUCTION

Since 2006, the Walloon government has been financing university-industry R&D projects within the framework of the competitiveness clusters of Wallonia (French part of Belgium). This policy complements the set of R&D instruments already deployed in Wallonia to sustain innovation through the linkage of companies and research institutions. While the support of university-industry relationships is a stable component of innovation policies (Behrens and Gray 2001) not only in Wallonia but worldwide, their actual effects are still opened to discussion and the public debate about the role of university is still topical (Audretsch et al. 2002). In particular, one may question the role of academic laboratories as knowledge suppliers in joint R&D projects that focus on different phases of the R&D process.

R&D projects that focus on the exploration of a new technological trajectory rather than its exploitation have specific stakes, objectives, deliverables and resources (Utterback 1994). Likewise, the specific role of partners in joint R&D project should depend on the nature of the alliance (Faems et al. 2005), allowing a large spectrum of learning opportunities. And yet, this phenomenon remains largely unknown (Faems et al. 2005; Faems et al. 2007), specifically when universities and other research actors are involved. In this paper, we explore knowledge exchanges between academic laboratories and their industrial partners as the R&D activities vary between **prospect**, **exploration** and **exploitation**. We propose a qualitative, longitudinal approach to investigate how the nature of an R&D project influences knowledge transfer between partners. This approach has several advantages. Firstly, it takes into consideration the bilateral nature of knowledge flows between partners (Meyer-Krahmer and Schmoch 1998). Secondly, it distinguishes between four forms of knowledge: Know who, Know what, Know how and Know why (Lundvall and Johnson 1994; Johnson et al. 2002), therefore acknowledging that collaborators share more than only scientific knowledge (Davenport et al. 1999; Autio et al. 2008). Thirdly, it allows following potential iterations between prospect, exploration and exploitation as the projects meet blocking points, go back to fundamental understanding and sometimes even give up their commercial ambition. In fact, this paper aims to contribute to the empirical micro studies of what is learnt, how, and by whom (Johnson et al. 2002) in University-Industry collaborative research of different natures.

By considering that R&D projects can take various forms and even evolve along time, we contribute to the development of a dynamic view of inter-organizational knowledge transfer (Faems et al. 2005) as well as to the burgeoning research on exploratory and exploitative innovations (Jansen et al. 2006). Findings should be of interest for various strategic actors involved in innovation networks: public authorities in charge of the policies, industrial and academic partners directly involved in the projects as well as the administrators of the network as this study may provide clues to better manage its projects' portfolio. In section 1, we focus on technological maturity as a contingency factor of University-Industry collaborations. In section 2, we develop the conceptual framework used to study the impact of the nature of the project on knowledge transfer between partners. Section 3 presents the methodological approach to answer the research question: the multiple case studies guided by the dual approach of Leonard-Barton (1990). Specifically, we combine insights from an in-depth longitudinal case study – Axis-1 – with replicated cases (SP7; SP9; SP10). Each project is part of a common mega-project named Mirage (see Figure 1). Section 4 presents the result of this work and we conclude in section 5.

