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Progressive University Technology Transfer of Innovation Capabilities to SMEs: an Active and Modular Educational Partnership

Mauricio Camargo¹, Laure Morel, and Pascal Lhoste²

Abstract Regarding SMEs' relationship with R&D and technology, University Technology Transfer (UTT) programs have evolved in recent years toward approaches that are more focused on a systemic and continuous exchange between firms, university departments and R&D centers. Financial support such as innovation vouchers and open initiatives have been applied for a few years, and only recently have research works analyzed the impacts of these programs on the innovative capabilities of SMEs. Existing studies are based on short-term analysis, but there are no studies on the medium- or long-term influence of innovation vouchers on firms' innovation capabilities. This chapter aims to contribute to this topic through a longitudinal exploratory study of two SMEs in eastern France. It puts forward an original modular program proposed by an engineering school at the University of Lorraine, where groups of students participate throughout the academic year in innovation-related projects. Empirical evidence shows that this type of project has positive impacts on firms' innovative capabilities, but also fosters the analytical skills and self-directed learning capabilities of students.

Keywords: UTT, SMEs, innovation capabilities, open innovation, innovation vouchers, problem-based learning.

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¹ Corresponding author: Université de Lorraine, ERPI-ENSGSI, 8 rue Bastien Lepage, 54000, Nancy, France.

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1. Introduction

For several years now, academia and policymakers have been convinced of the need to get political, economic and academic actors to work together to foster the development of territories by boosting the skills and performances of SMEs (McAdam et al. 2012). For many universities and schools, this third mission in addition to their classical missions of training and research, which makes them an actor of economic development, is often considered as unnatural.

In particular, in order to support the implementation of innovation processes within SMEs, most universities rely on Technology Transfer Offices (TTOs) to disseminate their research results toward these companies. In our view, this close, almost inseparable link between Research and Innovation has not yet been fully understood by politicians, scientists and the media, and thus represents one of the obstacles to the effective development of innovation in small companies in traditional sectors. Most SMEs (at least in France) that seek to innovate - and not only from a technology point of view - are discouraged when they learn that research is the answer. Indeed, while research can lead to innovation, it is often an uncertain, time-consuming and expensive process. And these companies need to develop their presence in their markets very rapidly and, if possible, at low cost. Furthermore, the innovation process is usually much more structured (in terms of processes and resources) than that of SMEs.

The challenge for public policies is then to provide a simple but effective ecosystem offering SMEs access to innovation pathways. Some of these companies do not have sufficient financial resources to develop their own R&D function or are not ready for the scale and nature of the risks involved. In order to overcome these difficulties, partnerships with universities are an alternative route toward innovation for these firms. However, the real challenge is not to develop one-shot partnerships, but a genuine, long-term and trusting relationship that allows firms to enhance their capabilities and build toward an adapted

process of innovation (Peerbaye & Mangematin, 2005). Although there is a vast conceptual literature on this topic, most SMEs in traditional sectors are still looking for satisfactory answers to this issue.

Through a longitudinal case analysis, this chapter seeks to provide empirical evidence of the mechanisms supporting technology appropriation by SMEs, but also to compare these cases with the conceptual models proposed in the literature.

Our cases have been collected and analyzed over a period of 10 years within the framework of an innovation engineering school founded in 1993 in France (ENSGSI: Ecole Nationale Supérieure en Génie des Systèmes et de l'Innovation/ National School for Systems and Innovation Engineering) (Castagne 1987). Within this school, special pedagogical tools have been developed and deployed with firms at the regional level, resulting in a modular process to support local SMEs' innovation capabilities (Boly, Morel, Assielou & Camargo, 2014). Some of these tools combining training and industrial partnerships are financially supported by the Regional Council as part of its policy of economic development for SMEs under the innovation voucher scheme. The program under the coordination of the University has been integrated in a modular process to accelerate innovation capabilities and technological appropriation named ATI-Activ'PME. The program itself, is composed by a set of tools, called "**48hrs to bring ideas to life**[®]" (48h pour faire vivre des idées[®]) and "**Transfer and Innovation Workshop**[®]" (ATI: Atelier de Transfert et d'Innovation[®]), but also supported by technological platforms. These constitutive elements will be further detailed in this chapter and their concrete application explored in terms of the transfer of innovation capabilities at micro level.

As a conclusion, this study will demonstrate through empirical evidence and case studies that it is possible for universities and schools to support the appropriation of innovation capabilities by SMEs through dedicated pedagogical means. It will also show that it is possible and virtuous for universities and schools to make a contribution to the regional economic development of SMEs in tandem with their educational and research missions.

2. Overview of University Technology Transfer-linked concepts: Innovation Vouchers and Action Research

The broad development and popularity of University Technology Transfer (UTT) and Open Innovation theories (Chesbrough 2006) has provided a potentially fertile ground for integrating SMEs from traditional sectors into the university-research ecosystem. However, in our view, as well as high motivation and managerial engagement, these firms have to achieve a minimum level of technological innovation and have sufficient organizational capabilities to become effective receptors of competencies and technologies and to transform them into new products and services. As a consequence, continuous interactions with universities are needed to support this learning process, following a constructivist approach (Boly, Morel, Renaud & Guidat, 2000). In this sense, as proven by the research of (Wynarczyk 2013) on a sample of SMEs in the UK, Open Innovation practices, and in particular external collaborations with universities, have a strong influence on the firm's competitiveness.

