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Abstract:

Open innovation has become a major topic in innovation management. Research however has mostly focused on large companies, in the area of inbound open innovation, on the technological scope or industrial protection. The topic of outbound open innovation, the processes implemented and the management practices deployed in SMEs have been less well investigated. This article aims to go some way towards filling this gap. A collaborative longitudinal case study was carried out by a researcher and two practitioners in a robotics SME. The results show the impact, mainly positive, of open innovation on the company. The functions of technological gatekeeper and "innovation project promoter", created while the open innovation process was being established, are illustrated through the examples of previous collaborative projects and a current major research European project applied to robotics in which the company is involved.

Keywords:

Inbound open innovation, outbound open innovation, innovation process implementation, SMEs, collaborative projects

Introduction

Small and Medium-Sized Enterprises (SMEs) are the most common firms in many countries. In Europe (EU-27), 20 million SMEs employ more than 80 million people. They represented, in 2012, 99.8% of all enterprises, 66.5% of employment and 57.6% of gross value added (GVA) (Gagliardi et al., 2013). In 2014, 2.23 trillion Euros of GVA were produced by European SMEs (Zhang et al., 2014). In the USA, the ratios are similar (Hausman, 2005).

In the 1980s, public bodies became aware of the importance of SMEs and devoted increasing attention to their innovation capabilities (Hassink, 1996; Cooke, 2001). They play an important economic role in the regions they are located in as they contribute to maintaining and to developing employment and economic competitiveness (Vickers and North, 2000). Raising SME competitiveness, especially through encouraging innovation and by leveraging their innovative abilities, has thus moved to the heart of policy incentives (Forsman, 2011).

Due to their size, SMEs have strong innovate assets, such as creativity, flexibility, responsiveness, risk acceptance and closeness to customers. Public innovation support has however struggled for a long time with their limited in-house resources, not only financial and human but also structural, methodological and cognitive (North et al., 2001; Narula, 2004; Boldrini et al., 2011; Parida et al., 2012). In consequence, the success of SME innovation projects is often not as great as would be hoped.

Traditionally new technologies have mostly been developed in-house. As and when they became more complex and require a broader portfolio of knowledge than a single firm is likely to have, collaboration with external partners (suppliers, customers and competitors) gains the ascendancy. Access to partners' resources compensates for the lack of internal ones. The idea of testing the concept of open innovation (Chesbrough, 2003) as a means to overcome SMEs' difficulties has gained ground from the mid-2000s because it seemed to be a promising solution for SMEs struggling with a lack of resources (Lee et al., 2010). It could allow them to develop new technological combinations of previously unconnected knowledge and capacities as well as to be able to take advantage of a wider range of market opportunities (Dahlander and Gann, 2010; Parida et al., 2012).

As open innovation was initially designed for large firms, SME practices need further investigation in order to better understand them as well as the challenges that they have to face in implementing open innovation (Van de Vrande et al., 2009; Lichtenthaler, 2009, 2011). This article aims to identify the open innovation processes implemented in a SME involved in collaborative projects in order to develop.

The paper is structured as follows. Firstly, we review the literature on innovation and SMEs. We give evidence of the SMEs' paradoxical situation regarding innovation and we compare the benefits and the limits of open innovation in SMEs. Secondly, we present our methodology, a longitudinal and qualitative case study in a French robotics SME. Thirdly, after a short presentation of the company, we describe its journey in open innovation with the examples of two collaborative projects Robm@rket and STAMINA. Finally, we describe and comment on the impact of open innovation on the company.

1. SME innovativeness

SMEs are concerned in innovation collaborations with external partners but their characteristics (e.g. small size, lack of resources), at the same time positively influence their innovativeness and explain the barriers they have to overcome (North et al., 2001; Narula, 2004; Hausman, 2005).

1.1. SMEs' paradoxical situation regarding innovation

In SMEs the personality and the motivations of the managing directors or founders are key determinants for the innovative success of the company as they tend to formulate its strategy (Vickers and North, 2000). However they are sometimes reluctant to delegate authority, they tend to reject external help, they may doubt the value for money or they may be skeptical about non-expert advice and prefer autonomy (North et al., 2001).

A great deal of research has studied the strengths and weaknesses of SMEs in terms of innovation processes (Vickers and North, 2000; North et al., 2001; Kaufman and Tödtling, 2002; Hausman, 2005; Tödtling and Trippl, 2005; Van de Vrande et al., 2009; Lee et al., 2010; Parida et al., 2012). These studies reveal that SMEs are in a paradoxical situation regarding innovation (table 1). On the one hand, they have distinctive strengths (e.g. flexibility, reactivity), on the other hand, weaknesses (mostly lack of resources) restrict their innovativeness. There are also characteristics which may be positive or negative: depending on their personality, managers may be innovation champions or inward-looking.

Table 1. SMEs' paradoxical situation regarding innovation.