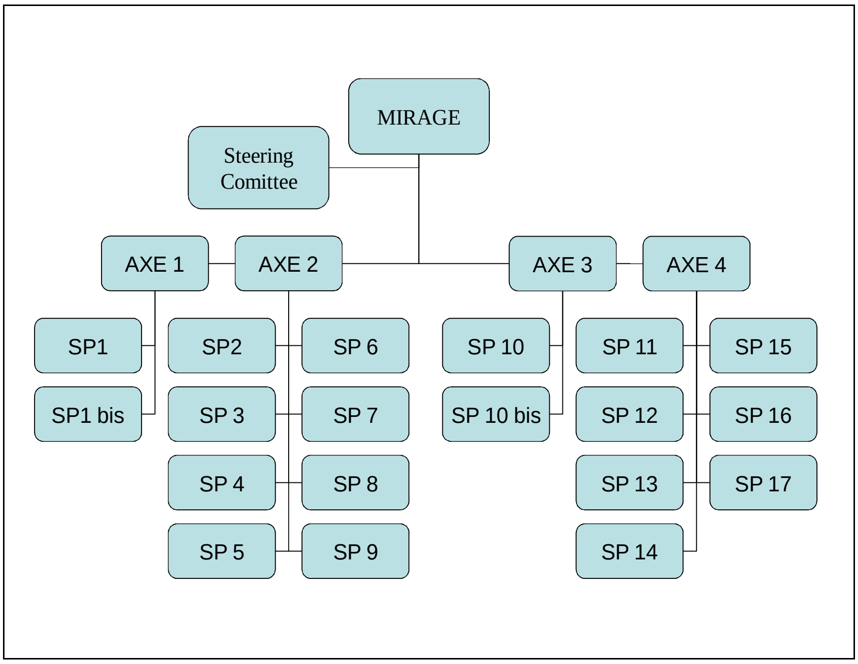

FIGURE 1 MIRAGE AS A PORTFOLIO OF PROJECTS, ADAPTED FROM KUTY (2008)

1. TECHNOLOGICAL MATURITY AS A RELEVANT CONTINGENCY FACTOR

Since the work of Rogers on the diffusion of agricultural innovations (Rogers 1962), the research community has dedicated important resources to understand the innovation process and the evolution of innovative efforts that the firm has to undertake for its survival. For instance, authors such as Jansen and his colleagues (2006), Koza and Lewin (1998), Rothaermel and Deeds (2004) and Cesaroni et al. (2005) build on March (1991) to distinguish between R&D activities of exploration and exploitation depending on the targeted stage of the innovation process. In the context of strategic alliances (Koza and Lewin 1998; Rothaermel and Deeds 2004) and R&D activities (Cesaroni et al. 2005; Chanal and Mothe 2005), the exploration is associated to the prospect of new horizons with the desire to discover new opportunities (Koza and Lewin 1998). On the contrary, exploitative R&D will focus on the “D” of the process (Koza and Lewin 1998; Rothaermel and Deeds 2004; Chanal and Mothe 2005). It has regards with standardization, up-scaling and finally commercialization (Rothaermel and Deeds 2004) by building on the existing competences of the firm (Chanal and Mothe 2005; Jansen et al. 2006) or by pooling assets from complementary partners (Koza and Lewin 1998; Cesaroni et al. 2005).

Carayol (2003) studied the various forms of science-industry collaborations and found the novelty, nature and risk of the research to be the most significant variable to typify University-Industry collaborations. As the nature of the collaboration evolves, the role of partners should also vary, allowing for a wide-ranging spectrum of knowledge transfers (Faems et al. 2005). However, the way R&D alliances of different nature impacts knowledge transfers is still a puzzled and under-studied phenomenon (Faems et al. 2005; Faems et al. 2007), especially when an academic partner is involved. For instance, Freeman (1992) pointed to a higher need for users-firms linkage rather than Science and Technology networks in the case of incremental innovation while Monjon and Waelbroeck (2003) found that knowledge spillover from local universities provided the most benefit to firms pursuing imitative and incremental innovation. In fact, academic laboratories are presented as privileged knowledge suppliers all along the technological journey (Lee 2000). As University is usually associated with exploration (Rothaermel and Deeds 2004; Bercovitz and Feldman 2007) rather than exploitation R&D activities, it should be useful to understand the role of academic laboratories as privileged research partners in innovation networks.

2. Conceptual Framework

2.1 Typology of joint R&D projects

We propose a typology of joint R&D project which takes into account two main criteria: on the one hand, the pursuit of a concrete realization in industrial environment and, on the other hand, the need for fundamental understanding (see figure 2). In line with the literature on dynamic industrial R&D, both exploration and exploitation R&D projects lead to a realization within the firm (March 1991; Koza and Lewin 1998; Rothaermel and Deeds 2004) but are distinguished on the basis of their quest for a fundamental understanding on the one hand, and for the right design in the other hand. R&D activities that lead to concrete deliverables realized outside the firm, in other words in the academic laboratory or the research centre, are called prospective R&D. In fact, this typology combines the motives that traditionally guide the scientific work in universities and industries (see Godin 2006): the quest for fundamental understanding in the former, practical profitable results in the latter.

