Modeling Technology Transfer between a Technology Transfer Center and SME

Hanen Kooli-Chaabane, Mauricio Camargo, Vincent Boly, Bernard Yannou

Abstract for conference paper and presentation competition, Track 7: Technology Transfer, Marketing and Commercialization.

MODELING TECHNOLOGY TRANSFER BETWEEN A TECHNOLOGY TRANSFER CENTER AND SME

H. KOOLI-CHAABANE,

Nancy University / ERPI (Equipe de Recherche des processus Innovatifs, 8, rue Bastien Lepage 54010 Nancy Cedex, France, Hanen.Kooli@ensgsi.inpl-nancy.fr

M. CAMARGO, V. BOLY

Nancy University / ERPI (Equipe de Recherche des processus Innovatifs, 8, rue Bastien Lepage

54010 Nancy Cedex, France

Mauricio.Camargo@ensgsi.inpl-nancy.fr, Vincent.Boly@ensgsi.inpl-nancy.fr

B. YANNOU

Ecole Centrale Paris / LGI (Laboratoire Génie Industriel, Grande Voie des Vignes F92290 Châtenay-Malabry, France)

bernard.yannou@ecp.fr

Technology Transfer (TT) is well recognized as one of the most important means to enhance innovative capabilities within firms. However, transferring technology is a complex process resulting from actions taken by various actors and organizations. In addition, when transfer actions occur, very often participants do not label it as technology transfer which makes it difficult to study.

Many models describe the technology transfer process. Some models consider this process as a linear progression of steps. This process begins with idea generation and technology development at the university in order to establish a university-private firm relationship through a formal research agreement. Some models describe technology transfer as networking arrangements between two parties without relevant formal research. Others are based on the 'broadcasting analogy' where the technology to be transferred is assimilated to be a radio transmitted message.

Based on a comprehensive literature analysis of existing technology transfer models and a long-term field observation of five transfer projects, this paper proposes one conceptual model for a better understanding of the technology transfer process between a Technology Transfer Center (TTC) and Small and Medium-sized Enterprise (SME). The model describes the stages of the technology transfer project from the step one of making contact to the step five of adoption. Based on five in-depth technology transfer projects analysis, this paper highlights the dynamic of a TT project by applying the proposed model.

Keywords: technology transfer, model, technology transfer center, observation.

1. Introduction

The ability to implement an appropriate new technology is becoming a success key factor for companies (Morrissey and Almonacid 2005). Hence, knowledge transfer is a critical factor in the firm's ability to innovate. It contributes to sustain a competitive advantage even in a dynamic industry context (Zahra and George 2002; Chauvet 2003).

Various stakeholders and organizations may be involved in Technology Transfer (TT). Collaboration may be described between university and industry, between several firms within a national or international context, and between transfer agencies and industry. In fact, technology transfer occurs informally and effectively in most business, academic, governmental and other organizations. Often, participants neither label their project as technology transfer when it happens nor understand the relation between technology transfer and their own set of circumstances (TEURPIN 2001).

Within the scope of this paper, technology transfer is considered as an exchange process of ideas, objects, know-how, technical knowledge or contract of intellectual property. This exchange process occurs between an institution that holds knowledge and an industrial firm. This process is dynamic, limited in time and can involve other stakeholders such as public institutions or other industrial structures. This paper focuses particularly on technology transfer from an academic technology transfer centre (TTC) to a target group of firms. The technology transfer centre has direct access to the university's resources, but remains independent in its business dealing.

During the past ten years, research on university and government technology transfer became a major concern (Bozeman 2000; Peerbaye and Mangematin 2005). Two approaches in the literature may be distinguished. Within the first approach attention is directed toward the conceptualization and the modeling of technology transfer processes (Harmon et al. 1997; Szulanski 2000; Amesse and Cohendet 2001; Malik 2002). The second one highlights the identification of external variables influencing this process and its evaluation (Van Den Beemt 1997; Greiner and Franza 2003; Kumar and Uruthirapathy 2007). The technology transfer process models found in the literature are mostly concerned with the description of tasks and exchanges at a macro level (between companies or universities). This paper summarizes the most important models and identify theirs limits.

This paper focuses on modelling technology transfer process from a micro level perspective. The main goal of this modelling is a better understanding of technology transfer underlying phenomena so that it can be effectively managed. In this work, the attention has been directed toward a better understanding of technology transfert stages at a micro point of view in order to propose a model that avoids some limits of models identified in the literature review. To fill the gap between the proposed model and the real complexity of the technology transfer process, the present research relies on five case-studies. Each case study illustrates the technology transfer process at project level where each event or action is tracked and analyzed.

Thereafter, this paper is structured as follows. The next section is an overview of the literature dealing with technology transfer process modeling. In section 3, the research approach is explained. Then, the proposed model of technology transfer process is presented. In section 5, the research results are exposed and discussed.