Among the different modes of university technology transfer (Fig. 1) (Carayannis & Campbell, 2012; Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994), policymakers are searching for more open and co-creational ways to lead the UTT process more efficiently.

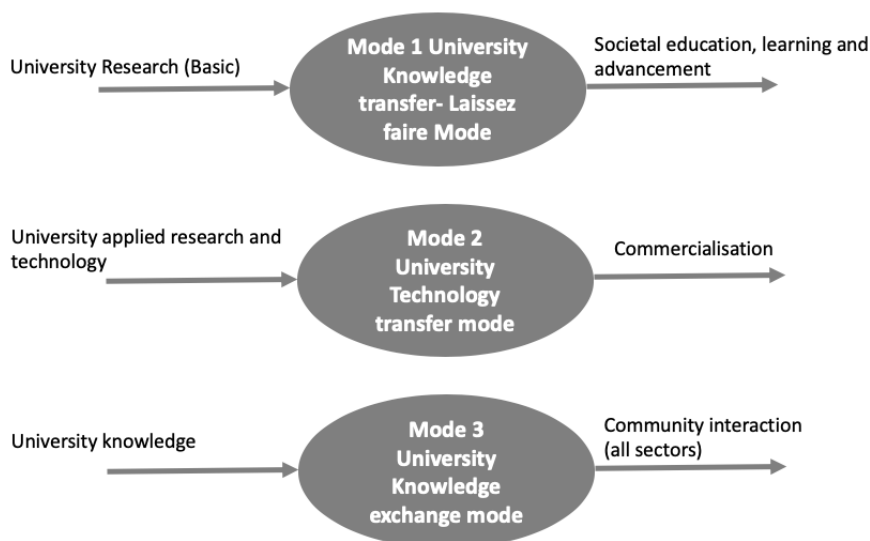


Fig. 1. Knowledge production modes and university knowledge transfer, Source: (Gibbons et al., 1994)

In figure 1, technology transfer “Mode 3” (Carayannis & Campbell, 2009) proposes a “systemic approach to this transfer for the 21st century” alongside the traditional technology transfer office. Through a dynamic knowledge exchange further to continuous joint activities such as training, small-scale development projects and long-term collaboration, this approach offers a better and more natural mechanism of transfer between universities and firms (Miller, McAdam, and McAdam 2018). Moreover, as pointed out by (Bjerregaard 2010), a long-term collaboration approach may be relevant not only as an opportunity for technological knowledge production, but also for learning within the organization. Furthermore, there is still a need for practical evidences proving that local enterprise partnerships can benefit from a faster learning curve (McAdam et al. 2012).

In recent decades, governments have attempted to support this type of technology transfer initiative (Sala, Landoni, and Verganti 2016). An example of this type of policy is the Innovation Vouchers, which are defined as small lines of credit/grants (up to 10,000 euros) provided by governments to enterprises (SMEs) to purchase services from public knowledge providers with a view to introducing innovation (new products, processes or services) into their business operations (Cornet, Vroomen, and Van der Steeg 2006). They are traditionally used to solve minor technological problems or scope out larger technological issues. This scheme has been widely used for more than 20 years in Europe and elsewhere because of its simplicity. In Europe alone, by 2009 more than 25 such programs were reported at regional level. By 2018, it is estimated that more than fifty voucher schemes operate at all levels of territorial governance.³

In further research, Bakhshi, Edwards, Roper, Scully, Shaw, Morley & Rathbone (2015) found that 75.8% of firms receiving an innovation voucher were more likely to engage in future innovations. More recent research on the effects of innovation vouchers on SMEs (Chapman and Hewitt-Dundas 2018) found evidence on the effects of vouchers on the attitudes of senior managers to innovation, within the framework of a program carried out

³ <http://www.eurada.org/eurada-news-2019-02-europes-innovation-voucher-schemes/>

over the period between 2012 and 2015 in the UK. Specifically, their findings show that these vouchers induce positive changes in managers' support for innovation, increasing their risk tolerance and openness to external knowledge. These results suggest that the innovation voucher is a particularly effective mechanism to change attitudes to external knowledge. These recent studies, covering more than 2500 firms, have provided significant evidence of the relevance of this type of support tool for long-term learning by SMEs, innovation openness and risk-seeking attitudes. However, in these studies, the answers collected remain declarative based on individual experience, and the studies offer a short-term analysis. In conclusion, there are no studies on the medium- to long-term influence of innovation vouchers on firms' innovation capabilities.

In this chapter, we intend to show how this type of Open Innovation-based tool can redefine Government/enterprise/university relationships by developing new ways to finance innovation. In a period of budget reduction, universities and regional authorities need to develop new tools to provide innovation support services to companies, especially SMEs, in a win-win relationship.