Innovation strengths	Innovation weaknesses	Ambiguous characteristics
• Flexibility • Proximity to customers and suppliers • Superior customer or market knowledge • High reactivity • Risk acceptance	• Limited internal resources (human, organizational, time, financial...) • Lack of know-how or capabilities in R&D, design, management, marketing • Limited innovation portfolio • Few external relations outside business partners • No formalized methods to assess ideas and to manage projects	• Manager's personality and motivations • Small size • Specialization in one business or in a particular know-how • Emphasis on technical development • Informal and highly personalized networks • Weakly formalized structures • Polyvalent employees • Short term concerns • Short time, operational and little formalized information processing

The synthesis of previous research, in table 1, shows that it is impossible for most SMEs to have a complete range of innovation expertise and to manage the whole process internally due to their lack of resources. SMEs need to find the missing resources externally, but they often experience difficulties in accessing them. To overcome these limits Regional Technology Transfer Agencies (RTTAs) were set up, in European countries, in the mid-1980s, in order to provide support to SMEs (Hassink, 1996; Vickers and North, 2000; North et al., 2001). For the last fifteen years the concept of open innovation (Chesbrough, 2003) has emerged and developed to become the present dominant innovation paradigm.

1.2. SMEs and Open Innovation

Chesbrough et al. (2006) define open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively." Open innovation was firstly implemented and studied in high tech and multinational enterprises, however, recent research shows that SMEs are also using open innovation and that they are increasingly doing so. Inter-firm collaboration may provide the missing knowledge or the complementary assets needed to go beyond their limits. However reducing open innovation to science-based products and formal R&D would seriously distort the understanding of innovation in SMEs. (Van de Vrande et al., 2009; Lee et al., 2010). In SMEs, innovation is often integrated into daily business, development work or experimentation. Innovation processes are hidden even for people involved in these functions (Forsman, 2011).

Open innovation is often divided in two core processes. *Inbound open innovation* is "the practice of leveraging the discoveries of others: companies need not and indeed should not rely exclusively on their own R&D". *Outbound open innovation* "suggests that rather than relying entirely on internal paths to market, companies can look for external organizations with business models that are better suited to commercialize a given technology" (Chesbrough and Crowther, 2006). Some authors (Gassmann and Enkel, 2004; Mazzola et al., 2012) consider a third process. *Coupled innovation* is co-innovation with complementary partners that "combines the inbound with the outbound processes, to bring ideas to market and, in doing so, jointly develop and commercialize innovation." Linking both technology exploration and exploitation increases the overall value orchestration (Chesbrough and Crowther, 2006; Lichtenthaler, 2008; Lindgreen and al., 2012). Table 2 summarizes the main characteristics of inbound, outbound and coupled open innovation (adapted from Gassmann and Enkel, 2004; Van de Vrande et al., 2009; Dahlander and Gann, 2010; Chiaroni et al., 2011; Mazzola et al., 2012; Frishammar et al., 2012).

Table 2. Inbound, outbound and coupled open innovation.

Open innovation	Inbound	Outbound	Coupled
Synonym	Technology acquisition Inward technology transfer Outside-in	Technology exploitation Outward technology transfer Inside-out	Technology acquisition and exploitation
Characteristics	• Low tech industry for similar technology acquisition • Act as knowledge brokers and/or knowledge creators • Highly modular products • High knowledge intensity	• (Basic) research-driven company • Objectives like decreasing the fixed costs of R&D, branding, setting standards via spillovers	• Standard setting • Increasing returns • Complementary products with critical interfaces • Relational view of the firm
Main practices / activities	• Integration of customers, suppliers and external knowledge sourcing • External networking • Inward IP licensing • Funding research	• Bringing ideas to market • Technology commercialization • Selling IP • Divest, spin-off, venturing • Multiplying technology different applications	• Co-patent • Joint-venture • Alliances with mainly complementary partners in R&D, manufacturing...
Associated capability needed	Absorptive capacity	Multiplicative capability	Relational capacity

Despite strong complementarities these types of innovation were not implemented simultaneously or together. Firms generally started by experimenting with inbound innovation, with only a few of them trying outbound innovation (Lichtenthaler, 2009; Huizingh, 2011; Chiaroni et al., 2011; Frishammar et al., 2012). A possible explanation for companies being more inclined towards inbound activities than outbound ones is that outbound activities require “a higher level of managerial challenge due to imperfections in markets for technologies and a lack of systematic internal process to drive such initiatives” (Parida et al., 2012) and because “creating new markets takes time and requires a major investment of resources” (O’Connor et Rice, 2013).

The literature on the benefits of open innovation does not concur. For Mazzola et al. (2012), collaboration tends to be beneficial to a firm’s performance. Other research finds that open innovation is only relevant for large firms and in cases of high product modularity or high industry speed (Gassmann and Enkel, 2004; Parida et al., 2012). Dahlander and Gann (2010) think that research should also pay attention to the disadvantages. Huizingh (2011) shows that establishing partnerships is an essential but also a time-consuming factor in open innovation, with possible negative effects on long-term profits. Openness may also lead to slower and more costly development projects compared to projects with less openness (Knudsen and Mortensen, 2011).

Prior to the emergence of the open innovation concept, the value of inter-organizational relationships had already been extensively investigated. According to Barringer and Harrison (2000) the potential advantages include: access to particular resources or markets, economies of scale, risk and cost sharing, learning, speed to market, and flexibility. The potential disadvantages may be: loss of proprietary information, management complexities, financial and organizational risks, becoming dependant on a partner, partial loss of decision autonomy, clash of cultures, loss of organizational flexibility. A number of studies on open innovation reiterate these arguments (Enkel et al., 2009; Van de Vrande et al., 2009; Lichtenthaler, 2009; Lee et al., 2010; Dahlander and Gann, 2010; Parida et al., 2012; Mazzola et al., 2012; Frishammar et al., 2012) but also provide new ones (table 3).

