TECHNOLOGY ACQUISITION:

SOURCING TECHNOLOGY FROM INDUSTRY PARTNERS

This thesis is submitted

for the Degree of Doctor of Philosophy

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July 2013

To the most important people in my life:

Luzselene, Margarita, Jorge, Georgina y Elizabeth.

ABSTRACT

This thesis describes the conditions that influence technology acquisition when an industry partner is involved. The objective of this thesis is to contribute to the knowledge regarding the conditions that affect effective acquisition of technology by collaboration by identifying and describing the relationship between the following variables: key activities and influential factors.

The results are drawn from the analysis of eleven case studies involving experiences from different industries including chemicals, oil and gas and biofuels. The research adopts the perspective of an acquiring firm, which is interested in incorporating a new technology into its operations in order to meet a particular business need. Such a business need can be, for example, entering into a new market, meeting key customer requirements or improving operational efficiency.

The results indicate that technology acquisition involving an industry partner can be described as a six-stage process where the acquiring firm may or may not get involved in the development of the technology concept. During the process a number of factors can influence the acquisition and implementation of the technology in the acquiring firm's operations. These factors can be divided into six categories: business alignment, structural match, development management, technology uncertainty, implementation opportunity and contextual factors.

The results also suggest that effective acquisition of technology by means of collaboration is achieved by the combination of three conditions: effective partnership management, effective execution of the co-development project and effective transference of the technology to the recipient system in the acquiring firm.

The research provides relevant implications for theory and practice. On the one hand, technology acquisition by means of collaboration has been marginally addressed in technology management literature; extant literature has given more attention to organisational modes to acquire technology by collaboration rather than increasing our understanding of the dynamics of technology partnerships. On the other hand, the outcomes offer practitioners an account of the key factors and activities in technology acquisition projects involving an industry partner. These insights are key to systematically managing collaborative projects aimed at acquiring new technologies.

PREFACE

Except for commonly understood terms and accepted ideas, or where specific reference is made, the work reported in this thesis is my own and does not include the outcome of work done in collaboration. No part of the dissertation has been previously submitted to any university for any degree, diploma or qualification.

This thesis contains 52 figures and approximately 64,900 words. It is therefore within the limits (of 150 figures and 65,000 words) allowed by the Degree Committee of the Department of Engineering.

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ACKNOWLEDGEMENTS

This thesis results from the support, guidance and comments of numerous individuals. Firstly and foremost, I would like to extent my sincere thanks to David Probert and Rob Phaal for their constant guidance, patience and confidence in my work. Their wise advice and challenging comments guided my formation as researcher through the last four years. I am also immensely grateful to Luzselene Rincon for her tolerance, encouragement and endless constructive feedback. I would not have completed this thesis without her support.

I would like to thank to Tim Minshall, Rick Mitchell, Letizia Mortara, Simon Ford, Michélle Routley, Agustin González, José Sámano and Héctor Huerta for many helpful comments and suggestions.

Finally I would like to thank to all the people that accepted the invitation to participate in this research. I am deeply grateful for their willingness to openly share information and insights into their activities and industry experience. Their participation contributed significantly to complete this thesis.

My research was made possible through financial support from the *Fondo Sectorial SENER-CONACYT-Hidrocarburos*, *Instituto Mexicano del Petróleo*, Engineering Department of the University of Cambridge, RADMA and Clare Hall College. Many thanks for sponsoring this research project.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ACAP	Absorptive capacity
C&SAM	Collaboration and strategic alliances management
CC	Coordination capability
CEOs	Chief Executive Officers
CF	Contextual factors
CIP	Centro de Investigación en Petróleo
CNDT	Centro Nacional de Desarrollo Tecnológico
Co-development	Collaborative development
D&D	Dehydration and Desalination
DTECH	Dehydration Technologies Ltd.
ETI	External technology integration
IP	Intellectual property
IPR	Intellectual Property Rights
JDA	Joint development agreement
JV	Joint venture
KBV	Knowledge based view
MyASA	Metales y Aceros SA
NPD	New product development
OCG	Operative Control Group (Internal group at PGSA)
OT	Offshore Technology
PCT	Patent Cooperation Treaty
PGSA	Petróleo y Gas SA

R&D	Research and development
RBV	Resource based view
SA	Strategic alignment
SM	Structural match
SPE	Society of Petroleum Engineers
TA	Technology acquisition
TAF	Technology acquiring firm
TCE	Transaction cost economics
TM	Technology management
TPF	Technology providing firm
TRL	Technology readiness level
TU	Technology uncertainty

1 INTRODUCTION

Contents

1.1 Focus of the research

Technology acquisition (TA) is one of the core processes in technology management (Gregory 1995). TA concerns how firms obtain the technology[1] that is needed to accomplish their business objectives (Cetindamar et al. 2010). TA covers the decisions and activities that firms carry out to incorporate selected technologies effectively into their operations (Gregory 1995).