2. State of the art of TT models

The numerous technology transfer models have typically focused on transfers between: firms, public research establishments and private sector and industrial organizations and government. "One first step toward incorporating difficulty in the analysis of knowledge transfer is to recognize that a transfer is not an act, but a process. A process view allows a closer examination of how difficulty evolves over the stages of the transfer" (Szulanski 2000). Among the different models describing the process of technology transfer in the literature, it would be dogmatic to accept either a linear or an interactive model as the main model of technology transfer. First of all, it is a simplistic characterization that the interaction between the provider and adopter embodies technology transfer. In fact, roles can be inverted between provider and adopter during the process of transfer. Moreover, the process may involve several other actors, such as user, customer, and sponsor. Hence, the model based on the broadcast analogy is verified at $t = t_1$ but the role of "transmitters" and "receivers" can be inverted at $t = t_1 + \Delta t$. As a consequence, the broadcast model represents an elementary approach and does not represent the dynamic and the complex nature of the TT project. Secondly, to understand such complexity it is important to examine the development and flow of knowledge and technology in projects involving multiple actors and diverse impacts (Kingsley et al. 1996). Thus, every transfer project has its own features. Linear or interactive models may be pertinent according to the stage of the process being considered.

Only a few models concentrate on transfers within the firm (Bercovitz and Feldmann 2006), and they remain rather general (Malik 2002). Finally TT is a two-way iterative process and not simply one-way linear sequence. That's why its description remains difficult. (Geisler 1993) affirms that the variety of models has generated only marginal contributions to design in the domain of TT. This is mainly because the models identify actors and activities, rather than providing intense descriptions and explanations of technology transfer phenomena.

The Table 1 presents a synthetic description of the relevant models of TT found in the literature. We notice that there is no model dealing with technology transfer centre to industry level. In addition, the most part of the TT models don't consider the dynamic nature of the TT process since the building aspects where the provider learns almost as much as the adopter is not addressed. Also, the transition between the TT stages during the time and the influence of environmental and organisational factors are not highlighted.

Table 1. Description of TT models

Reference	Level	Specificity	Limits
(Souder et al. 1990)	from federal governments to industry	Based on a literature review, the authors propose a four stages model: prospecting (information collection and concept definition among others), developing (set of design tasks), trial (testing the technical, marketing and financial characteristics of the new product), and adoption (standardization of the new technology among the partners). In this model TT is a managed process of conveying a technology from one party to its adoption by another party.	The author admit that TT implies a systematic interpersonal process of passing the control of a technology from one party to another but building aspects where the disseminator learns almost as much as the user is not addressed.
(Large and Barclay 1992)	from universities to industry	The authors introduce a marketing perspective. They consider technology transfer as a buyer-seller relationship between university and industry. While universities are sellers, companies are buyers. In this transaction, the intermediary organizations for technology transfer play a major role. They evaluate technologies to be transferred and look for potential buyers. They also arbitrate patenting negotiation.	The building aspects where the provider learns almost as much as the adopter is not addressed.
(Levin 1993)	Within an organization	A model based on organizational theory which identifies the transfer as a social, technical, learning and developmental process (TLD process). Levin presents technology as a social construction where human choices and values determine the outcome.	Human and technical are not the only factors of success of the TT process. There is other influent like environmental and organisational factors.
(Trott et al. 1995)	Within an organization	The others split the technology transfer process into a series of sub-processes: “awareness”, “association”, “assimilation” and “application”. Thus, knowledge transfer is dynamic and part of a process of continuous learning.	The building aspects where the provider learns almost as much as the adopter is not addressed
(Gilbert and Cordey-Hayes 1996)	Within an organization	The authors propose a five-step model: “acquisition”, “communication”, “application”, “assimilation” and “acceptance”. As a consequence before assimilation, individuals must accept the changes introduced during the application stage.	We may question the appropriateness of creating an independent step of communication. In fact, communication is normally present at each step of TT.
(Harmon et al. 1997)	from universities to industry	The authors describe technology transfer as networking arrangements between two parties without relevant formal search. Combining formal search and informal networking arrangements.	The configuration of technology transfer with more than two parties is not considered.

Reference	Level	Specificity	Limits
(Szulanski 2000)	Intra-organizational	The authors propose a four stages model of TT: initiation, implementation, ramp-up, and integration.	The building aspects where the disseminator learns almost as much as the user is not addressed.
(TEURPIN 2001)	Intra-organizational	Through the collective experience of the (TEURPIN 2001)[1] group, a flexible and adaptive network map model has been developed. The complexity of the relationship between the different actors of the TT process is represented through a classification integrating primary, secondary and tertiary players with the addition of a facilitator who overseeing the whole process. Under this model primary strategic decisions are taken exclusively between the technology provider and adopter. The other actors only support the decision making process. They must be aware that the final decisions and responsibility lie with the primary players. The secondary players can interact with other players within the model but their responsibility must be defined in relation to only one primary player. Tertiary players depend on the secondary players.	Focuses on the hierarchical and legal aspects of TT. The authors admit interaction between actors but the building aspects where the provider learns almost as much as the adopter is not addressed.
(Malik 2002)	Intra-organizational	A model based on an analogy between technology transfer and information broadcast where "Transmitter" refers to the technology owner which could be an R&D group sending messages about its invented technology. This broadcasting may be aimed at pre-selected "receivers", for example a business unit.	The broadcast analogy is verified at $t = t_1$ but the role of "transmitters" and "receivers" can be inverted at $t = t_1 + \Delta t$. As a consequence, the broadcast model represents an elementary approach and does not represent the dynamic and the complex nature of the TT project.