Table 3. Benefits and limits of inbound and outbound open innovation for SMEs.

Benefits
• Fuel internal innovation process and shorten innovation time.
• Allow the development of complex products through integration of tested and proven technologies.
• Improve the preemptive advantage of already developed technology.
• Use almost-ready technology to address merging gaps in the market.
• Provide revenue and access to knowledge.
• Commercialization of inventions by selling or licensing-out ideas.
• Freedom to operate thanks to cross-licensing agreements with other organizations.
• Set industry standards.
• Limit a competitor's first-mover advantage.
Limits
• Difficulty of exploiting technology developed elsewhere (NIH syndrome, prominent barrier for external knowledge acquisition).
• Expertise required to search for and evaluate external ideas.
• Inadequate or insufficient absorptive capacity to benefit from external knowledge.
• Organizational and cultural issues due to number of external contacts.
• Difficult transfer of know-how if high level of tacit knowledge associated with the technology.
• Reduction of the ability to develop in-house core competencies if too much sourcing.
• Costs of coordination to bridge organizational boundaries.
• Costs of protecting ideas to which others have access.
• Free-riding, opportunistic partners.
• Inventors' reluctance to reveal their developments, "only-used-here" syndrome (OUH).
• Fear of selling corporate crown jewels.
• Lock-in problems due to too much or not enough proximity (cognitive, organizational, social, institutional or geographical).
• Increase in short term profit may weaken specific R&D capabilities.

To summarize, there is a curvilinear relation between open innovation and performance. Companies should carefully weigh up the benefits and the drawbacks of open innovation, particularly SMEs, which experience difficulties in investing limited internal resources in order to access stronger external ones (Dahlander and Gann, 2010; Huizingh, 2011; Parida et al., 2012).

There is however little information available on SMEs to help them make this judgment. Researchers mainly focused their early studies on inbound innovation in large and high-tech companies. Works on outbound innovation came later (Mazzola et al., 2012). Most of the academic papers analyze only one of these two forms (Dahlander and Gann, 2010). Few studies have investigated the implications in SMEs (Parida et al., 2012), the internal managerial activities in out-licensing (Frishammar et al., 2012) and the processes coupling and transforming inbound innovation into outbound innovation (Forsman, 2011; Mazzola et al., 2012).

SMEs are mainly motivated by market-related targets as their main problem is less invention than commercialization. Collaboration with industry incumbents might overcome this difficulty (van de Vrande et al., 2009). Lee et al. (2010) also suggest that technology exploitation, for market opportunity, should be addressed more than technology exploration in SMEs. Which is a strong argument for more research on the outbound dimension, in particular in SMEs (Enkel et al., 2009; Parida et al., 2012).

2. A longitudinal case study carried out through a researcher-practitioner collaboration

In order to deal with the above-mentioned lacunae we asked ourselves the question: "What open innovation processes need implementing in order to develop a SME involved in collaborative projects?"

To answer this question we studied the case of a French high-tech industrial SME. A case study allows an in-depth examination and a fine-grained understanding of complex processes (Yin, 1994) and is a convenient means of investigating resources, activities and organizational structures. A longitudinal approach can also reveal any effects on performance (Mazzola et al., 2012).

The research was carried out through the active cooperation between a researcher and two practitioners. The choice of a participatory approach (Lewin, 1964; Argyris et al., 1985) was for two reasons: 1) producing data not only to describe the present situation of the firm but also to enable its transformation, 2) producing knowledge that serves both action and management science theories. Researcher-practitioner collaboration enhanced the visibility of the products of the research and the traceability of knowledge transfer and is one of the most pertinent ways to produce and disseminate reliable and useful knowledge in SMEs (Mohrman et al., 2001; Cummings and Kiesler, 2005; Mesny and Mailhot, 2012).

The researcher collaborated with two "practical theorists", that is to say with actors who have internalized theoretical knowledge (Nonaka, 1994) in innovation management and who are able to link it to their daily practice. One of the practitioner is the SMEs' innovation director.

An electronic and automation engineer, he also has a PhD in management science. He can act as an intermediary between the industrial and academic worlds and is interested in both practical and theoretical dimensions of knowledge. He introduced, from 2007, inbound open innovation processes to the company (Caverot et al., 2014). The second practitioner is a junior executive in charge of promoting innovation projects. The practitioners and the researcher are experts in their areas but also share common knowledge (innovation management). As the practitioners were in the field daily and the researcher only occasionally, they made up an insider/outsider research team (Bartunek and Louis, 1996).

The practitioners were real stakeholders in the research and legitimate knowledge co-producers. The main processes of the research were shared at each stage: diagnosis, definition of the research questions, revision along the way, research design, academic literature reading, data collection and fact finding, establishment of a model of the organization, analysis of field documents, and most importantly, discussion, confrontation of views, interpretation of results and definition of possible paths for change. As a result, the co-authors were collectively involved in a learning process.

The empirical data of the research was made up of the internal documents used during the company's innovation projects (emails, business and technological documentation, minutes of meetings, etc.) and academic works (a PhD dissertation, trainee's report). Data were easy to access and of high value because the practitioner co-authors were used to writing to explain their practice. The various theoretical levels of the data (presented facts or intermediary theory) enabled both dialogue with the practice and dialogue with the general theories. As knowledge was coproduced by interaction in the field, the researcher participated in the action in a concrete manner. The movement back and forth between theoretical levels revealed similarities and conflicts between literature and experience, clarified inferences between both and guaranteed the scientific nature of the results, that is to say their internal validity (logical coherence) and their external validity (conditions of generalization) (David, 2002). Triangulation was also achieved by combining the three authors' viewpoints.