The following section will describe how an innovation voucher-type program was designed at the University of Lorraine. Within an action research (AR) approach (Avison, Baskerville, and Myers 2001; Kaplan 1998), two firms using the voucher program were then monitored over a period of 10 years. This qualitative research approach, with the emphasis on collaboration between the research team and practitioners, implies the direct involvement of researchers in the project. This approach was selected for this research because it provides a twofold contribution: solving practical issues and contributing to a scientific field. It has been widely used in social sciences, but also in management and entrepreneurship (Schultz, Mietzner, Hartmann, 2016).

A further original contribution of the present work is that it focuses on the application of AR in industrial engineering for a period of about 20 years, within the ENSGSI educational program. More precisely, our discussion, centered on two SMEs from different industrial sectors that used the program over a period of 10 years, will illustrate the observed implications of our work and the evolution of the university-firm relationship.

3. ATI-Activ’PME: A Modular Process to Accelerate Innovation Capabilities and Technological Appropriation

The approach used was conceived as a modular program whose constitutive modules aim to fit with firms’ current technological needs and enhance their innovation capabilities over the long term. As shown in (Fig. 2), it starts with a formalization of the firm’s need, followed by ideation (48hrs to bring ideas to life), and then the ATI projects themselves, supported by the university’s research facilities and available platforms. This implies that the modules are deployed in line with each project’s dynamics. While past experience has shown that not all companies go through the entire process, participation in the program represents a unique opportunity for them to form ties with the regional research and innovation system.

Since the first deployment in 2004, the program has been extended to the entire University of Lorraine and more than 70 SMEs have taken part. Today the program is supported by the regional authorities and the European Union through the European Regional Development Fund (ERDF), under the name *ATI-Activ’PME*. For the current cohort through to 2020, 18 SMEs are participating in the program.

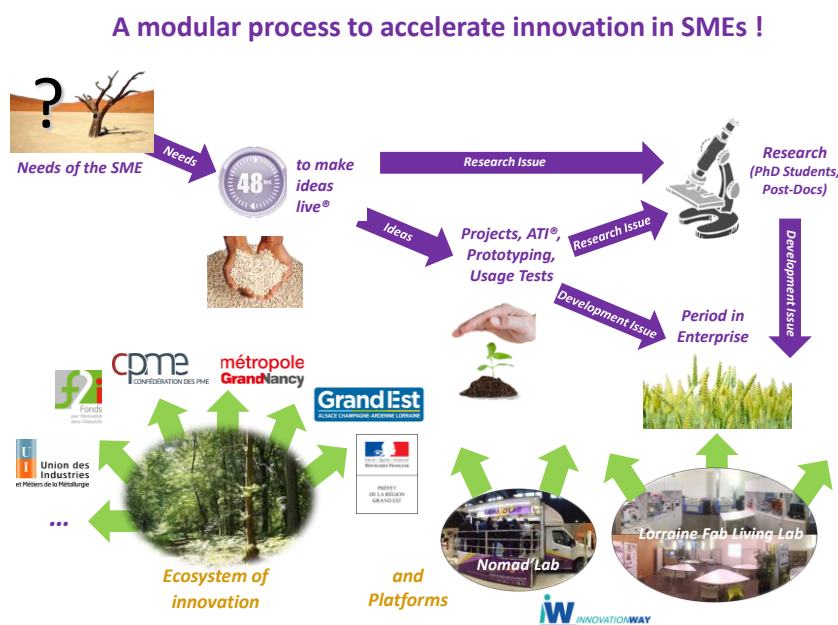


Fig. 2. Modular process to support the development of the innovation capabilities of SMEs

First, a dedicated team of professionals and related people from the relevant schools seek to *identify the SMEs' needs*. Then, if needed and depending on the problem to be addressed, a creative workshop of *48hrs to bring ideas to life*[®] may be deployed to meet a specific requirement, or as a part of the launch stage within a *TIW-ATT*[®] project. As a result of this one-year period of interactions, certain particular issues may be transferred to the university's local network of 80 *research laboratories*. Otherwise, depending on the degree of maturity degree of the project, a link will be established with *technology platforms and/or the business support ecosystem*.

As mentioned in section 1, the pedagogical model at ENSGSI is organized around the student-subject-project triangle (Kleine et al. 2018). Supporting problem-based learning is the preferred approach, as it aims to foster the analytical skills and self-directed learning capabilities of students (Bary and Rees 2006). It requires students to work on problems proposed by companies in the region during their studies, which implies a commitment from the company, permanent dialogue and even the participation of company employees as guest lecturers during regular projects (Dupont, Morel, and Lhoste 2015; Morel and Guidat 2005). The main dedicated tools comprising the modular program are detailed below.

3.1 48 hours to bring ideas to life^{®4}

Nurturing creative competencies allows firms and organizations to explore promising fields to be developed, to ignite the emergence of new concepts and designs or to propose solutions to specific unsolved problems (Gabriel et al. 2017). Consequently, for a number of organizations, improving these competencies has become a priority, and methodologies and tools to support creativity have gained in popularity among industrialists, as well as in the academic world.

⁴ <http://www.48h-innovation-maker.com/ensgsi/>

Within the CSP (Creative Solving Problems) paradigm (Osborn 2013), *48 hours to bring ideas to life*[®] is a training workshop module developed by the ENSGSI in the form of a creativity contest to generate original ideas, and focused on the early stages of the innovation process. It was created in 2001 (Boly and Grandgeorges 2001). Since then once a year, this challenge brings together participants from different disciplines, universities and countries at a simultaneous and distributed event. In 2019 more than 1700 students from six countries participated (8 centers in France and 5 international universities). Topics for the workshop are proposed by partner companies (e.g., in 2019, 14 topics proposed by 14 enterprises), so people from these companies play an active role during the preparation, implementation and outcomes analysis of the workshop.