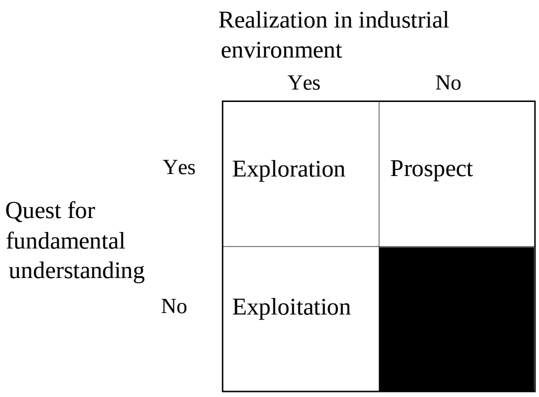

FIGURE 2 TYPOLOGY OF JOINT R&D PROJECTS

In this typology, projects that neglect the quest for fundamental understanding are exploitation R&D project: as the technology mature, scientific and technological uncertainties diminish and the central quest of R&D switches from fundamental understanding to the search for the right design. Those projects can generate new knowledge but are not considering fundamental understanding as a central objective (Stokes 1997). On the contrary, the main goal is to develop a new product or process with the right design and that will quickly enter the market or the production process of the factory. Deliverables of exploitation R&D projects will include new products and processes, sometimes still as an industrial prototype, sometimes as an enhanced version of existing products, and the members of the project will not encourage publication activities.

When the search for additional information leads to a blocking point or, more generally, when more scientific knowledge is required to develop the product or process targeted by the industrial partner(s), the quest for fundamental understanding takes the lead and defines the project as an exploration R&D project. Like exploitation R&D projects, exploration projects are directed towards the development of practical application of knowledge but exploration project specifically acknowledge the need for more understanding of the underlying phenomenon. This distinction is particularly important in the framework of University-Industry links (Stokes 1997) as it should shape the role of the academic partners: from recipients of existing knowledge to producers of new understanding. As a result, deliverables are the crystallization of the newly-created knowledge: incorporated into prototypes that are integrated to the industrial environment, as well as materialized into scientific publications.

To distinguish between explorative and prospective projects, we use the criterion of "realization in industrial environment" (see figure 2). Behind this criterion lays the capacity and/or will of the partners to integrate the newly-created knowledge into existing industrial activities. Indeed, each project led by a quest for fundamental understanding generates new scientific knowledge which is crystallized into a prototype, a proof-of-concept or a scientific article. But it is important to distinguish on one side the deliverables that will be integrated into industrial environment and on the other side deliverables that stay in the laboratory (Auerswald and Branscomb 2003). While this concern mainly comes from sectors such as aeronautics and the Defense, it is of particular importance in University-Industry joint R&D projects – whatever the targeted sector – as both kinds of environments co-exist: the laboratory and the industrial factory. As a result, prospective R&D projects lead to the development of new competences according to the shared vision of the partners who actively encourage scientific publication. Those competences are developed within the academic laboratory and will need further development before being integrated into industrial environment.

2.2 KNOWLEDGE TRANSFER

The nature of knowledge is usually explored through dichotomies (Jensen et al. 2007): tacit and explicit knowledge (Polanyi 1967; Nonaka and Takeuchi 1995), individual and social (or organizational) knowledge (Kogut and Zander 1996; Spender 1996; Nahapiet and Ghoshal 1998), public and private knowledge (Maskus and Reichman 2004). To explore the nature of knowledge flows within the joint R&D projects, we took distance of those dichotomies and used the four forms of knowledge developed by Lundvall and Johnson (1994; Johnson et al. 2002) for the study of innovation networks (De la Mothe and Foray 2001) : Know-What, Know-Why, Know-How, Know-Who (see table 1).