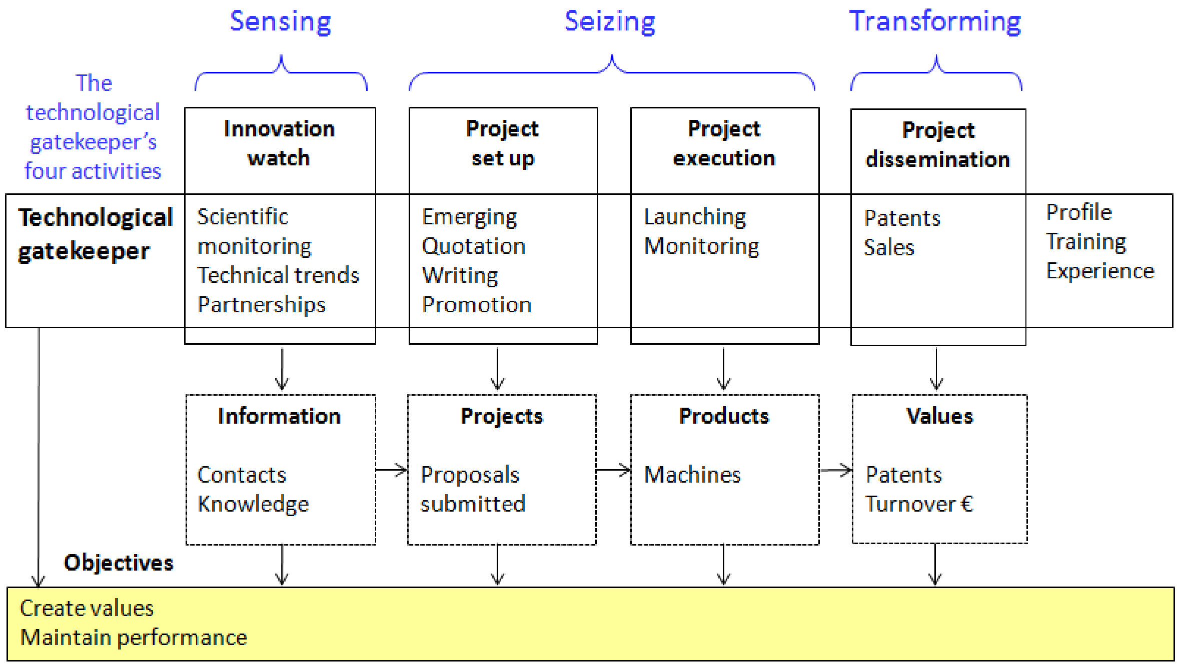
3. The journey of a French robotics company in open innovation

BA Systèmes is a French company created in 1975. It designs, manufactures and maintains intralogistics solutions using Automated Guided Vehicles (AGV) for industries such as agrifood, bottling, and pharmaceutical. The company also develops specific mobile robots to cater for emerging needs in other industries such as automotive, building, healthcare. In 2015, the company employed 150 people. Half of them are engineers or possess a Ph.D. More than 15 % of the sales revenues is devoted to R&D.

3.1. From closed innovation to inbound open innovation

In 2007, BA Systèmes, with 70 employees, was developing AGVs internally. A strategic orientation arose: to generate revenue through a greater opening to its environment. The president of the company decided to develop an open innovation strategy and put one of their engineers in charge. The missions were to set up an innovation cell, to implement a technological gatekeeper mechanism (Allen, 1977) adapted to the needs of an SME, and to develop parnerships with academic laboratories, end users, industrial companies, universities and research enablers at regional and national levels. For five years, this engineer was the technological gatekeeper within the innovation cell. On top of the core business, this ad hoc structure allowed him to participate in collaborative projects and to develop new mobile robots in partnership by exploiting internal resources, while benefiting from freedom of action and autonomy. Simultaneously, as a doctoral student, he was conducting intervention research (David, 2002) developing four actions directly linked with open innovation (scouting, project set-up, project implementation, project results promotion) and the strategic objectives. Thanks to this technological gatekeepers's activity three dynamic capacities were developed (Teece, 2007): 1) the capacity to work with academic world (*sensing*), 2) the capacity to manage fuzzy front end projects (Reid and de Brentani, 2004) (*seizing*) and 3) the capacity to promote innovations in the market (*transforming*) (Caverot et al., 2014). Figure 1 shows the relationships between the strategic objectives, the three dynamic capacities and the gatekeeper's activity.

Figure 1. Relationships between strategic objectives, dynamic capacities and gatekeeper's activity (Caverot et al., 2014).



Out of 15 projects carried out over the period 2007 - 2014, table 4 provides four examples illustrating their diversity and their main characteristics.

Table 4. Four examples of collaborative robotic projects (adapted from Caverot et al., 2014).