There are different ways through which firms can obtain technology, for example internal development, collaborative development, licensing and acquiring the company that holds the technology (Chiesa and Manzini 1998). These mechanisms have been explored in technology management (TM) literature. However some ambiguity remains on particular aspects of the acquisition process, for example how the acquisition process changes when an external party is involved.

Sourcing technology from an industry partner usually implies a certain level of interdependence between the acquiring firm and its partner (Chiesa and Manzini 1998). These relationships are commonly referred to as technology collaborations, technology alliances (Hoffmann 1997), or strategic technology alliances (Van Haverbeke et al. 2002). It is widely known that companies collaborate with suppliers, customers, competitors, R&D centres and universities on a frequent basis to get access to the technology required to develop products, processes and services (Lhuillery and Pfister 2009, Paixao-Garcez et al. 2010).

This research addresses TA featuring a particular type of technology collaboration: collaborative development (also referred to in this document as co-development). In this kind of technology collaboration, participant organisations become intimately involved in a development project where they combine their expertise. Often, the acquiring firm (or customer) provides the expertise in the application of the technology and the providing firm (or technology partner) provides the core technology expertise (Neale

[1] The working definition of technology adopted in this research is "any form, material or social, into which knowledge has been embodied. This includes hardware, software, products, rules, procedures, organizational structure, and know-how or technical expertise." (Rebentish and Ferretti, 1995). There are a number of definitions proposed by different authors (e.g. Bunge 1976, Steele 1989, Roussel et al. 1991, Twisss 1992, Floyd 1997, Betz 1998, Arthur 2009), however the researcher considers this definition as appropriate for the purposes of this research because it denotes that technology is something that contains an accumulated set of experience, knowledge and expertise that is used for practical purposes.

and Corkindale 1998). The outcome of this kind of collaboration is usually a new technical capability, typically a new product, process or service (Chesbrough and Schwartz 2007).

1.2 Research context

Getting access to technology by involving an industry partner brings advantages in relation to internal development or purchasing from external developers. Among the benefits are development of technologies/products tailored to firm's needs, reducing development time, as well as sharing development costs and risks (Littler et al. 1995, Bhaskaran and Krishnan 2009). In addition, industry partners may provide support to identify and select the right technology, to estimate development costs and even to manage the development process. However, getting access to technology through an industry partner is risky, particularly when the firm works with the partner for the first time (Fraser et al. 2003) or possesses limited prior experience in alliances (McCutchen Jr et al. 2008). Indeed, McGee and Dowling (1994) reports that prior managerial experience in R&D cooperative activities helps to identify the risks and benefits of engaging in such cooperative activities. Ireland et al. (2002) stress that the ability to effectively manage collaborations is fundamental for those firms that need to access key resources possessed by other companies.

In a series of interviews with practitioners, the researcher found that one of the biggest concerns in TA regards partner selection. Interviewees often attribute the failure of technology collaborations to the involvement of the wrong partner, which is an observation supported also by extant literature (e.g. Emden et al. 2006, Lee et al. 2010). Scholars have pointed out partner selection as a key success factor in inter-firm collaborations (Littler et al. 1995). Nevertheless, one of the interviewees made a comment that defined the final focus of this research. Based on his experience in the chemical sector, he pointed out:

> "…even when you think you have selected the best partner, you find that a change in their organisation destroys the relationship". Expert_05

This comment highlights the fact that firms are dynamic entities; therefore the failure (or success) of collaborations seems to depend on several factors and not only on how effectively firms chose their partners. Extant literature has addressed different topics related to technology collaborations, for example, choice of governance mode (Chiesa and Manzini 1998, Van de Vrande et al. 2009, Bhaskaran and Krishnan 2009, Van de Vrande et al. 2011), critical success factors (Campione 2003, Buse and Armonaitis 2011), technology uncertainty (Steensma and Corley 2000, Stock and Tatikonda 2008, Cui et al. 2012) and type of partners (Miotti and Sachwald 2003, Belderbos et al. 2004, Faria et al. 2010) amongst others. However, only a few authors have attempted to provide a comprehensive framework to understand the different factors that affect the outcomes of technology collaborations (e.g. Mora-Valentin et al. 2004, Emden et al. 2006, Barnes et al. 2006) and to manage the collaborative process (e.g. Duysters et al. 1999).