[1] The trans-regional collaboration project "TEURPIN" involved three European Member States, namely the UK, Italy and Sweden, and the Associated State of Iceland. The aim of the project was to improve trans-regional technology transfer (2001).

3. Research approach

The research presented in this paper is an investigation of the interactive nature of technology transfer at micro level by conducting five case studies that related to transferring the technology of brazing during the period 2007 to 2009. “Brazing is a process for joining solid metals in close proximity by introducing a liquid metal that melts above 450°C (840°F)”(Schwartz and Aircraft 1993).
In this study, technology transfer (TT) concerns a centre of technology transfer (CTT) and a target group of firms. The role of the technology transfer centre is to seek an appropriate solution to the company’s problem. The technology transfer team has access to the university’s resources, but is independent from a business and financial point of view. The originality of this work is the possibility of following the whole set of activities of different projects thanks to the tight collaboration with the transfer team.

Data collection

During the experimentation, data gathering includes observation, listening, conversations, questions and answers. This required both quantitative and qualitative observation methods (Boujut and Blanco 2003), (Eckert and Boujut 2003). This mixed approach imposes a long-term in situ experimentation to gather sufficient data. Long period observation is in line with our special interest about the dynamic and multidirectional dimensions and the numerous impacts of the TT process. Data was gathered from attending over than 38 work meetings and analyzing over than 145 e-mails exchanges. The clinical research goes over 3 to 24 months period for each project. Authors achieve a day-to-day observation campaign. Every stakeholders meeting, technology deployment and product result is followed-up. Hence they participate to each design meeting, read all documents and had access to every mail between stakeholders. Aspects influencing the experimental period include: delays in technical problem solving, team members not involved full-time in TT project, skills of top management and project leaders in anticipating future problems and particular events (e.g. steel supplier in stock out). Experimental work starts when the first contact is stated between the technology transfer centre team and the company who benefits from the transfer. It ends when the technology transfer project is over.

General background to TT observed projects

Table 1 gives a description of the five companies of the panel. The choice of a limited number of projects observed is made in order to promote the quality and duration of observation. Moreover, variety is favoured in terms of technical level of enterprises involved, as well as the ultimate goals of the transfer projects.

Table 1 Projects description

Enterprise	Sector of activity	Existence of leadership	Market pull	Decision-maker commitment	Technical level	No. of meetings	No. of ITO[2] observed	Observation period
A	Aerospace	Yes	Yes	Yes	(High tech SMB)	10	26	24 months
B	Agricultural tools	No	No	No	(Low tech SMB)	4	12	12 months
C	Aeronautics	Yes	Yes	Yes	(High tech SMB)	13	151	18 months
D	Mechanical	Yes	No	No	(High tech SMB)	9	11	13 months
E	Mechanical	Yes	Yes	Yes	(Low tech SMB)	2	10	3 month

4. Proposition of a model

The proposed model describes the stages of a technology transfer project between a TT centre and an SME. It has two main functions: allowing a better understanding of observed phenomena (by a descriptive and explicative role), and making action on the observed system easier and more relevantly. Indeed, modeling helps the identification of the influential variables. Also, the proposed model aims to detail discussions on how technology transfers can be planned and optimized.

This model is inspired from models of TT found in the literature review. These models agree on the existence of four stages in a TT project. In this work we add a fifth stage “Contact / confidence level”. In fact, many authors (Carr 1992; Malik 2002; Erlich and Gutterman 2003; Kumar and Uruthirapathy 2007) mention the importance of contact and confidence but without formalizing them in a stage. In the proposed model, “Project n+1” depends on “Project n” (see Figure 1) thanks to the stage “Contact / confidence level” which preserves the memory of collaboration between the two parties.

The first stage of the proposed model (“Contact / confidence level”) is the least formalised. In fact, this stage depends on the history of the collaboration between the stakeholders. The

[2] An intermediary transfer objects (ITO) is an object created to materialize an evolving knowledge. It is a result of a specific task within the project. An ITO can potentially be updated during the process of technology transfer. Example of ITO: broken product, drawing, procedure…

proper conduct of the stage “Contact / confidence level” determines the “go or no go” of the project between the two parties.