Robot name	ROBM@RKET 	ROBAGRO 	AGILA 	ROBO-K 
Function	Automate picking	Feed cattle	Assist medical staff	Help functional rehabilitation
Research program	National	Regional	National	National
Duration	2008-2011	2008	2010-2012	2012-2014
Number of partners	5	3	5	6
Budget (k€)	1 700	300	18 000	3 700
Target market	Logistics	Agriculture	Surgery	Rehabilitation

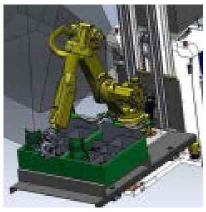
The implementation of the three dynamic capacities positively affected the SME's performance. The four projects in figure 1 alone gave rise to worldwide sales of innovative robots, the construction of a production unit to provide robots to a world leader in the healthcare industry, the publication of 7 patents within 3 years and the acquisition of new internal competencies (e.g. quality, transversal management of innovation projects).

Mobile robotic systems are made up of technological components. The collaborative R&D projects brought various benefits to BA Systèmes. The components are continuously being improved and adapted to new needs. The development of prototypes may lead to the manufacture of new robots and thus increase the company turnover . Through the snowball effect, over the long term, the SME increases business opportunities, expands its partnership network and gains credibility and name-recognition. Initially the company looked to acquire new knowledge and technologies (e.g. laser guidance, embedded energy). The technological gatekeeper constantly tried to exploit the results of the collaborative projects he was involved in, but his actions were not formalised. Initially, the dissemination and industrial exploitation action took place according to opportunity. The main outward activities were conferences, involvement in scientific societies, and lectures in higher education institutions, in order to use internal knowledge and to reinforce the SME's visibility. Over time, innovation and research partnerships gained in importance as part of a conscious strategy of the company.

3.2. From inbound to outbound open innovation

Between 2012 and 2014, open innovation activities grew significantly in importance. A new strategic plan, in 2012, had diversification and development of know-how in mobile robotics as objectives.

Table 5. Main characteristics of the STAMINA project.

Robot name	STAMINA  
Function	Bin-picking and kitting
Research program	European
Duration	2013-2017
Partners' number	7
Budget (M€)	4.5 M€
Target market	Automotive industry

The earlier R&D Robm@rket project led to a new one, named STAMINA (table 5). STAMINA is a collaborative project supported by the European Framework Program 7 (FP7). It aims to develop a sustainable and reliable robotic system for parts handling in manufacturing. The STAMINA robotic system will, for example, undertake repetitive and tiresome tasks in the automotive industry.

FP7 rules explicitly require that the R&D projects plan and implement innovation actions in order to increase their impact by transforming scientific knowledge into added-value post the project. The STAMINA consortium decided to entrust the work package dealing with dissemination and industrial exploitation to BA Systèmes. A report entitled "plan for disseminating and use of foreground" (PDUF) laid down the foundations for effective external communication of STAMINA's results and to increase the visibility and the impact of the results (successful market launch and potential profits for stakeholders). Within the partnership, the PDUF helps to build a common vision of the project results. It increases partner cooperation and motivation to succeed. It lays down the allocation of intellectual property rights. It gives a practical orientation towards the valorization of the results in line with each partner's individual interests (scientific publications for research institutions, turnover for industry).

As "exploitation manager" within the project, BA Systèmes was responsible for implementing the strategy laid out in the PDUF through concrete action but they had no adequate internal human resources. Thus, a junior "innovation projects promoter" (third author) was hired. His brief is to describe industrial results, to promote open innovation, especially outbound, and to promote the STAMINA project's results and BA Systèmes know-how in new innovation projects (booklets, posters) and outside (newspaper articles, international competitions, fairs).

The STAMINA project and the junior innovation projects promoter's activity, in addition to the technological gatekeeper's activity in inbound open innovation, benefitted BA Systèmes in reinforcing a network of alliances with international robotics partners, diversifying the company activities (a new family of products), and establishing a new, dedicated, resource centre to file patents and thus generate intellectual property rights.

4. The impact of open innovation at BA Systèmes

This section will focus on three themes arising out of the introduction of open innovation in BA Systèmes: Firstly, the revitalization of its processes, organizational structures and skills; Secondly, as the challenges faced by SMEs in implementing outbound open innovation is underexplored in the literature, we will focus on the original solutions that were successfully tried out at BA Systèmes; Thirdly, how BA Systèmes linked inbound and outbound open innovation processes into couples.

4.1. The revitalization of BA Systèmes's processes, organizational structures and skills

Chiaroni et al. (2011) argue that the implementation of open innovation follows a three-phase process (unfreezing, moving and institutionalizing) and that the resulting changes involve four major dimensions (networks, organizational structures, evaluation processes and knowledge management systems). This framework, used to study a large company, is also relevant in the case of BA Systèmes (table 6).

Table 6. The innovation journey at BA Systèmes (adapted from Chiaroni et al., 2011).