Following Jensen and his colleagues (Jensen et al. 2007), those four forms of knowledge require specific learning paths: the Know-What and Know-Why are usually associated to codified and public instruments such as patents, scientific journals, conference proceedings, data bases; on the contrary, Know-How and Know-Who are shared through practice and interactive learning. The joint R&D projects are thus a privileged instrument for the development of that kind of knowledge, which become more and more important in a context of increasing cross-disciplinarity in the academic world (Katz and Martin 1997) and of increasing complexity in industrial sectors (Johnson et al. 2002). Following the nature of the project, one can expect that some forms of knowledge will be more desirable than others. For instance, prospective projects should favor the sharing of Know-Why and

Know-What (state of the art, research agenda, market trends). Exploration projects might create iterations between Know-Why from the laboratory and private Know-How from the industrial partner in order to incorporate scientific knowledge into an industrial prototype. Finally, exploitation projects might focus on the exchange of Know-How in order to reach standardization and cost reduction. By focusing on those four forms, this study acknowledges that learning in joint R&D projects is not confined to the scientific domain (Davenport et al. 1999; Autio et al. 2008). Informed by the structuration theory (Giddens 1984), even Know-why is not always about scientific results as it participates to sense making within the project.

	Know-What	Know-Why	Know-How	Know-Who
Individual level	Fact, ingredients, state of the art	Causality principles, scientific explanation	Practical competences, intuition, based on experience	Information about who to reach and how to reach them
Systemic level	Shared data	Cognitive dimension : shared interpretive schemes (script and role)	Relational dimension : routines, shared norms of behavior	Structural dimension : links and configuration of the relevant network

TABLE 1 THE FOUR FORMS OF KNOWLEDGE, BASED ON JOHNSON ET AL. (2002), NAHAPIET & GHOSHAL (1998) AND GIDDENS (1984)

3. METHODOLOGY

This paper is organized around a principal case, called Axis-1, which was chosen because of its richness in terms of iteration and hybridization: while some typical cases stay prospective, explorative or exploitative from the beginning to the end of the project, Axis-1 experienced an important iteration from exploitation to exploration; besides, subparts of Axis-1 were identified as being of a different nature than the main part of the collaborative research, providing prospective sub-cases. Four cases were explicitly taken into account (see Figure 3): (1) Axis-1 as an exploitation R&D project before the iteration, (2) Axis-1 as an exploration R&D project after the iteration as well as (3) Peri_UMH and (4) Peri_CMI as prospective cases through peripheral research. A third prospective case was partially taken into consideration in the analysis: (5) Peri_thesis. Indeed, one of the researchers was supposed to conduct a thesis while working on Axis-1. Unfortunately, the thesis kept changing direction and did not materialize.

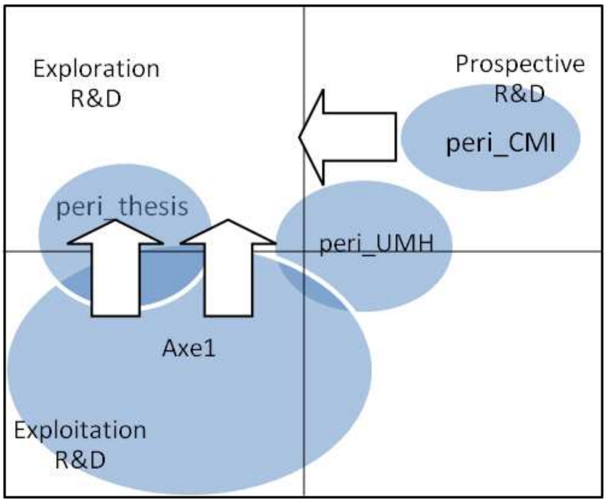

FIGURE 3 AXIS-1 AND ITS PERIPHERAL RESEARCH

Ultimately, we enhanced the research design with the dual methodology proposed by Leonard-Barton (1990). With this methodology, insights from a single longitudinal case (Axis-1) are compared to retrospective replicated cases (Leonard-Barton 1990; Yin 1994), in this case other subprojects from the same collaboration framework, Mirage, that allow for literal replication. Indeed, Mirage provides a field for quasi-experiment: subprojects were designed by the same persons, are financed based on the same rules, are conducted by the same (organizational and sometimes individual) actors who are subjected to the same consortium agreements. This time, three cases were selected for their typicality based on the description of Mirage, interviews with the R&D coordinators and peer debriefing.