The four other stages are dominated by the importance of the technical aspect. Stage II, “Prospecting” is characterized by its focus on preliminary analyses, searching, and screening to find the suitable technology. “Developing” (Stage III) consists in physical and laboratory R&D activities: enhancing, elaborating, embodying, and tailoring the selected technology from Stage II. During the “Trial” stage (Stage IV), the developed technology is tested. The “Adoption” stage (Stage V) consists in final development and modification of the technology to fit the condition of use. In reality, the four last stages of the model are dynamic. Their scopes and durations may vary with the nature of the project. The four last stages may be carried out in parallel, and the activities within each stage may overlap. In some cases it is necessary to return to prospecting for better technology after having accepted, developed, and tested a previous one. The prospecting, developing, trial, and adoption activities may be repeated several times before the technology becomes appropriate for implementation.

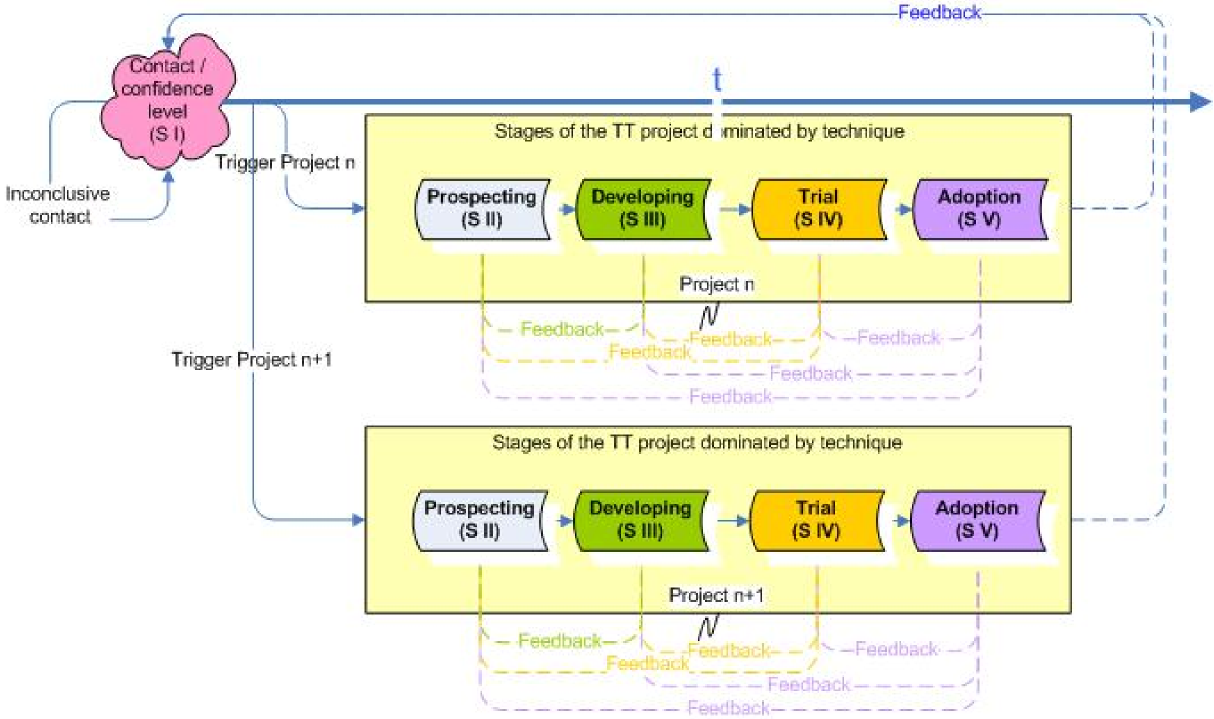

Figure 1. Model of a TT project

5. Discussion and conclusions

Case study “A”

Description

This case study is composed of 2 projects. The first one is a short term project. Its aim is the replacement of SALT-BATH DIP-BRAZING technology with FURNANCE BRAZING technology on a product line. The second one is a long term project. Its aim is to develop an innovative procedure of FURNANCE BRAZING. The 2 projects was part of a strategic plan of the company.The collaboration was an R&D directed project. The objectives of the 2 projects were fixed at the beginning. The technology transfer was an objective. The trigger event of the study was that the centre of transfer has access to an industrial furnace of brazing purchased by the university. In the 2 projects, the cost and complexity of the products was moderate. Decider maker was involved in the projects. There was a champion in the 2 projects.

Results

The Figure 2 illustrates the proposed TT model applied to the case study A. We note that the proceeding of stages for the 2 projects was different. In the short term project, the stages did not overlap. The stage "Trial" was a success but the company decided not switching to the “Adoption” stage because of a delay in the planned investment. The stage of “Prospecting” was used for the two projects. The dynamics of the exchange was globally about two contacts per month. The long term project is still on going but initial tests were a success. The stage of “Trial” was performed in parallel with the “Developing” stage.