Open innovation	Outside-in dimension			Inside-out dimension		
	Unfreezing	Moving	Institutio-nalising	Unfreezing	Moving	Institutio-nalising
Networks	Informal contact with industrial partners and higher education institutions	Robm@rket: first R&D collaborative project with industry and academy	Regular collective candidacy for R&D calls for projects	Informal exploitation actions when opportunity arises	STAMINA partnership	Agreements with ≈ 30 regular partners to support BA Systèmes's growth
Organiza-tional structures	President's decision to open the company to a more extended environment	Implemen-tation of a technological gatekeeper function	Creation of an innovation cell under the technological gatekeeper's supervision	Informal sharing and transfer of knowledge by the technological gatekeeper	An innovation projects promoter to maximize the results of STAMINA project and to extend outward activities	Establish-ment of a business development unit to promote company know-how and technologies
Metrics of evaluation of processes	---	Identification of 7 criteria	7 criteria followed-up	---	≈ 10 criteria trialed in STAMINA	In progress
Knowledge management systems	Sharing information with partners through electronic platform	Knowledge transfer from gatekeeper to R&D staff, filing of the first patent	Industrial property management system	First outward actions by the technological gatekeeper	STAMINA "Plan for disseminating and use of foreground"	In progress

Network evolution

In order to transform their closed boundaries into a semi-permeable membrane (Lee et al., 2010; Chiaroni et al., 2011), BA Systèmes started to make and to reinforce contact with suppliers, acquiring a limited number of technologies (guidance systems). To create links with higher education institutions and research laboratories, the technological gatekeeper proposed educational or research projects to them. The SME could then acquire specific knowledge (mechatronics, robotics). When mutual knowledge and confidence was high enough, and when shared interests are clearly identified, the first collaborative R&D project, Robm@rket, was launched. The experience acquired with Robm@rket allowed BA Systèmes to respond to more than 10 other calls for projects. The number of patents filed, the technological components developed, and the promising prototypes provided many possibilities for technological exploitation. These were initially only taken advantage of when opportunities occurred. For example, the SME created value by entering into supplier-customer relations with a large firm. It has built a plant dedicated to manufacture healthcare robots for a major multinational company in this industry. The fact that valorization activities are compulsory in R&D projects funded by European FP7 was probably a crucial impetus in taking up outbound innovation. Today BA Systèmes has agreements and regular exchanges with more than 30 partners in industry, R&D laboratories, higher education institutions, clusters and public bodies.

Organizational structures

The President’s decision to open BA Systèmes more widely to its environment entailed significant organizational changes. The creation of the technological gatekeeper function had a pivotal effect in leveraging the network because identifying relevant partners is a major difficulty for SMEs (Frishammar et al., 2012). The establishment of an independent innovation cell, on top of the R&D department, for managing innovation projects, was a strong signal that the status quo had been unfrozen, but without interfering with existing processes and routines (Chiaroni et al., 2011). In fact, the core activities in new AGV development was still performed internally. This allowed the company to concentrate on a limited number of technologies (mechatronics, supervision) and to retain a high level of internal competencies. This expertise facilitated its absorptive capacity and made it attractive for partners (Cohen and Levinthal, 1990; Lee et al., 2010; Frishammar et al., 2012)

Once the inbound innovation processes had been successfully implemented, the SME could not ignore the benefits of reinforcing initial outbound activities. Commercialization is the logical continuation of invention, and while SMEs are good at invention, they often lack adequate resources for commercialization (Lee et al., 2010; Frishammar et al., 2012). Recruiting a manager to promote innovation project results for external technology exploitation was an explicit way to find new profitable applications and to gain additional revenue through new commercial channels, sometimes far from their core business (Lichenthaler, 2011), such as functional rehabilitation or contemporary art. External technology exploitation is however more complex than the commercialization of goods or services because technology markets do not directly match product markets and because transaction costs are higher. Outbound innovation involves a higher level of managerial challenge (Lichtenthaler, 2009; Frishammar et al., 2012; Parida et al., 2012). So it is surprising, at first glance (but only at first glance, cf. section 4.2), to see that the manager in charge of promoting the results of innovation projects is a junior executive.

Open innovation processes and evaluation criteria

The process by which innovation projects are evaluated are key levers to implementing open innovation and require specific metrics (Chiaroni et al., 2011). The steps taken to introduce inbound open innovation in BA Systèmes were similar to the four identified by Parida et al. (2012): 1) technology scouting in order to detect easy-to-start opportunities which will have a positive effect on innovation performance, 2) horizontal collaboration with partners outside the value chain for incremental innovation, 3) vertical collaboration with strong customers in the value chain, or with end users or lead users, if radical innovation is targeted (here with a major healthcare company) and, 4) technology sourcing, as another route to achieving radical innovation, by acquiring licenses or other forms of technology or by tapping into higher education knowledge (e.g. guidance with camera, battery management systems) to help the company to commercialize new-to-the-world products such as the STAMINA robotic system. As the objective of the technological gatekeeper was, during the inbound open innovation phase, to implement dynamic capabilities, the criteria he chose to assess their replication through successive projects were those presented in tables 7 and 8.

Table 7. Indicators linked with inbound open innovation dynamic capacities.

Inbound dynamic capacity drawn up	Indicators
Establish alliance with academic world (sensing)	Type and frequency of contacts
Management of fuzzy front end projects (seizing)	Number of collaborative projects submitted and launched
Promote innovations in the market (transforming)	Turnover, number of patents, new competencies acquired

Table 8. Evolution of the indicators on the period 2003-2015.

Indicators	Period 2003-2006	Period 2007-2011	Period 2012-2014
Patents filed	0	7	5
Collaborative projects submitted to financing programs	0	12	15
Collaborative projects funded	0	5	7
Markets addressed	Manufacturing industry	+ medical, building	+ services, art
Frequent links (>3 per year) with laboratories	2	12	10
Frequent links (>3 per year) with facilitators	5	17	15
Educational projects submitted	2	5	4
Full time jobs generated by innovation activities	0	20	25
Sales revenues in the period (M€) (from innovation)	30.8 (0)	37 (1.2)	52(?)