Principles	Data collection methods	Data Sources				
Enquiring	Semi-structured interviews		Axis-1	SP7	SP9	SP10
		Front line researchers	9	1	1	2
		Academics	2	0	0	0
		Managers	2	3	0	2
		Total	13	4	1	4
Experiencing	Observation of collaborative interactions	Observation and informal conversation during plenary meetings	15	3	3	3
		Other: team building events & conferences				
Examining	Examination of prepared & unprepared documents	Documents prepared to attest formal interactions: research contract, convention, minutes of plenary meetings				
		Organizational documents: internet website of the Global Clusters policy, publications towards stakeholders, etc.				
		Unprepared documents: mails from the project's mailing list, mails from the cluster's mailing list, memo, letter, field notes.				

TABLE 2 DATA COLLECTION METHODS

Data were collected through three main paths: semi-structured interviews, observation and the examination of documents. Interviews were tape-recorded and a verbatim transcript of each interview was produced. In some cases, the respondent asked not to be recorded. As a result, we prepared a report based on written notes taken during the interview.

In order to complement the thematic analysis conducted with the qualitative data analysis software “Weft QDA”, results were synthesized in Words table in order to enhance cross-case analysis and iterations from empirical evidence to theoretical statements. Those tables provide chains of evidence (Yin 1981; Yin 1994) as extracts of interviews, observation notes or documents are attached to it. Another analysis tool (and chain of evidence) related to the longitudinal nature of the case was the construction of timelines with the main events of the project and associated extracts. Finally, extracts and references to the various data sources are included in the results section. When we cite or refer to industrial respondents, we use (INDx), while we use (ACAx) for academic respondents.

4. Results

4.1 The context

Mirage is best described as a portfolio of subprojects (SP) that were characterized by various levels of innovativeness: some subprojects explored technologies and products that were new for the partners or even for the industry while other subprojects, like Axis-1, focused their efforts on the enhancement of existing products or production processes. In Axis-1, Arcelor-Mittal wanted to improve its easy-cleaning steel and develop a new product with antibacterial properties while AGC Flat Glass Europe already had an antibacterial product but was missing a self-cleaning product produced through vacuum surface treatment. To summarize, the goal was “either to sell something at a higher price (with added value) or to produce at lower costs”. On the basis of the experiences of the crystallizers and the existing scientific knowledge about photocatalytic coatings, Axis-1 was designed as an exploitative R&D project. In other words, it was built with a focus on realizations in industrial settings and on quest for the right design rather than on a quest for fundamental understanding.

	Arcelor-Mittal	Cross-fertilization	AGC Flat Glass Europe
Self-cleaning	Enhancement of existing self-cleaning surface through plasma surface treatment		Development of a self-cleaning surface with photocatalytic effects induced by plasma surface treatment
Antibacterial	Development of an antibacterial product through plasma surface treatment		Enhancement of the existing antibacterial product through plasma surface treatment

Table 3 Initial industrial targets of Axis-1

The academic partners involved in the projects were the University of Liège, the University of Namur (Laboratories CMI and LARN), the University of Mons, and the Laboratory MateriaNova.

4.2 Synthesis of the results

Exploitative R&D project

In the exploitative R&D projects, knowledge exchanges were revolving around an industrial challenge with the quest for the right design given a set of well-defined specifications. In Mirage, academic laboratories were not automatically integrated in this kind of projects. As expressed by one respondent:

"We are really close to a final product, so to speak, and I have the impression that the development that academics could bring is more upstream, well before what we are doing now. Here, we are assembling layers that already exist, I must say that… academics, I don't know what they could do" (IND20).

We nevertheless observed exploitative R&D projects that involved academic laboratories. In SP9, the lab was in charge of "a small contribution… if the lab has a contribution, it is really in terms of characterization: we have to determine the optical properties of materials, they sent the samples, we measure and give back the properties (…) we send the results and they treat it with their software" (ACA14). As such, the role of the laboratory was the one of technical service provider with restricted experimentation. Exchanges were limited to Know-What transfer between partners: specifications against results (ACA14). This situation was also witnessed at the beginning of Axis-1 when it was acknowledged that "the industrial partners know more than us (*academics*)": industrial partners were in charge of the direction of the project (ACA8) and were providing requirement for the next batches based on the characterization results (ACA7). In such cases, academics were involved in the project to accelerate the processes of sampling deposition and characterization: by sharing the work with academics, the industrials partners did not have to do every experience by themselves and therefore were expecting to save time (IND7). Another reason was the access to characterization methods that the industrials did not mastered. As a matter of fact, both SP9 and Axis-1 faced situations where they needed some kind of characterization and had to look outside the collaborative research to find a laboratory that was able to measure what they wanted. Finally, the academics in Axis-1 also wanted to contribute to the project by explaining the evolution of results based on their existing expertise (IND7): "otherwise, there is no need to come fetch us". On the contrary, partners in SP9 were comfortable with the arm's length arrangement "specification against results".