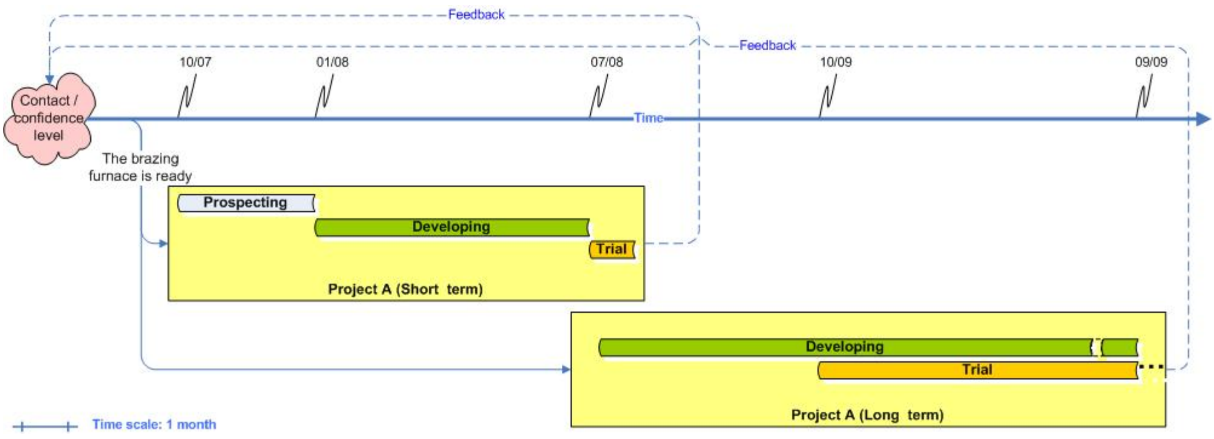

Figure 2. Model of a TT project applied to case study “A”

Case study "B"

Description

This case study is composed of one project. Its aim is the creation of a new activity based on brazing. Mastering the technology and finding a commercial opportunity were objectives of the project. The collaboration was a partnership. The objects of the projects were not related to strategic objectives. The technology transfer was an objective. The trigger event of the study was that the company is strongly competed by Asian countries on its core business and wants to diversify its activities by developing its brazing activity. The cost and complexity of the products was low. Decider maker implication was limited in the projects. There was not a champion in the projects.

Results

The Figure 3 illustrates the proposed TT model applied to the case study B. We note that the. The stage "Prospecting" and a part of the "Developing" stage began before the start of our study. The dynamics of the exchange was globally about one contact per month. The stage of "Trial" was performed in parallel with the "Developing" stage. The stage of "Adoption" has been reached but the company has not profited from the obtained results because of encountered economic difficulties. However, an actor of the company exploited the knowledge acquired to spin-off.

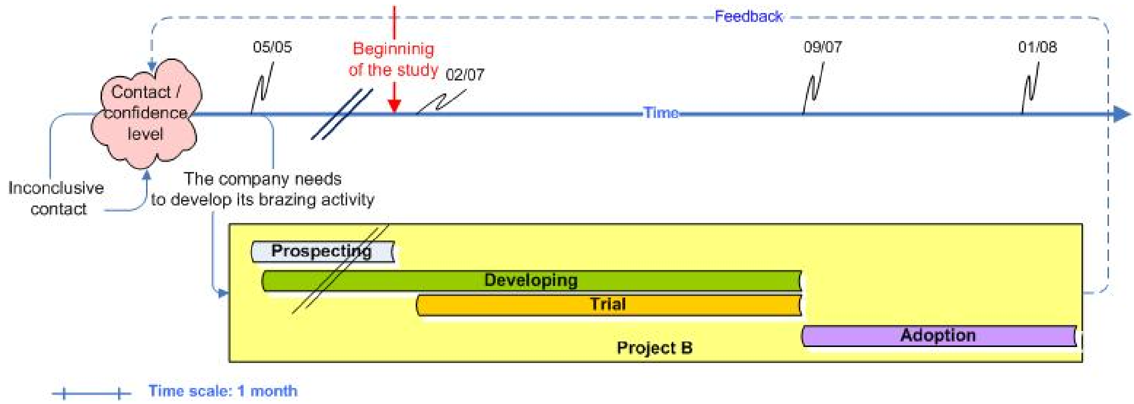

Figure 3. Model of a TT project applied to case study "B"

Case study "C"

Description

This case study is composed of one project. Its aim was assembling a multitude of pieces made using exotic materials with brazing and assistance in design. The collaboration was a partnership to realize a high value project for an important client. The technology transfer was not an objective. The transfer of knowledge occurs as a consequence of long-term collaboration between the same actors. The trigger event of the study was that the centre of transfer has access to an industrial furnace of brazing purchased by the university. The cost and complexity of the products were very high. Decider maker was involved in the project. There was a champion in the project.