The aims of the workshop are twofold. First, it allows participant students to develop entrepreneurial capabilities by giving them a better understanding of the main skills and behaviors used by innovators at the early stages of projects. Second, it provides firms with a real outcome, enabling them to explore potential new innovative projects. At the end of the process, each participant firm receives a detailed report containing a set of idea grids (including detailed information on each idea) and an adapted methodology to evaluate these ideas, as described in (Gabriel et al. 2016).

Fig. 3 describes the systematic methodology used during the two-day workshop and its principal steps and associated activities. The workshop is composed of two main processes, divergent and convergent thinking (Bary 2005). During the divergent phase, creativity techniques are applied to ignite the creative process and generate an original set of potential solutions to the proposed problem. Then, during the convergent phase, analytical techniques to challenge and select promising solutions are used by participants. These processes should be as balanced as possible, as each problem is different (context, definition, participants' skills), and this balance will depend on the degree of definition of the problem, but it is important to ensure that participants identify novel solutions (Leonard and Swap 1999).

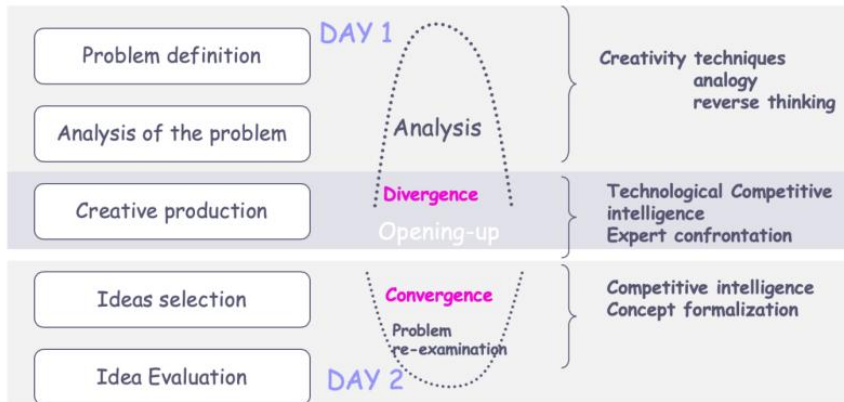


Fig. 3. 48 hours to bring ideas to life[®] - methodology description

The workshop ends with a presentation before a jury by the different participants of the selected ideas. The set of ideas considered as having potential to become new products or services may be developed by the company or further developed by another group of students within the framework of a TIW (Transfer and Innovation Workshop).

3.2 Transfer and Innovation Workshops[®] (TIW - ATI)

The Transfer and Innovation Workshops[®] or “ATI[®]” (for: Ateliers de Transfert et d’Innovation[®]) is a program created in 2004 at the ENSGSI and adopted by the University in 2007. Originating from a collaborative process among Engineering, Business, Architecture and Design schools, this program functions as an “innovation vouchers” scheme. It affords SMEs from the Lorraine region⁵ access to the university and its research infrastructure and competencies to launch innovative projects, while allowing undergraduate students to learn through real projects in an industrial environment (Morel,

⁵ <https://www.univ-lorraine.fr/content/atelier-de-transfert-et-dinnovation>

Camargo, and Lhoste 2019). The financing principle is simple: it is a co-financing procedure, that is, an SME is awarded a grant of up to 6000 euros per project by the Regional Council and co-finances this project to a minimum amount of 1000 euros. It allows even start-ups to be part of the program. The main expected outcome is to boost the efficiency of exchanges between Research/Training/Companies/Territories, in order to:

- Trigger the exploration of the early stages of new potential projects within local companies , whereby ill-defined constraints (regulatory, market or customers) and/or spinoff opportunities are not easily measurable in advance.
- Gradually integrate SMEs into the knowledge economy, facilitate and accelerate their innovation capabilities, develop their teams' knowledge in terms of steering innovative projects, and develop their collaboration and networking practices by providing them with access to a set of methodological and technological resources devoted to innovation.
- Train students using active pedagogy including concrete and innovative needs and foster a collaboration between the university and a company through a multidisciplinary project
- Verify the relevance of an innovation project (products or processes) and its technical and economic feasibility.
- Integrate teams with different skills from different backgrounds: engineering, management, design and industry.

From an operational point of view, Fig.4 shows the timeline of the TIW-ATI during the academic year.



Fig. 4. Organization of an ATI-ITW

The originality of this concept lies in its design. Three working environments were developed:

- A multidisciplinary team: each workshop has at minimum students from one engineering school and one business school, two managers (professors at the same schools) and one member of the SME (chosen by the firm's management). The team has 8 to 10 participants.
- A dedicated period: the TIW are held every Friday throughout the year and are organized into 2 semesters, with distinct but complementary objectives and methods. As a result, all the engineering and business schools concerned, and the SMEs, have to homogenize their respective schedules and to book the Friday for the workshops.
- Free access for the SMEs to a university technology platform and various kinds of resources (training, research, transfer).