During the formalization of the outbound open innovation phase, the activities implemented or reinforced were once more quite similar to those described in the literature[1], in particular the Lichenthaler's six-step approach (2011): 1) formulate and communicate a licensing strategy through a new strategic plan in 2012, 2) ensure executive champion support (the director of innovation, a highly experienced executive) to guarantee active out-licensing and to overcome cultural barriers to technology transfer, 3) assign dedicated employees as coordinators and central contacts for all issues related to licensing and to ensure that the licensing program is executed in a systematic way (the recruitment of an executive to promote innovation project results), 4) identify projects with profitable applications and markets for their technologies (e.g. STAMINA), 5) establish a project organization for each out-licensing deal (specific management process adapted from core business) and 6) transform the corporate culture so that every employee embraces out-licensing (in progress with newsletters, general meetings).

To measure the performance of the exploitation and dissemination activity in the STAMINA project, indicators (table 8) were used from the beginning as they could have a relevant

[1] The differences and advances will be presented in section 4.2.

impact on the potential resulting benefits (Chiaroni et al., 2011). The project is, however, not as yet advanced enough to quantify the progress as outlined in table 9.

Table 9. Indicators to measure the performance of the dissemination / exploitation of STAMINA activity.

Results to measure	Indicators
Turnover generated	Number of business projects (contracts, projects, offers) and their value
Knowledge produced	Number of patents and scientific publications
Promotion, communication	Number of: press articles published, meetings attended, industrial shows and visitors, visits on the website

As can be seen, and contrary to Chesbrough and Crowther's opinion (2006), BA Systèmes has created specific processes and metrics to assess its progress in open innovation.

New skills in knowledge management

Technology scouting and partner searching are cornerstones for inbound open innovation, especially for SMEs. Due to limited resources, it is not easy for them to identify many potential ideas or partners and it is also difficult to manage and to prioritize them (Parida et al., 2012). An intermediary may aid the SME in creating a collaboration network (Lee et al., 2010). At BA Systèmes this intermediary was an internal resource. For five years, the innovation director spent 60 % of his time on exploitation activities (his former job) and 40 % on exploration activities, that is to say in implementing the function of technological gatekeeper while doing his PhD. Apart from scouting, his main activities, as technological gatekeeper, were to translate knowledge accessed from outside and to link partners that were not previously in contact. Translation here is to be understood as the four "moments" of translation in the Actor Network Theory (Callon, 1986): problematization, interessement of possible partners, enrolment of new resources and mobilization of spokespeople to increase the projects' chances of success. The technological gatekeeper has developed and assimilated competencies in areas related to these partners (e.g. management, healthcare, arts) in order to co-develop new ideas that originate both from internal and external complementary sources (Dahlander and Gann, 2010). So the technological gatekeeper is a major change agent (Rogers, 1995) at the heart of the networks. His empathy skills are important to building and to managing them.

Once BA Systèmes had improved competencies such as managing internal R&D knowledge, industrial protection, and licensing, it became easier to identify technology sales opportunities

(Van de Vrande et al., 2009; Dahlander et Gann, 2010; Chiaroni et al., 2011; Frishammar et al., 2012) and then to develop new skills to generate new knowledge. For example, BA Systèmes organized a cross-industry exploratory partnership (Gillier et al., 2010) with some of its partners in order to find other applications and markets for STAMINA as well as design business models for the promising applications (O'Connor and Rice, 2013). By establishing a specific process for identifying exploitation opportunities, the company is trying to reduce the risks and transaction costs associated with the technology markets (Frishammar et al., 2012).

4.2. An innovation projects promoter to value the outcomes of collaborative innovation projects

BA Systèmes exhibits two very unusual characteristics for an SME: a full time innovation projects promoter to value the outcomes of collaborative projects and a portfolio of exploitation activities, some of which are not identified in the literature. The innovation projects promoter's first degree was in foreign languages applied to business. After doing a Master in innovation management and entrepreneurship, he acquired, among others, competencies in business, marketing of innovative products and services and industrial protection. He first arrived at BA Systèmes for a six-month internship. His mission was to develop exploitation tools to promote the results of the STAMINA project. Without any technological experience in robotics, he could be considered, at that time, as a paraprofessional aide (Rogers, 1995) that is to say that he had a lower technical expertise than the company engineers, but probably a greater social expertise. His youth, his lack of technical competency and his position as an intern were probably favorable factors for the introduction of exploitation activities dealing with marketing and sales to an engineering and technology-centered company. As he was not involved in internal power games, and thanks to his fresh view, he could unfreeze the situation to turn it to more market-orientation. He needed, however, the support of an executive champion (Rogers, 1995), the director of innovation / technological gatekeeper, to overcome the possible reluctance of other employees to implementing outward activities because of a fear of transferring the "corporate crown jewels" (Kline, 2003 *in* Lichenthaler, 2011).

The outbound open innovation outcomes most often quoted in the literature are patents and licenses. Not all the results of innovation projects however are sold or licensed out, some of them are non-pecuniary. Revealing (non-pecuniary) refers to how firms reveal internal resources to the external environment without immediate financial reward, seeking mainly indirect benefits (Dahlander and Gann, 2010). Obviously revealing and selling are not exclusive. The case of BA Systèmes shows (table 10) the continuum between them. Three kinds of exploitation can be distinguished: promotion, knowledge dissemination and sales initiatives.