In Axis-1, we observed that the definition of requirements could lead to the transfer of Know-How from the industry to the academic laboratories in order to facilitate the realization of the services and ensure the comparability of results. In informing and guiding the academic laboratory, the industrial partners enhance the relevance of the generated Know-What (characterization results for instance), while enhancing the relative absorption capacity (Lane and Lubatkin 1998) of the collaboration: the academic partners are better equipped to face future demands. A lack of access to this Know-How – in particular a lack of access to the persons that have this Know-How inside the company – can be an important source of frustration. Likewise, the industrial partners need access to the Know-Why behind the methods to make sure that the academic labs are actually measuring what needs to be measured.

Another source of frustration lays in the absence of exploration. Indeed, the "raison d'être" of an academic laboratory is research excellence and the quest for fundamental understanding. When designing an exploitative University-Industry joint project, partners should ensure that this quest is negotiated in parallel with the exploitative work, not only for the laboratory but also for the individual researcher who is actually doing the job and might grow “bored” of repeating the same tasks while he was hired as a doctoral candidate. In SP9, researchers were involved in multiple projects and were able to develop new characterization methods and to publish this progress. In Axis-1, the laboratory CMI (University of Namur) and the University of Mons (UMH) negotiated the quest by developing peripheral research with alternatives processing methods, the laboratory LARN (University of Namur) took opportunity of the project to break in its new equipment, MateriaNova (Mons) was developing a new PVD (Physical Vapor Deposition) technique and the University of Liège negotiated the conduct of a thesis.

	Nature and direction	Role of laboratories	Points of interests
Exploitative R&D project	Know-What U <=> I Know-How I => U Know-Why P <=> P Creation of new Know-How I	Service provider, restricted in the experimentation	Construction of an effective support for Know-What exchanges (platforms) Negotiation of the quest for understanding Transfer of Know-How and Know-who within the project to develop relative absorption capacity
Explorative R&D project	Know-What U <=> I Know-How I => U and Know-Why I => U Creation of new Know-Why U => I Creation of new Know-How I	Service provider , open to experimentation	Alignment between the exploratory nature of the project and the objective of industrialization Transfer of Know-Why between companies and academic laboratories for an enhanced relevance of new scientific knowledge and its integration into industrial settings
Prospective R&D project	Creation of new Know-How U Associated Know-What and Know-Why U => I Know-Why I => U	Creator of new scientific knowledge and new technologies that are relevant for the industrial base	Transfer of Know-Why from the industrial partners to academics for the orientation of fundamental research Support of hierarchy : heads of laboratories and R&D industrial coordinators

TABLE 4 ALIGNMENT BETWEEN SPECIFIC FLOWS AND THE NATURE OF PROJECTS

EXPLORATIVE R&D PROJECT

Per definition, exploratory R&D projects include a quest for fundamental understanding and the exploration of one or multiple phenomena within the collaborative research. As such, exploratory activities are associated to other stakes and potential frustrations. In Hermans and Heck (2010), we identified the lack of alignment between the exploratory nature of a project and the flow of knowledge developed between partners as an important threat for the collaboration. In this example, the coexistence of the industrialization objective and the quest for understanding was a consensual agreement: the companies, final users, were asking for an operational sensor – whatever its origin – while the academics wanted to explore a promising technology that should have led to an innovative sensor. This arrangement created a drift between parties in terms of timing and flow requirement: while the industrial partners were waiting for “something that works” according to their well-defined specifications, academics were only beginning to explore the concept and needed Know-Why from their industrial partners to select the appropriated research paths. Such lack of focus was experienced as a heavy weight by the academic laboratory.