1.3 Research question and objectives

Although extant literature has explored how firms acquire technology and the factors that affect the outcomes of technology collaborations, there is no comprehensive evidence indicating how the technology acquisition process may change when an industry partner is involved and what the specific factors that affect technology acquisition by collaboration are. In addition, a practice review indicates that firms find particular situations in technology acquisition projects involving an industry partner problematic. Therefore, this context leads to the following research question:

> *How can the conditions that affect the effective acquisition of technology by collaboration be described?*

Specifically,

> *How may the technology acquisition process be depicted when an industry partner is involved?*

and

> *What are the factors that affect effective collaborative development and integration of technologies into the operations of the acquiring firm?*

The objective of this research is to contribute to knowledge regarding the conditions that affect the effective acquisition of technology through collaboration by identifying and describing the relationship between the following variables:

a) Key activities. Sequence of tasks carried out to incorporate a given technology into the operations of the acquiring firm.
b) Influential factors. Circumstances that either enable or impede the effective incorporation of technologies into the operations of the acquiring firm.

1.4 Research approach

In order to answer the research question, a qualitative approach was chosen because of two reasons: 1) there is a limited amount of previous research addressing TA by collaboration, and 2) the need for a deep understanding of the TA process when a firm collaborates with an industry partner.

The case method was the main research approach in this research. Candidate cases were collaborative development projects, where the driver to collaborate for one of the partners was to acquire a new technology. Data was collected primarily through semi-structured interviews. The results were drawn from a combination of three analytical methods: grounded analysis, narrative analysis and cross case analysis.

This research was carried out in four phases: practice review, framework development, framework refinement and framework verification. The first phase aimed to inform the research design by validating the relevance of the topic from the practitioners' perspective. The second phase aimed to explore the technology acquisition process by identifying key activities and influential factors. Then, the following phase aimed at verifying whether the factors and activities found in the previous phase would also be present in a new set of case studies. Finally, the objectives of the last phase were verifying the terminology utilised in the resulting framework, identifying limitations and exploring further practical implications of the research outcomes.

1.5 Structure of the thesis

The content of this thesis is divided in four parts (Figure 1.1): research foundations and methodological approach (Chapters 2 to 4), framework evolution (Chapters 5 to 7), discussion and conclusion (Chapters 8 and 9), and addenda (references and appendices).

Chapter 2 presents an overview of relevant literature and theories that provide insights to understand the key activities and factors that affect technology acquisition by means of collaboration. Chapter 3 presents a discussion of knowledge gaps between extant literature and practice. The results of this discussion support the practical relevance of the research question and provide elements to inform the design of the methodological approach. Chapter 4 describes the methodological approach and key considerations undertaken in this research.

Chapters 5 to 7 show the evolution of the framework resulting from this research. Chapter 5 presents a framework built upon the empirical evidence obtained through the analysis of seven collaborative projects. A refined version of the framework is presented in Chapter 6. This refined version of the framework was the result of a deep analysis of four additional cases. Chapter 7 presents the results of a focus group session where the refined framework was presented to a forum of practitioners in order to obtain feedback and identify limitations of the results.

Chapters 8 and 9 present the results discussion and conclusions respectively. Chapter 8 comprises a detailed description of the final version of the framework as well as a discussion of the theoretical and practical implications of the outcomes. Chapter 9, on the other hand, presents the contributions to theory, evaluation of the research approach, limitations and further work on the basis of the results achieved. Table 1.1 presents a summary of the purpose and main arguments of each chapter.

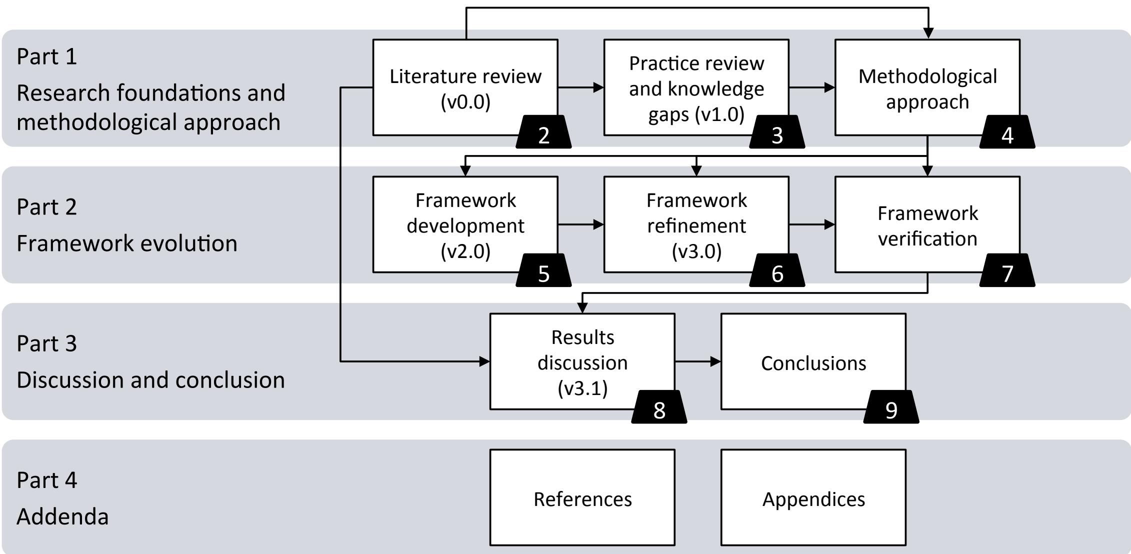


Figure 1-1 Thesis layout. Arrows indicate the links between chapters.