3.3 Technology platforms to support the modular innovation process

Getting access to resources enabling to exchange, prototype and test the emerging products and services is also a fundamental part of the program. Here some of these resources will be described.

NOMAD'LAB: Technological support for innovation

Increasing the number of pathways to promote and develop innovation is one of the challenges successfully taken up by ENSGSI and ERPI thanks to a Mobile Fab Lab (Fig. 5) (named NOMAD'LAB), the first in France (Morel, Dupont, and Lhoste 2015). Thanks to the Lorraine Regional Council and the University of Lorraine, which made this investment possible, as well as CPME Lorraine (an employers' union, which financed the first years of operation), Lorraine was the first region in France to acquire such a tool. This embedded Fab Lab, an original concept, was born from the desire to get as close as possible to companies and citizens in order to stimulate their creation and experimentation capacity.



Fig. 5. NOMAD'LAB, a mobile innovation laboratory.

By erasing borders (geographical, temporal, economic, social, cultural), the Mobile Fab Lab reverses the usual relationship of access to technology and brings innovation to companies, cities, schools, high schools, etc. This proactive approach establishes a new proximity with users. The development of specific spaces is not always possible or relevant (too long, technical constraints, unsuitable premises, etc.). Employees of SMEs cannot necessarily travel to the heart of the Nancy urban area, so to the Fab Lab has to meet them where they are.

Lorraine Fab Living Lab®: Technological and methodological support for innovation

The priority challenge to which the Lorraine Fab Living Lab®⁶ (including NOMAD²LAB) was aiming to respond was to initiate and lead a dynamic of collective reflection on our living environment (Morel et al. 2015). The challenges of society are explored in order to provide shared responses, the development of which involves the creation or renewal of products, processes and even organizations. To successfully carry out this mission and reach economic actors as close as possible to their place of business, the Lorraine Fab Living Lab® (LF2L®) designs and develops concrete solutions using a roadmap system. The LF2L® is a research platform of the ERPI Laboratory dedicated to the prospective assessment of innovative usages. It supports creation and the achievement of results through established processes based on the usage paradigm, bringing together complementary advanced tools and methodologies in the same space.

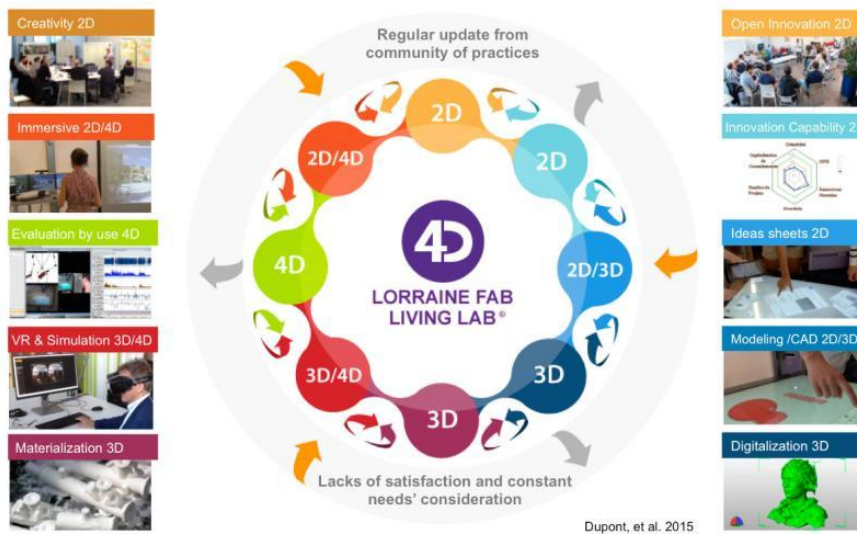


Fig. 6. The LF2L® Framework

The originality of the LF2L® is its ability to host, support and associate different communities (user citizens, entrepreneurs, researchers, students, etc.) using a common conceptual framework. This framework includes 2D (concept), 3D (object) and 4D (evolu-

⁶ <http://lf2l.fr>

tion scenarios) approaches involving different types of stakeholders in order to obtain a forward-looking assessment of a new concept, technology or project. This approach is particularly useful to support the 48h and ATI operations and, further, to accelerate the deployment of demonstrators in various fields (industrial, urban, institutional, etc.).

Innovation Way®: Methodological support for innovation

Created in January 2017, Innovation Way® SAS is a spin-off of the ERPI laboratory. For more than 20 years, the laboratory had been convinced that innovation is no coincidence. After auditing more than 300 companies, ERPI developed a set of methods to facilitate the development of innovation in companies. Among these methods, a repository of good practices associated with an algorithm can be used to evaluate the maturity of the companies' innovation management system (Camargo, Morel, and Boly 2015). Indeed, before a company takes the decision to carry out innovative projects, it must first measure its capacity to do so (Galvez et al. 2018). The evaluation of the SME's capacity to innovate is based on 6 innovation management practices (Strategy, Generation of new ideas, Design, Project management, Human resource management, Knowledge management). The self-assessment tool proposed to SMEs by Innovation Way® allows them to compute an indicator of their capacity to innovate, according to 4 key categories:

- PASSIVE: more oriented towards basic improvements than towards a real spirit of innovation,
- REACTIVE: under strong market pressure, able to react by proposing mainly incremental innovations,
- PREEACTIVE: anticipates changes in the environment and knows how to manage innovation projects,
- PROACTIVE: innovation is at the heart of business processes.