Results

The Figure 4 illustrates the proposed TT model applied to the case study C. We note that the stage "Developing" was overlong because of the products complexity. Indeed, the development phase required many steps to avoid technical risks when switching to trials. .
The stage of "Trial" was performed in parallel with the "Developing" stage but not for the same piece. In fact, the stage of "Developing" was done for the next assembly (n+1) in parallel with the "Trial" stage of the previous assembly (n). The dynamics of the exchange was globally about 9 contacts per month. This project is characterized by a multitude extra project exchanges and work orders noted O_i in the Figure 4.

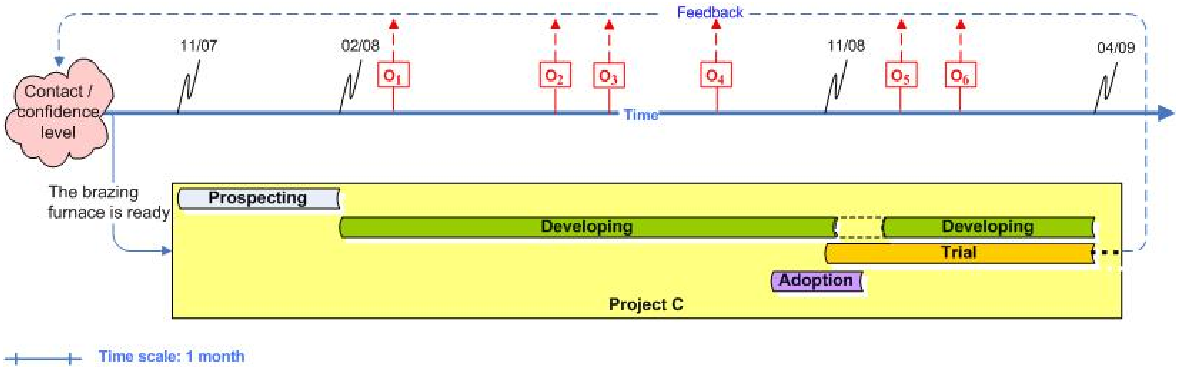

Figure 4. Model of a TT project applied to case study "C"

Case study "D"

Description

This case study is composed of one project. Its aim was the optimization of the quality of brazing process. The collaboration was discontinuous with short studies related to quality problems. The technology transfer was not an objective. The transfer of knowledge occurs as a consequence of long-term collaboration between the same actors. The trigger event of the study was that the centre of transfer presented its competence during an industry-university meeting that the chief executive officer of the enterprise attended. The cost and complexity of the products were moderate. Decider maker wasn't involved in the projects. There was a champion in the project.

Results

The Figure 5 illustrates the proposed TT model applied to the case study D. We note that the "Prospecting" stage was discontinuous. The dynamics of the exchange was globally about one contact per month in active period of the project with long period of inactivity. The company has not continued the project because it has encountered economic difficulties but the SME has made investments to improve the quality of production thanks to the expert recommendation.

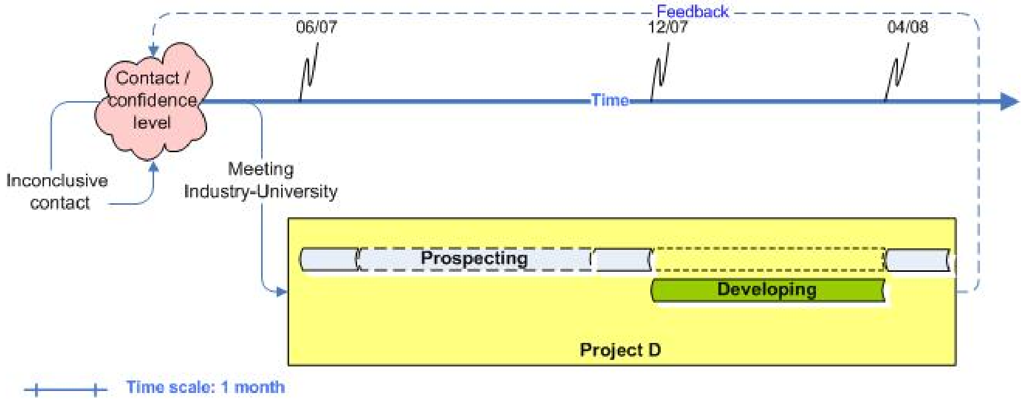

Figure 5. Model of a TT project applied to case study "D"

Case study "E"

Description

This case study is composed of 1 project. Its aim is the optimization of the quality of brazing process. The project was part of a strategic positioning of the company.The collaboration was an R&D directed project. The objective of the project was fixed at the beginning. The technology transfer was an objective. The trigger event of the study was that the company is developing an innovative product that need assembling by brazing. The cost and complexity of the products were low. Decider maker was involved in the projects. There was a champion in the project.

Results

The Figure 6 illustrates the proposed TT model applied to the case study E. We note that the "Trial" stage was performed in parallel with the "Developing" stage. Due to the simplicity of the project and the implication of the decision maker, the "Adoption" stage has been reached quickly.