On the contrary, the quest for fundamental understanding was clearly recognized by industrial partners in Mirage (at least after the iteration of Axis-1) which provided partners with plenty of opportunities to transfer Know-Why from the industrial partners to the academic laboratories. In SP7, the exploratory activities were being channeled by the industrial partners: “they are deciding about what need to be done” (ACA12) but they also expose their vision about the future usage of the product being developed, choose the materials to be explored and explain the reasons behind their decision as asked by the research partners (ACA12). In Axis-1, academic partners were also waiting for their industrial partners to “get out of the fog” (ACA8): criteria about the right direction and focus were provided during the first plenary meetings by the industrial partners and stayed unchallenged even after the iteration from exploitation to exploration.

Like in exploitative R&D projects, the exploratory activities required the exchanges of Know-What under the form “requirement against results”. But contrary to the exploitative projects, the industrial partners were calling for the development of scientific Know-Why around those results. In SP7, the team work was therefore organized around specific technical points to be resolved through “the science behind” (IND18), the bibliographic work of the academic partners was seen as a source of new ideas for the project (ACA12) and the presentations of Know-What such as the characterization results were opportunities to highlights new paths. In this case, the lack of involvement of the partners who stick to a restricted exchange of Know-What might create frictions in the project: this phenomenon was witnessed in Axis-1 when the R&D managers needed to rechanneled the exploratory effort from the peripheral research to the main collaborative work while an academic partner stuck to its strict role of service provider. A side effect of this “refocus” and the subsequent inertia of the academic partner was the lack of trust towards academic sidetracks which nevertheless constitute the richness of academic work.

The new scientific Know-Why was subsequently integrated to the development of industrial Know-How such as new production lines or the elaboration of new materials (IND18). While this work was undertaken by the industrial partners alone in the exploitative projects, the exploratory nature of SP7 required a closer involvement of academic partners. For instance, one researcher from Namur was finally invited to contribute to the elaboration of new components with the industrial partner in complement to his characterization work at the laboratory.

PROSPECTIVE R&D PROJECT

Like exploratory projects, prospective R&D activities are characterized by a quest for fundamental understanding but this time without a clear objective of industrialization. As a matter of fact, neither the peripheral research of Axis-1 nor SP10 were targeting industrialization in the context of the project. In Peri_UMH and Peri_CMI, the laboratories developed new Know-How about sol-gel processing and shared the associated Know-What (bibliography) and Know-Why with the partners of Axis-1, even if it did not always contributed to the main collaborative research. In SP10, research partners were performing technology watch as well as developing new Know-How in order to come to a proof of concept at the level of the laboratory (IND21). As the targeted technology was evolving, some industrial partners took opportunity of the existing development to integrate it into their own equipment. As a result, even if the underlying technology is still “far away from industrialization” (IND21), it nevertheless contributed to the enhancement of industrial competences and the creation of new markets for the industrial partners. This project also generated various prototypes but the partners in SP10 quickly realized that they were lacking information about what kind of market could be interested, and in which direction should those prototypes be further developed. As a result, an additional industrial partner was brought in during the conduct of SP10 in order to assess the relevance of the prototypes and to provide the required Know-Why (IND19).

As a result, the development of the absorptive capacity takes a twofold path in prospective project: the direct access to scientific knowledge for the industrial partners on the one hand; the orientation of fundamental research within the academic laboratory on the other hand. Like in the other R&D projects, the transfer of Know-Why from Industry to University is central as it allows academics to understand the – scientific, organizational, commercial – problems that the industry faces, their causes and consequences. As such, it should diminish the institutional frictions that impede inter-organizational learning (Lane and Lubatkin 1998) as well as the journey in the valley of death (Auerswald and Branscomb 2003; Ford et al. 2007). In order to ensure the durability of exchanges, the prospective project needs the involvement of the hierarchy from both worlds, even if industrialization might seem far away. It should also support the development of technological platforms that are of interests for both the industry and the scientific search for excellence (IND2).

ITERATIONS AS EMOTIONAL SHOCKS: THE BOOMERANG COMPLEX

The previous section provided a check list of expected flows as the R&D project focus on exploitation, exploration and prospect. While the alignment between expected flows and the nature of the project is an important stake of the collaboration, partners should allow for flexibility as the project might experience iteration.