Table 1-1 Thesis layout

Chapter	Purpose of the chapter	Main arguments/findings	Framework version	Data sources / Analytical method
2- Literature review	- Citing relevant literature and theories that provide insights to understand the activities and factors that affect technology acquisition by means of collaboration. - Providing a summary of relevant activities and factors that have been addressed in extant literature.	- Relevant work has been published in different literature streams, namely technology management, knowledge and technology transfer, new product development, management of strategic alliances, organisational culture, resource based view and absorptive capacity. - Technology acquisition may comprise six stages: definition of technology requirements, identification of available technology, technology evaluation and selection of the source, negotiation, implementation as well as value added audit and relationship management. - Factors affecting technology acquisitions by collaboration can be divided into five categories: strategic alignment, structural match, coordination capability, technology uncertainty and contextual issues.	- Conceptual Framework (v0.0).	- Literature
3- Practice review and knowledge gaps	- Providing an overview of the activities and influential factors that affect technology acquisition by means of collaboration from the perspective of practitioners. - Discussing knowledge gaps between extant literature and practice.	- From the acquiring firm perspective, the acquisition process may comprise the following activities: definition of technology requirements, technology scouting, technology evaluation, partner selection, negotiation, development and exploitation. - From technology partners perspective, the activities in technology collaborations can be: technology concept development, building business reputation, demonstration of technology capabilities, negotiation, development and technology transfer. - In technology collaborations, each partner seems to perceive different influential factors. - The activities and factors mentioned by practitioners seems to be not entirely consistent with the activities and factors reported in extant literature.	- Practice-based Framework (v1.0).	- 13 Semi-structured interviews / Grounded analysis
4- Methodological approach	- Outlining the scope of the research project (research objectives and theoretical boundaries) - Describe the research methodology, data collection methods, as well as analytical approaches.	- A qualitative approach is more appropriate for enquiries whose aim is to understand a particular phenomenon. - Case study was chosen as main research approach given the fact that it is a flexible method that allows for a combination of a number of data collection and analytical techniques. - The research project comprised four phases: practice review, framework development, framework refinement and framework verification. - Empirical data was collected through semi-structured interviews and one focus group. - Analytical methods included grounded analysis, narrative analysis and cross case analysis.	- -	- Literature

Chapter	Purpose of the chapter	Main arguments/findings	Framework version	Data sources / Analytical method
5-Framework development	- Discussing key activities and factors that affect acquisition of technology based on the analysis of seven case studies. - Describing the elements of the emerging framework.	- The acquisition can comprise the following key activities: definition of technology requirements, technology scouting, technology risk evaluation, partnership set up, agreement formalisation, co-development execution and implementation. - Factors affecting technology acquisition by collaboration can be divided into six groups: strategic alignement, structural match, development management, implementation opportunity, technology uncertainty and contextual factors. - The activities and factors identified through the analysis of case studies provide a better understanding about the conditions that affect the effective acquisition of external technologies than current literature.	- Emerging Framework (v2.0).	- 7 case studies / Grounded analysis and cross case analysis.
6- Framework refinement	- Discussing key activities and factors affecting acquisition of technology based on the analysis of four in-depth case studies. - Examining how effectively the emerging framework (v2.0) describes the activities and factors observed in a further set of case studies. - Describing the elements of the refined version of the framework.	- The acquisition process seems to comprise two kinds of activities: partnership related activities and acquisition related activities. - Partnership related activities comprise collaboration assessment and agreement formalisation. - Acquisition related activities can include the following activities: definition of technology requirements, technology scouting, technology concept development/selection, prototype testing, product development and implementation. - Factors affecting technology acquisition by collaboration can be divided into six categories: strategic alignment, structural match, development management, technology uncertainty, implementation opportunity and contextual factors. - The effect of the factors that affect technology acquisition projects can be divided into three domains of impact: partnership stability, co-development execution and transference of the outcomes to the recipient system.	- Refined Framework (v3.0).	- 4 case studies / Narrative analysis and cross case analysis.
7- Framework verification	- Presenting the results of a focus group session where the refined framework (v3.0) was presented to a forum of practitioners.	- The comments and feedback provided by participants supported the results of the research. - Participants agreed that the dimensions of the framework are appropriate and complete.	- -	- Focus group.