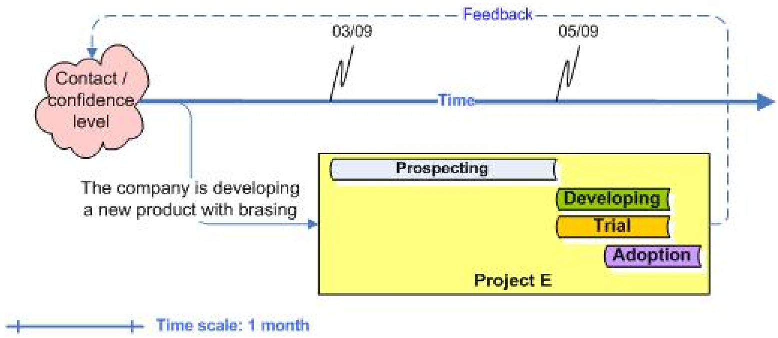

Figure 6. Model of a TT project applied to case study "E"

Lessons learned from the TT projects

Nonlinearity of the technology transfer process: TT process is a combination of operations

In the five observed case studies, we noted that the sequences and the length of the TT project stages are different. The limit between the stages of TT project is not always clear. In fact, it seems that the nature of the boundary between the different stages is fuzzy. In the projects A (long term), B and E for example, the "Trial" stage was carried out in parallel with the "Developing" stage. In the project A (long term), the "Prospecting" stage was absent since the enterprise exploited the result obtained in the "Prospecting" stage of the short term project. Hence, during technology transfer projects, the combination of stages and operations seems to be related to the complexity and cost of the products.

Influence of complexity and cost of the products

When the complexity and cost are moderate the "Development" and "Trial" stages are very close and often conducted in parallel (A, B, E). In the project C the high cost and complexity of the pieces required a more long stage of "Development" to ensure the final success. Moreover, the "Trial" stage was conducted on simplified and less voluminous pieces.

Importance of the involvement of the stakeholders

The implication of the stakeholders in the TT project seems to be crucial in the TT project. Indeed, the TT process is based primarily on human relationship. In project B, the lack of implication of the decision maker of the SME penalized the project and produced a climate of no confidence between involved actors and particularly in the SME side**.** This led to the suspension of the project after an active collaboration period and despite encouraging and tangible results.

In the project A, C and E, the active implication of decision makers induced a dynamic relationship of exchange and all the periods of static exchanges were justified (supplier out of stock, annual holiday of the SME etc.)

In project D a partial implication of the decision maker led to a cyclical dynamics of collaboration. When the decision maker devoted time to the project, intensive exchanges were made.

Technology transfer is a process of exchange that increases the competences of the different stakeholders,

In three observed projects, the TT expert and the SME actors admitted that they gained new competences thanks to the project. In the project A, the expert deepened his competence in SALT-BATH DIP-BRAZING applications and the SME enhanced its competences in metallurgy and in FURNANCE BRAZING. In the project B, the expert has deepened its understanding of wearing in the agricultural field and has improved his knowledge in organization of workshops. In project C, the expert and the partners deepened their knowledge in exotic metals. The reports of tests realized are used by the SME and the expert as standard. In project D, the relation between the TTC and the SME is characterized by long inactivity period relation. The actors have not expressed openly on the contribution of the project but due to the expert recommendation the SME has made investments to improve the quality of production. In the project E, the actors have not expressed openly on the contribution of the project but due to the expert recommendation the SME has realized the importance of surface preparation in the brazing operation and therefore the need for better operator training to this task.

Extra-projects exchanges

In the projects A, B, C and D, there was extra-projects exchanges. Theses exchanges can be informal like advices for marketing brochure, metallurgic phenomena explanation, etc.(A, B, C, D) or formal like request of defect analysis, subcontracting (A,C, D).

Technology transfer is not an on-off activity

The first TT project is a starting point of a continuous learning process and collaboration between the SME and the TTC. During the project, extra-projects exchanges may happen and enhance the “Contact / confidence level” which is the memory of the relationship between the various participants.

6. Conclusions

The overall aim of this paper was to make a contribution to the identification and description of a conceptual framework that illustrates the complex and dynamic nature of technology

transfer between a TTC and SME at micro-level. This conceptual framework was introduced as a TT model to improve the process understanding and avoids some limits identified in the literature review.
Thanks to the proposed model, it was highlighted that the sequences and the length of the TT project stages are different and their combination depends on the complexity and cost of the product. Also, technology transfer is not an on-off activity since it's a continuous learning process and multidirectional collaboration.
Moreover, this work linked the stakeholder's involvement and financial conditions of the enterprise to the dynamic and outcomes of the TT process.
In conclusion, technology transfer project is not a singular event. The model presented above enables managers in charge of transfer processes to be aware of possible threats and assure successful technology transfer projects by implementing the adequate procedures and incentives. Thus, it helps to capture more fully and clearly the dynamics and complexity of technology transfer at micro level. However, the proposed model may be improved since it doesn't take into account environmental factors.