The main benefit of identifying the profile of the firm is that it enables managers to define priority actions to enhance the innovation capabilities of their firm. A benchmark report is also drawn up, making it possible for them to compare the results with those of other companies in the same sector.

Based on the recommendations made to the assessed SMEs, it is possible to offer them suitable development support, for example 48 hours, ATI, student internships, research,

etc. All the companies supported have emphasized the relevance of the approach and have seen their success rate in innovative projects improve. In constant collaboration with ERPI, Innovation Way® is currently developing two similar approaches to measure the ability of SMEs to export and drive their digital transformation.

4. Empirical Evidence on a Longitudinal Campaign: Two Case Studies

Based on our experience since the program was started, this was a first attempt to exploit long-term partnerships with two firms that initiated a collaboration with the university in innovation management through this program. They continue to participate but had enlarge their collaboration to research programs. As the primary objective of this type of voucher-based innovation scheme is to encourage knowledge transfer between the higher education sector and small and medium-sized enterprises (SMEs), our analysis is focused on the vectors of knowledge transfer and creation.

*TEA Ergo*⁷

TEA Ergo is a company specialized in the development, supply and implementation of physiological sensors for data measurement and analysis, related to physical activity, movement and eye-tracking, as well as software for processing the data from the sensors. It operates on the ergonomic workstation market.

TEA has its own set of sensors and different data processing software, including CAPTIV, designed by the National Institute of Research and Safety (INRS), the main French research center focusing on work safety. CAPTIV is itself the result of a technology transfer. TEA focuses exclusively on niche markets, selling sensors and data processing software for workplace ergonomics, neuromarketing, research, and man-machine interfaces. TEA works in a sector where technologies change continuously and rapidly: the market stimulates the company's activity and its capacity to innovate.

⁷ <http://teaergo.com/wp/?lang=en>

The company has proven expertise in R&D and technology and innovation management. This combination of skills allows the company to propose a wide range of products and to adapt to its customers' needs. TEA also experiences a high rate of technological change: an average of one new technological system every five years. Each new project requires new competences: the company hires new employees, takes students on internships or organizes partnerships. As the company is part of a dynamic market, finding the right skills quickly represents a key factor of success, as is change management.

*Noremat*⁸

Noremat is a highly innovative company that works with professional customers helping them to achieve the most profitable roadside maintenance solutions. The company offers a broad range of innovative machines, technologies and associated services. At the heart of its business is the ability to listen and provide a close local service to customers through a network of 9 regional centers in France and specialized importers abroad. Internationally, Noremat supports an exclusive network of importers.

Today, Noremat has expertise in R&D and technology and innovation management. This combination of skills allows the company to propose a wide range of products and to adapt to customers' needs. The company's competencies have allowed it to develop and commercialize an entire vehicle adapted to its mowing machines. It is the leader in the French national market it is initiating a dynamic international expansion.



Firm 1 : Ergonomic systems for measure and human interactions



Firm 2: Roadside mowing machines and Systems

⁸ <https://www.noremat.fr/en>

Fig. 7. Firms' main industrial activities*Data gathering*

As mentioned in section 2, this research has been conducted using the action research (AR) approach and is based on a longitudinal study (10 years) of two companies deploying joint ATIs. In order to formalize these experiences, student reports over the period were gathered and projects were classified according to their main goal, as follows: new product development (NPD), exploring new markets (NME) and innovation management (IM) issues. For each case, the set of already completed projects were then discussed with industrial tutors (in both cases, the CEO of the company) and, through semi structured interviews, the lessons learned were registered and validated after consensus. Table 1 shows the firms' ATI project highlights.

Table 1. Typology of projects and R&D-related activities

Firm	Sector	No of employees 2017	Number of Joint projects	Type of project			Related Postgraduate students		
				NPD	NME	IM	Master	PhD	Post- doc
Firm 1	Ergonomics instruments	16	10	5	3	2	2	2	-
	Roadside Mowing machines	280	7	3	2	1	1	1	1

Total	17	8	5	3	3	2	1
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NPD: New product Development

NME: New Market exploration

IM: Innovation Management

5. Discussion and Main Implications

This experience shows that the SMEs' primary motivation to collaborate with the university was to resolve short-term technical issues related to product development. Next come exploratory projects for new products, or even new markets. However, as the relation became more trusting over time, strategic issues emerged through discussions and managers are now more confident of tackling subjects related to the innovation capabilities and mean to long term strategy of the firm. Both experiences show that a higher level of maturity has been achieved through the firm's engagement in research projects. However, this process may take several years depending on the initial innovation capabilities of the firm, but also on the CEO's attitudes.