Chapter	Purpose of the chapter	Main arguments/findings	Framework version	Data sources / Analytical method
8- Results discussion.	- Describing in detail the final version of the framework. - Discussing the results of the research project in terms of: theoretical contributions and implications for practice.	- Technology acquisition by collaboration can be described by three elements: partnership-related activities, acquisition-related activities and influential factors. - Effective acquisition of technology requires attention in three areas: partnership stability, co-development execution and transference of the product that contains the technology to the recipient system. - The results provide hints to explain and understand practitioners concerns in four themes: selection of the right project, partners' business alignment, partner selection and management of acquisition projects.	- Final Framework (v3.1).	- -
9 - Conclusions.	- Reviewing whether the results answer the research question and meet the objectives. - Evaluating the methodology approach and limitations of the results. - Pointing out areas for further research	- The outcomes answer the research question and meet the original objectives. - The dimensions of the resulting framework capture the relevant activities and factors that affect technology acquisition by collaboration. The specific tasks and factors that characterise a particular project may depend on its context. - The results provide a first attempt to fill the theoretical gap in the technology management literature regarding the acquisition of technology by collaboration. - There are a number of possible limitations of the research due to methodological approach, selection of the sample and measurement criterion.	- -	- -
References	- Citing the references used in this document.	- -	- -	- -
Appendixes	- Providing supporting documents and templates, including data collection protocols and examples of analytical procedures.	- -	- -	- -

2 LITERATURE REVIEW

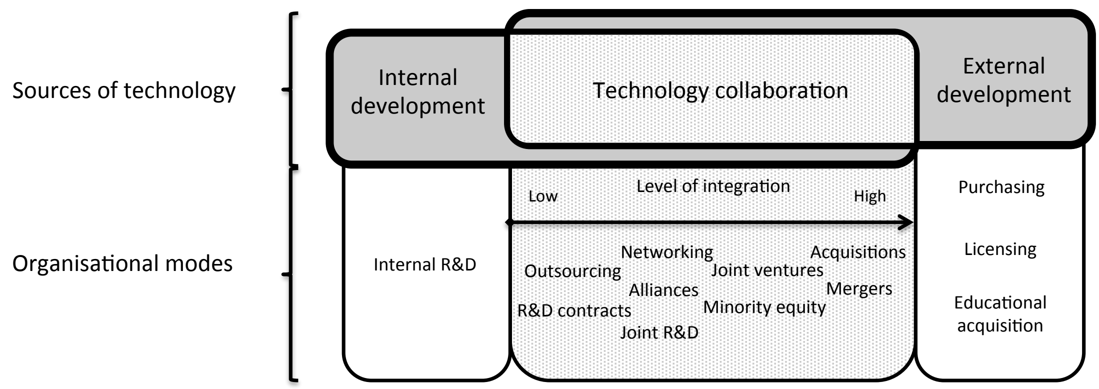
Contents

This chapter provides a conceptual overview of the circumstances that influence the effective acquisition of technology by collaboration. The core literature is presented from four perspectives: technology acquisition, knowledge and technology transfer, management and organisational barriers, as well as strategic management. These perspectives are combined into a conceptual framework, which was used as a base to design and carry out this research.

2.1 Technology acquisition

Firms are motivated to acquire technology for a variety of reasons. Ford and Probert (2010) argue that there are four main reasons: developing technological capabilities, developing strategic options, gaining efficiency improvements and as a response to their competitive environment. Firms may have the internal capabilities and resources to develop the technology knowledge required to support strategic or tactical business strategies, but eventually they may opt to acquire it from an external source (Stock and Tatikonda 2008).

Technology can be acquired in different ways, for example by recruiting experts, carrying out collaborative development with other organisations or by purchasing the business that holds the exploitation rights of the technology (Gregory 1995, Jones et al. 2001, Ranf and Lord 2002, Van Haverbeke 2002, Cetindamar et al. 2010). Common sources of technology include customers, providers, competitors, universities and public research centres (Arranz and Fernadez de Arroyabe 2008). In addition, the acquisition of externally developed technology can be governed by different mechanisms such as corporate venture capital investments, non-equity technology alliances, joint ventures, minority holdings, and mergers and acquisitions (van de Vrande et al. 2009). Figure 2.1 presents an overview of the sources and organisational modes to acquire technology.



Source: the author with data from Chiesa and Manzini 1998

Figure 2-1 Sources and organisational modes to acquire technology

Acquiring technology implies a series of activities and decisions that range from the definition of the technology needs to the implementation of the acquired technology knowledge into current operations or into a new product (Durrani et al. 1999, Baines 2004, Daim and Kocaoglu 2008). In order to achieve effective TA, firms not only have to succeed in identifying and assimilating it, but also applying it to practical ends (Jiménez-Barrionuevo et al. 2011).

The process to acquire technology can be broadly summarised as a six-stage process:

1. Definition of technology requirements.
2. Identification of available technology.
3. Technology evaluation and selection of the source.
4. Negotiation.
5. Implementation.
6. Value added audit and relationship management.