References

Amesse, F. and Cohendet, P. (2001). Technology transfer revisited from the perspective of the knowledge-based economy. *Research Policy*, 30(9), 1459-1478.

Bercovitz, J. and Feldmann, M. (2006). Entpreprenerial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer*, 31(1), 175-188.

Boujut, J. F. and Blanco, E. (2003). Intermediary objects as a means to foster co-operation in engineering design. *Computer Supported Cooperative Work: CSCW: An International Journal*, 12(2), 205-219.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy*, 29(4-5), 627-655.

Carr, R. K. (1992). Menu of best practices in technology transfer (Part 2). *The Journal of Technology Transfer*, 17(2-3), 24-33.

Chauvet, V. (2003). Construction d'une échelle de mesure de la capacité d'absorption. In *Proc. Int. Conf. XIIème Conférence de l'Association Internationale de Management Stratégique*, (eds.), pp Les Côtes de Carthage.

Eckert, C. and Boujut, J. F. (2003). Introduction: The role of objects in design co-operation: Communication through physical or virtual objects. *Computer Supported Cooperative Work: CSCW: An International Journal*, 12(2), 145-151.

Erlich, J. N. and Gutterman, A. (2003). A practical view of strategies for improving federal technology transfer. *Journal of Technology Transfer*, 28(3-4), 215-226.

Geisler, E. (1993). Technology transfer: Toward mapping the field, a review, and research directions. *The Journal of Technology Transfer*, 18(3-4), 88-93.

Gilbert, M. and Cordey-Hayes, M. (1996). Understanding the process of knowledge transfer to achieve successful technological innovation. *Technovation*, 16(6), 301-312.

Greiner, M. A. and Franza, R. M. (2003). 'Barriers and Bridges for Successful Environmental Technology Transfer'. *Journal of Technology Transfer*, 28(167-177.

Harmon, B., Ardishvili, A., Cardozo, R. N., Elder, T., Leuthold, J., Parshall, J., et al. (1997). Mapping the university technology transfer process. *Journal of Business Venturing*, 12(6), 423-434.

Kingsley, G., Bozeman, B. and Coker, K. (1996). Technology transfer and absorption: An 'R & D value-mapping' approach to evaluation. *Research Policy*, 25(6), 967-995.

Kumar, U. and Uruthirapathy, A. (2007). Critical Success Factors in Technology Transfer from Government Laboratories to Private Sector: A Study Based on Canadian Federal Government Departments. In *Proc. Int. Conf. Conference of the Administrative Sciences of Canada*, (eds.), pp Ottawa, Ontario.

Large, D. W. and Barclay, D. W. (1992). Technology transfer to the private sector: A field study of manufacturer buying behavior. *The Journal of Product Innovation Management*, 9(1), 26-43.

Levin, M. (1993). Technology transfer as a learning and developmental process: an analysis of Norwegian programmes on technology transfer. *Technovation*, 13(8), 497-518.

Malik, K. (2002). Aiding the technology manager: A conceptual model for intra-firm technology transfer. *Technovation*, 22(7), 427-436.

Morrissey, M. T. and Almonacid, S. (2005). Rethinking technology transfer. *Journal of Food Engineering*, 67(1-2), 135-145.

Peerbaye, A. and Mangematin, V. (2005). Sharing research facilities: Towards a New Mode of Technology Transfer? . *Innovation: Management Policy and Practice*, 7(1), 23–38.

Schwartz, M. M. and Aircraft, S. (1993). Introduction to brazing and soldering. In Welding, Brasing, and soldring ASM HAND BOOK (Vol 6), L. D. Olson, T. A. Siewert, S. Liu and G. R. Edwards (ed.), pp. 270–481. USA: ASM INTERNATIONAL.

Souder, W. E., Nashar, A. S. and Padmanabhan, V. (1990). A guide to the best technology-transfer practices. *The Journal of Technology Transfer*, 15(1-2), 5-16.

Szulanski, G. (2000). The Process of Knowledge Transfer: A Diachronic Analysis of Stickiness. *Organizational Behavior and Human Decision Processes*, 82(1), 9-27.

TEURPIN. (2001). European technology transfer guide to best practs. http://www.innovating-regions.org/download/teurpin%5Fguide%2Epdf. [16 November 2009].

Trott, P., Cordey-Hayes, M. and Seaton, R. A. F. (1995). Inward technology transfer as an interactive process. *Technovation*, 15(1), 25-43.

Van Den Beemt, F. C. H. D. (1997). Evaluating prediction of technology transfer success: An interim evaluation of the dutch sensor technology program. *Journal of Technology Transfer*, 22(2), 53-58.

Zahra, S. A. and George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27(2), 185-203.