For Firm 1, collaboration in research started after 8 years of undergraduate student projects, through the integration of a master's student internship. As shown in Table 1, the first projects were related to the integration of new sensors into the firm's existing system, and subsequently centered on design and technical issues (5 projects). Next, there was a period in which projects were carried out related to the exploration of new markets, in particular mass-market products, supported by the core competencies of the firm. The last projects were related to the firm's strategy, such as building a technological roadmap or creating an adapted methodology to support export capabilities and the firm's strategy. During this period, research activities gradually came under discussion and master's students were also involved in projects.

As far as the projects involved joint competencies between the university and the firm, research subjects came to discussion. Seeking for resources to support these research pro-

grams was a shared decision in 2018. Since, the research department of the university and the firm have recently been awarded a research grant by the government and are creating a joint research laboratory including postdocs, PhD students and engineers.⁹ The purpose of this program, founded by the French National Research Agency (ANR), is to encourage research actors to create new structured partnerships through the creation of "Joint Laboratories" between an SME or an intermediate-sized enterprise and a research laboratory. A Joint Laboratory is characterized by the signing of a contract defining its operation, including: common governance, a roadmap for research and innovation activities, resources to operate the roadmap, and a strategy to ensure value creation from research activities.¹⁰

Regarding Firm 2, it started its participation to the program by proposing a technical issue to be treated by a group of students. In this case, due to the company size and formal degree, the students projects have been used as exploratory projects before to transfer it to the internal R&D department. Then, after 5 years of student projects, the firm has decided to finance several master's students and a postdoctoral research project. Consequently, a more ambitious project is in the preparation phase, encompassing several of the university's research departments. As in the previous case, it should be underlined that this is because the firm has grown in size. The first industrial tutor was the R&D director. Then after three years, and because the subjects were related to the firm's future strategy, the CEO became the main interlocutor of the academic team.

For both firms, undergraduate student projects remain a valuable contribution.

The discussion below aims to underline some positive externalities regarding the main stakeholders of such projects: students, firms and researchers, in order to get a better understanding of all of these phenomena.

From the point of view of the students: These projects are carried out as part of their academic program. A slot of one day per week is dedicated to their ATI project throughout

⁹ <https://n-hum-inno.eu>

¹⁰ <https://anr.fr/en/call-for-proposals-details/call/joint-laboratories-between-research-organizations-and-smes-or-intermediate-sized-enterprises-labcom-2/>

the academic year, from October to June. It allows them to familiarize themselves with the dynamics and constraints of industrial innovation projects, and to develop communication skills and technical competencies. However, perhaps the most important competencies are self-directed learning skills. Indeed, these are of prime importance in the success of innovation processes. This led the teaching staff to set up a project aimed at integrating self-directed learning into the curriculum. The system is based on an alternation between active and reflexive phases. It also provides students with continuous support, thus transforming the role of the teacher into facilitator (Bary and al., 2006).

From the Point of view of the firms: The ATI projects opened up a strategic discussion space that allows SMEs to integrate points of view and resources from outside of the firm. Because the projects are formalized through reports, conference papers or journal papers, the companies have more extensively documented results and so can consider strategic issues.

Consequently, it can be noted that innovation management and strategy have started to be considered and integrated within the firms' day-to-day routines.

We observed that in both cases the initial joint projects were managed by mid-ranking engineers, but as the number of projects and their appropriation grew, the firm's CEO became the project interlocutor. This is because the later projects have direct impacts on the firm's strategy. Also, in both cases the engagement of the industrial tutor was of capital importance in maintaining the dynamics of the project and insuring that the industrial and pedagogical goals were achieved. During the interviews with the industrialists it appears that, in their understanding of the educational role of the project, they considered that it has been part of the social responsibility mission of their firms.

From the point of view of researchers: The ATIs provide an opportunity to strike a compromise between two academic activities: research and teaching. As these projects represent an occasion to apply and validate theories, methodologies and tools, they can be of interest for both the research and the pedagogy. Moreover, when integrating mixed teams of Master's and PhD students, there is usually a synergistic effect that allows each person to be aware of and take the measure of their role as part of an important and applied issue. As a non-negligible outcome, these projects will also contribute to one of the researchers' goals, namely "publish or perish".

To finish, this type of programs is not implemented without difficulties, when asked for the main difficulties they faced through the program, both CEO's agreed that the administrative tasks and the PI discussions with the juridical department of the university were the most time-consuming activities. They consider that the complexity of the entire process could be discouraging for new entrants. Although been part of the learning process, this process should be optimized.

It is worth to say also, that since its inception the program has also evolved, and adjustments have been introduced including the financial scheme, the coordination process and dynamics of the project in order to make it more adaptable to the SMEs' needs.

Although this study is based on only two examples and as a consequence lacks statistical significance, the authors consider that this experience is worth sharing as it contributes to the body of knowledge and offers researchers a better understanding of the evolution of this type of support program. Moreover, a modular pedagogical program that could be adapted to the specific characteristics and sector of each firm has been proposed. This experience shows that the program should be articulated with the research capabilities and infrastructure of the university.

Additionally, from our experience it could be concluded that the concept of "innovation voucher" cannot be reduced to its material (purely financial) aspect but may also be considered from a non-material (methodologies and competencies) perspective which today plays a real part in the value creation process. Furthermore, this type of program allows stakeholders to learn from each other, even though success is strongly dependent on human attitudes, engagement and trust.