Table 10. Valuing the results of innovation projects at BASystèmes.

	Kind of action	Objectives	Examples
Non-pecuniary (Revealing)	Promotion	• Increase company profile • Promote the projects • Provide legitimacy and recognition to the company • Prospect customers • Attract talented partners	• Brochures and posters • Project presentation leaflets • Video reportage • Press releases • Newsletter, website • Reference to awards and prestigious customers • Trade fairs
↓	Knowledge dissemi-nation	• Value and capitalize experience of the company • Create and reinforce links and partnerships with academy • Train future colleagues • Attract young talent • Reinforce company's renown • Develop trading relationships • Increase company profile	*In higher education institutes :* • Give lectures • Entrust a study or an innovation project to students • Host interns in company • Explore new applications and new markets for future products • Co-publish scientific articles *To general public :* • Conferences • Thematic on-site visits
Pecuniary (Selling)	Sales initiatives	• Ensure monopoly in a technology • Protect industrial property • Generate revenue • Improve competitiveness • Extent range of products • Extent range of markets on an international base	• Practice patenting and licensing • Implement technological components in own products • Sell technological components to partners • Sell prototypes • Market semi-finished products • Sell new products • Business proposals following innovation projects

Table 10 shows that outbound open innovation activities may be much wider than those generally reported in the literature. Promotion, for example, is considered to be fully an exploitation activity. Some activities as entrust innovation projects to students or co-publish scientific articles are really uncommon in SMEs.

4.3. Towards coupled open innovation

The technological gatekeeper and the innovation projects promoter share common managerial skills in project and innovation management and social skills such as empathy with partners. It facilitates their mutual comprehension. Their differences and complementarities also facilitate coupling the core processes of inbound and outbound open innovation (table 11). Due to their close daily interaction and exchanges, the two functions are brought closer until they are linked: for example a workshop on the applications for the STAMINA robotic system enables a strengthening of links with the academic network and also aids the exploitation of the project results.

Table 11. Complementarity between the technological gatekeeper and the innovation projects promoter at BA Systèmes.

Main function in open innovation	Technological gatekeeper	Innovation projects promoter
Main core process responsibility	Inbound open innovation Outbound open innovation	Outbound open innovation
Educational background	Industrial engineer (electronics, automation) Master in strategy (MBA)	Foreign languages, business, marketing
Position	Senior executive	Junior executive
Experience	Experienced project leader Customer services, creation and development	Associative and humanitarian experience
Profile	Executive champion with experience and legitimacy	Paraprofessional
Work background	Networks, external contacts	Fresh eyes
Change capacity	Power to promote change and to drive innovation	Relative freedom because outside power games

One can consider that coupled processes are operating when inbound and outbound activities make a closed loop. During a trade fair to promote the STAMINA project (raise public awareness), business talks occur with visitors that lead to joining in an emerging phase of a new collaborative R&D project, as well as selling mobile robots for other applications.

The implementation of coupled open innovation seems to be very similar to the out-licensing approach proposed by Lichenthaler (2011) who considers firms that are successful in out-licensing combine three approaches (structural organization, project organization and participatory organization). At BA Systèmes the structural organization is based on an innovation cell with dedicated professionals with complementary skills (table 11), who work full time on innovation projects. The project organization is focused on collaborative projects with innovative design methods (Le Masson et al., 2010) in cross-industry exploratory partnerships (Gillier et al., 2010). The participatory organization ensures the participation of both employees (especially R&D and marketing staff) and external partners (industrial and academic ones). So opportunities for innovation arise by recombining ideas from the firm's core expertise with ideas from outside (Frishammar et al., 2012).

The establishment of such a process requires freedom and a real time investment. In addition, it demands the confidence of the president of the company. The budget freedom comes from the sales of specific and/or innovative robots and grants on research projects. Time is needed to decide on action and structure and to convince of the feasibility of the projects both internally and externally, something which is legitimatised through the success of past action.

Conclusion

While a great amount of literature is now available on open innovation, most of it has focused on large an/or high-tech companies, on inbound open innovation and on the relationships between openness and performance. Understanding how SMEs face this challenge is, as yet, underexplored in the literature. The aim of this paper is to scrutinize, through an eight-year longitudinal case study on a French robotics SME, strategies for implementing open innovation. The depiction of its journey from closed innovation to coupled open innovation gives evidence that SMEs are also able to pursue an active and successful open innovation strategy. The research has three main results. Firstly, it brings to light the revitalisation of the SME's processes, organizational structures and skills under open innovation. Secondly, it highlights a rare and surprising outbound strategy: the SME has recruited an innovation projects promoter devoted solely to valuing collaborative innovation projects. The exploitation activities he has introduced are wider than those generally mentioned in the literature. Thirdly, the paper shows how inbound and outbound open innovation processes were coupled thanks to the complementary skills of the SME's technological gatekeeper and its innovation projects promoter.

A limit of this study is that it concerns a single company. While it has been able to cleverly overcome its limits in terms of resources and the liabilities of size, thanks to open innovation, further research is needed in other SMEs before generalizing on the benefits of open innovation in SMEs. Where knowledge is distributed among numerous, heterogeneous partners, it would also be beneficial to study in greater detail the role of individuals such as the technological gatekeeper and the innovation projects promoter, who are at the junction of the company and the external environment, in developing the absorptive capacity of the company.

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