These stages are based on a review of published approaches depicted in Figure 2.2 for comparison. The activities associated to each stage are described below.

1. Definition of technology requirements

This stage comprises the initial activities to define the technology needs of the firm. Activities in this stage aim to analyse the current situation of the firm and to identify the technologies that are important to build its competitive position (Durrani el al. 1999). An important outcome of this stage is the identification of the core competencies of the firm that will support the current and future business objectives. This is an essential input in deciding which technologies must be acquired (Cetindamar et al. 2010).

2. Identification of available technology

The next group of activities aims to explore different technology alternatives that can support the firm to sustain its current core competences and to build new ones. These activities include identification and classification of existing technologies, as well as potential technology suppliers. The result of such activities is an important input to outline a business case (Baines 2004).

Overall stages

	Definition of technology requirements	Identification of available technology	Technology evaluation and selection of the source	Negotiation	Implementation	Value added audit and relationship management
Durrani et al. 1999	Establish market place requirements	Identify technology solutions; Classify the technology solutions	Establish sources of technology acquisition	Finalise the technology acquisition decision		
Eskelin 2001	Initiation; Planning	Research	Evaluation	Negotiation	Implemen-tation; Operation	
Baines 2004	Technology profiling; Establishing the requirements of technology	Find a technological solution; Form outline business case	Choose technology source; Demonstrate technology	Confirm business case	Implement technology	Post-investment audit
Daim and Kocauglu 2008	Technology gap analysis or problem identification	Identification of technology alternatives	Evaluation of the technology alternatives	Acquisition of the technology		Impacts through the acquisition of technologies
Cetindamar et al. 2010	Goal setting	Finding technology suppliers	Choosing acquisition method	Contract preparation and negotiation	Technology transfer	Managing long-term collaboration

Figure 2-2 Comparison of the stages of the technology acquisition process proposed by different authors. Source Ortiz-Gallardo et al. 2013, p.146

3. Technology evaluation and selection of the source

This set of activities intends to evaluate the different technology alternatives from two perspectives: capability of the technology to meet the needs of the firm and reliability of the supplier (Cetindamar et al. 2010). This group of activities includes tests to verify that the technology is able to perform a particular application (Baines 2004), assessment of the potential suppliers and the selection of the acquisition method (Cetindamar et al. 2010).

4. Negotiation

The negotiation phase includes activities that are related to the definition of the terms of the acquisition and agreement formalization. These activities include confirmation of the business case (Baines 2004), preparation of the contractual agreement and negotiation of the scope of the transaction with the supplier (Cetindamar et al. 2010).

5. Implementation

The acquisition process is completed with the implementation of the technology into a final product. The activities considered in this group are associated with transferring the technology (Cetindamar et al. 2010) and solving operative issues to achieve the expected performance (Baines 2004).

6. Value added audit and relationship management

After the technology has been implemented, the acquiring firm may carry out an assessment of both, the value added by the acquisition and whether it is possible or not to keep a long-term collaboration with the provider (Baines 2004, Cetindamar et al. 2010).

2.1.1 Influential factors

There are several factors that can affect TA success reported in TM literature. Seventeen papers published between 1990 and 2011 report a large number of factors that may influence the outcomes of TA processes. Those factors can be broadly divided into two types (Table 2.1): project execution and contextual factors. A general notion from those categories is that TA is influenced by both internal and external factors.

Table 2-1 Factors affecting technology acquisition reported in technology management literature

Type of factor	Category (type of influence)	Factor	References *See note at end.*
Project execution	Technology selection (Internal)	Access to technology intelligence reports	7
		Additional costs of utilizing the technology	7
		Availability of technical data to evaluate the technology	7
		Decision making autonomy	6
		Evaluators of the technology	11
		Lack of information	1
		Technology assessment methods	4, 7
	Means to identify technology options (Internal)	Ability to identify emerging technologies	6
		Access to patents and literature information	7, 9
		Business ties with supplier and customer firms	9
		Contact with technology brokers	7
		Corporate venture capital investments	15
		Portfolio planning	9
		Participation in consortia	7
		Networking of R&D personnel with other firms and Research institutions	6
	Project management (Internal)	Ability to control project expenses	6
		Ability to protect codified/tacit knowledge and skills	6
		Communication	6, 9
		Financial forecast of costs of the project	6
		Management experience	6
		Coordination	5, 6
		Speed of incorporation into new products/processes	6
		Trust	16
	Resources (Internal)	Availability of financial resources	6
		Design/ manufacturing capacity	6
		Hiring individuals who know the technology	7
		In-house R&D capabilities	1, 6
		Internal resources needed to assimilate external technologies	7
		Professional skills and education level of the R&D personnel	9
	Contractual terms (External)	Collaboration method	7
		Bargaining power of the supplier	1
		Agreement terms	2, 10, 12, 13, 17
	Technology characteristics (External)	Further development to adapt the technology	7
		Tacitness	8
		Technical complexity	1, 2
		Technology attributes	10, 12, 14
		Technology maturity	3, 11
		Technology newness	13

Table 2-1 Factors affecting technology acquisition reported in technology management literature (cont.)