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Appendix

Overview of *48hrs to bring ideas to life*® since 2011

Year	Scope	Industrial subject	Number of firms	Students	Academic Partners	Ideas	Development
2011	Regional (Lorraine)	3 Sport (2), Urban furniture	5	100	10 Engineering Schools Lorraine INP	400	8 ideas developed 3 patents registered 1 inter-school collaborative projects continued
2012	Regional (Lorraine) & International	3 Boilermaking, Chemistry, Sport	3	130	13 Engineering Schools Lorraine INP + 3 international universities	400	5 ideas developed 2 patents registered 2 inter-school collaborative projects continued
2013		3	10	350	24	800	10 ideas developed,

	National <i>Special SME edition</i> 5 regional centers in France	Multimedia, Housing, Metallurgy	(business consortia involved)		Engineering Schools Management Schools		Many patents (>5) registered Many inter-school collaborative projects continued (>5)
2014	Regional National International 15 centers with 9 France + 6 international	5 Cosmetics, Agricultural machinery, Connected objects, Child-care, Cooking food	12 (business consortia involved)	1100	79	1800	Many (>15) ideas developed Many patents (>5) Many inter-school collaborative projects continued (>10)
2015	Regional National International 14 centers with 8 France + 6	7 Comfort & well-being at home, Meal and 3D printing, Rear of vehicle, Factory of the Future, Cosmetics Connected cars, Scaffolding	7	1000	60	1200	No information concerning potential patents Many inter-school collaborative projects continued (>10)

	international						
2016	Regional National International 17 centers with 10 France + 7 international	12 Sustainable building / construction; Engineering consulting in innovation, Adhesives and solvents, Organic specialized distribution, Energy networks, Aeronautics, Professional equipment, Sports, Professional training, Health, Sanitary equipment, Cosmetics	15	1500	60	1650	No information concerning potential patents Many inter-school collaborative projects continued (>10)
2017	Regional National International 12 centers 7 France + 5 international	10 New services using car data, Flying taxis, New personal services, Banker of tomorrow, Multimodal transport, Preservation of fauna and flora in desert area, Forests and cities, Cosmetics, New fertilizers & circular and durable economy, New devices	10	1200	60	1350	No information concerning potential patents Many inter-school collaborative projects continued (>10)

		for interaction between men in medical environment, Robotics & personal services					
2018	Regional National International 12 centers 8 France + 4 international	14 Satellite and agriculture, Foosball, Domestic hot water services, Library of the future, Security and palpation, Interactive objects for visually impaired, Artificial intelligence, Connected Parks and gardens, New products around wool, Territories and energy transport, Solar power stations, Medical compression, CV of tomorrow, City's water network in 2050, Living after climate disasters	14	1500	60	1800	No information concerning potential patents Many inter-school collaborative projects continued (>10) Specifically, 4 projects continued by groups of ENSGSI students during the academic year and aiming to develop concepts with high innovation potential selected by companies
2019	Regional National	14 Personal real estate space, Email of tomorrow, Design	14	1700	70	2000	Operating results in progress

	International 13 centers 8 France + 5 international	experience in a museum, Sanitary networks in the home, Boosting the QSE cul- ture in companies, Smart home, Men and trees, Street of the future, Cleaning of road shoulders, Feminization of technical and IT skills, Well-being of employees in quality control posts, New drones and new uses, Prefab- ricated concrete elements, Flows and territories in the city.					
	TOTAL	71	90	8580	436	11400	

THEMES OF ATI SINCE 2004

2004-2005: Nature in the city, Intermediate housing

2005-2006: Ecological and Economic Habitat

2006-2007: Intelligent Waste Sorting, Well-being in the bathroom, Mobile living base for construction workers, Day care structure for the elderly

2007-2008: Healthy house with modular design, School for all, Street furniture, Energy shelters, Rehabilitation of housing in a sustainable development approach, Smart POS advertising, Smart windows, Design of a product from recycled glass

2008-2009: Eco-habitat, Furniture and energy, Open Spaces, Urban lighting system and sustainable development, Innovative racing transport systems, Diversification of activities from the mechanical sector to the medical sector, SME innovation audits,

2009-2010: Positive energy gymnasium, Transformation of a hemp field into an eco-district, Eco-district in former military barracks, Communication and sustainable development, Actions to aid the development of Vosges SMEs, Collaborative time-sharing work platform for SMEs,

2010-2011: Rehabilitation of the site of the former slaughterhouses of Nancy, Promotion of the Meusian culture, Restaurant Quick in 2050

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2011-2012: Restructuring / modernization of a military base, Creation of an Ecocentre, Restaurant Quick in 2050

2012-2013: Auto repair garage of the future

2013-2014: Transformation of an old steel site into a creation workshop for artists, User services for multimodal platform, Classroom of the future

2014-2015: School of the future in rural areas, Restructuring of accommodation for the disabled, University residence of the future

2015-2016: Center for learning the languages of the future,

2016-2017: Solidarity and integration restaurant on an industrial site undergoing rehabilitation, Innovative wooden structure for events,

2017-2019: No ATI due to a new geopolitical division of regions

2019-2020: Nomadic medical device for the analysis of musculoskeletal disorders, Autonomous barges, Extension of the uses of anti-intrusion concrete blocks.