After the iteration of Axis-1, the academic partners shifted from a role of producers of Know-what (conditions of deposition, characterizations, etc.) and recipient of existing scientific Know-Why to a role of producers of Know-why to explain unclear results, explore new paths and “close the doors”. This shift came along with a reduction of Know-how creation at the level of the laboratory and a reduction of peripheral exploration, in other words parallel research that could have been undertaken by the academic researchers independently of the project. Several difficulties were associated with this shift. For instance, the design of the collaborative research became obsolete and the respect of a win-win situation was less clear for some academic partners

We uncovered a second impact that should not be underestimated: what we called the boomerang complex. A complex is a set of mental representations and recollections which have a high affective value, are contradictory, are partially or totally unconscious, and which influence the behavior of an individual (Alhadeff-Jones 2008; Institut National de la Langue Française 2010) or a set of individuals when this set of mental representations is shared within the group. In Axis-1, the iteration was experienced as an emotional event. It contributed to the construction of shared interpretive schemes, in particular the necessity to “fall back on our feet” (IND8). Partners redefined the research work as getting “something that works” in the laboratory even with unsatisfactory industrial conditions, and working towards industrial requirements only in a second step (ACA10). Such collective understanding can be very efficient to channel collaborative actors towards a common goal but it also creates a blueprint which impedes alternative thinking. In this project, it was an obstacle not only for the emergence of alternative paths but also for the recognition of alternative solutions, as crystallized by the work of the CMI researcher who proposed a product with acceptable properties but which was not immediately recognized as such by the partners (ACA10; ACA11).

5. Conclusion

In this work, we conducted an empirically grounded analysis of knowledge transfers in joint R&D projects.First of all, we contributed to a dynamic perspective on inter-organizational knowledge transfer. We showed that exploitation, exploration and prospect R&D contribute in different ways to organizational strategies and inter-organizational complementarities. Exploitation R&D project targets outcomes that are integrated to industrial settings, urging for the transfer of Know-how from the industry to the academic laboratory. They allows for the strengthening of the collaborative links on the basis of complementarities refinement, for instance through the refinement of methods according to the industrial partner’s requirement. In this case, the academic laboratory creates mainly Know-what concerning the samples and provides access to existing scientific knowledge. Exploration R&D also targets concrete results in industrial environment but acknowledges blocking points that are explored in the framework of the project, allowing the creation of relevant Know-why by the academic partners. Prospect projects acknowledge the quest for fundamental understanding while transferring Know-why about the industrial settings. In this case, the transfer of Know-how from the Industry to the University was less important than the transfer of Know-why about marketing criteria and industrial production methods.

Secondly, we presented the alignment between the nature of the project and the expected flows of knowledge as an important stake for the conduct of University-Industry R&D projects: for instance, if a prospective R&D project does not require the transfer of Know-how from the industrial partner to its own laboratory, a lack of such flows will be deteriorating in an exploitation R&D project. We agreed with Carayol (2003) about the importance of this alignment during the design phase of the project but we also showed that a lack of alignment can occurred during its conduct as the collaborative research experiences iteration. Such iteration can impact the role of partners, jeopardizing the negotiated terms of the project and therefore leading to frustrations and misunderstandings. In particular, we showed that the iteration of Axis-1 impacted the quest of fundamental understanding that was implicitly negotiated at the beginning of the project and restricted them in their research work. We also showed that iterations can be experienced as highly emotional events, influencing the rest of the collaborative work.

When designing this research, we decided to focus on one longitudinal cases and a number of replicated cases from the same environment. We acknowledge that is an important limit of this work which could benefit from the conduct of additional cases. In particular, this research area might benefit from the study of typical cases. Another important limit lays in the fact that we focused on knowledge transfer within the project rather than through the project (Jiang and Li 2009). An alternative level of analysis – the organization (laboratory or company) – should allow tackling this limit.

In conclusion, this work studied the nature of knowledge flows that are at stake in University-Industry R&D project at different levels of the innovation process. We showed that iteration in the nature of the project impacted the equilibrium that was attained during the designing phase of the project, urging for the renegotiation of the R&D problem and ways to solve it.

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