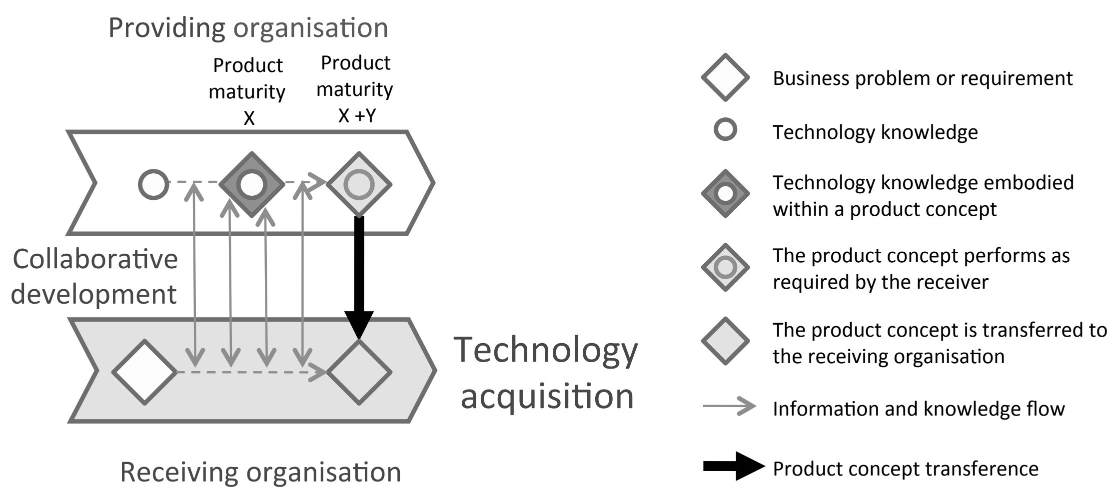
Type of factor	Category (type of influence)	Factor	References *See note at end.*
Contextual factors	Business drivers (Internal)	Business strategy	8
		Company's strategic priorities	6
		Fit with corporative objectives	6
		Gaining access to new markets	6
		Importance of the project	12
		Technology required to improve current products	7
		Technology strategy	1
	Organisational readiness (Internal)	Competency development	2
		Lack of understanding of the technology	7
		Organizational learning	2
		Technology familiarity	13
	Competitive environment (External)	Current products' performance in relation to competitors	7
		Environmental turbulence	13
		Industry competition basis	8
		Market place requirements	6
		Protection scope of intellectual property rights	9
		Technological level of competitors and other firms	9
	Risks (External)	Market risks	6
		Opportunity cost	6
		Reliance on highly specialized skills and expertise	8
		Technical risks	6
		Technology dynamism of industry	2, 3, 8
	Other external influences (External)	Characteristics of the acquiring firm	12, 14, 16
		Business alignment with supplier	5
		Characteristics of the providing firm	11
		Organisational compatibility with supplier	16
		Previous relationship with supplier	13
		Supplier support	16
		Urgency	2

References: [1] Sen and Rubenstein 1990; [2] Steensma 1996; [3] Lambe and Speckman 1997; [4] De Piante 1997; [5] Monczka et al. 1998; [6] Durrani et al. 1999; [7] Slowinski et al. 2000; [8] Ranf and Lord 2002; [9] Hemmert 2004; [10] Stock and Tatikonda 2004; [11] Galbraith et al. 2006; [12] Stock and Tatikonda 2008; [13] van der Vrande et al. 2009; [14] Karlsson et al. 2010; [15] van de Vrande et al. 2011; [16] Park and Ghauri 2011; [17] Cantarello et al. 2011.

2.1.2 Technology acquisition by collaborative development

Collaborative development (or co-development) is an option to acquire technology, in particular when firms have a strong familiarity with a particular market or product but are unfamiliar with the technologies embedded into the product (Roberts and Berry 1985). Co-development is also an option when firms do not have all the resources and knowledge required to develop a product or process by their own, or when no commercial solution addresses a particular business problem or requirement (Steensma and Corley 2000).

In a co-development process partners work together to apply and embed the technology into a product concept. Over this process it is possible to distinguish two main roles: the provider of technology and the receiver (Neale and Corkindale 1998, Cummings and Teng 2003). The technology provider is responsible for delivering key technical knowledge and skills required for developing and embedding the technology into a final product concept. The technology receiver, on the other hand, usually defines the specifications of the final product based upon the ultimate application of the technology (Neale and Corkindale 1998). Figure 2.3 shows an example of these two roles.



Source: the author

Figure 2-3 Main roles in collaborative developments

Figure 2.3 represents the case where the development process is led and performed by the providing organisation. Throughout the co-development process participating organisations became intimately involved by exchanging information and expertise (Neale and Corkindale 1998). The co-development process finishes when the performance of the product concept is demonstrated under real operation conditions (Steele 1989).

There are a number of factors that may influence the acquisition of technology when independent organisations work in collaboration. Over the last decade scholars have proposed frameworks that capture influential factors that affect the performance of technology collaborations. The factors considered in the frameworks are presented in Table 2.2. Each framework covers a different set of factors.

The frameworks suggested by Kim and Lee (2003), Barnes et al. (2006) and Paixao-Garcez et al. (2010) broadly cover three groups of factors: project-related factors, partner-related factors and contextual factors. The frameworks proposed by Mora-Valentin et al. (2004) and Emden et al. (2006) on the other hand, make more emphasis on factors related to the relationship between the partnering organisations. It is important to note that none of these frameworks make a distinction of the moment in the partnership where these factors are critical.

Table 2-2 Frameworks describing the factors that affect the performance of technology collaborations

Reference - Framework focus	Type of factor	Factor
Kim and Lee (2003) **- Key success factors in technology collaborations**	Project characteristics	• Demand certainty • Cost of share of government • Technological complexity • Strategic importance
	Partner characteristics	• Trust in relationship • Compatible strategic goals to the project
	Collaboration management practices	• Specificity of process and outcome • Commitment of focal firm to project planning • Information-sharing • Type of partner and role

Table 2-2 Frameworks describing the factors that affect the performance of technology collaborations (cont.)

Reference - Framework focus	Type of factor	Factor
Mora-Valentin et al. (2004) - Key success factors in R&D collaboration agreements	Contextual factors	• Previous cooperative experiences • Partners' reputation • Definition of objectives • Institutionalization • Geographic proximity
	Organisational factors	• Commitment • Communication • Trust • Level of conflict • Dependence among partners
Emden et al. (2006) - Partner selection	Technological alignment	• Technical ability • Technical resource and market knowledge complementarity • Overlapping knowledge base
	Strategic alignment	• Motivation correspondence • Goal correspondence
	Relational alignment	• Compatible cultures • Propensity to change • Long-term orientation
Barnes et al. (2006) - Managing collaborative R&D projects	Partner-related issues	• Partner evaluation • Project manager
	Project set up and execution	• Project management • Ensuring equality • External influences
	Other influences	• Cultural "gap issues" • Universal success factors
Paixao-Garcez et al. (2010) - Partner selection	Task-related factors / project factors	• Complementarities between the partners • Financial demands for the project • Project risk • Development time
	Partner-related factors	• Previous experience in alliances • Trust between partners • Partners convergent expectations for continuity of the project • Organisational culture similarity degree
	Contextual factors	• Company size • Nationality of the partners • R&D project type

2.1.3 Summary

This subsection has provided a brief overview of the current progress on the understanding of TA by collaboration. So far, TM literature suggests that acquiring technology follows a linear process and that there are a number of factors that may affect the outcomes. However, despite the fact that collaboration is being acknowledged as a means to obtain technology, it seems that scholars have not provided evidence yet that indicates how the acquisition process changes when technology is sourced by means of collaborative development. Further, there is not clear evidence that specifies the relevance of certain factors over the stages of the TA process. Scholars have reported a large number of factors that may affect technology collaborations, but so far there is no evidence indicating the relevance of these factors on the key activities of the TA process. Therefore, in order to understand the acquisition process by means of collaboration better, these two knowledge gaps needs to be addressed.

2.2 Knowledge and technology transfer

This section presents a review of literature related to technology collaborations from the knowledge and technology transfer standpoint. The factors that enable the movement of technology knowledge, and associated hardware, from one organization to another or within an organisation are explored in this section. Section 2.2.1 presents three knowledge and technology transfer models that provide an overview of the factors that either enable or impede the effective movement of knowledge and technology between developers and users. Section 2.2.2 presents two models that explore the factors that affect the transfer of knowledge within an organisation, and section 2.2.3 presents an overview of the particular factors that affect the integration of external technology knowledge in the new product development process. Overall, the knowledge and technology transfer frameworks presented in this section offer a large number of factors that help to understand the conditions that contribute to effective acquisition of technology by collaboration.

2.2.1 Knowledge and technology transfer models

There are many knowledge and technology transfer models proposed in the literature. The initial models, developed prior to the nineties, looked at the technology transfer processes mostly concerning the interaction between developer and user. They include (Sung and Gibson 2000, Wahab et al. 2009):

1. Appropriability model[1].
2. Dissemination model[2].
3. Knowledge utilization model[3].
4. Communication model[4].

Three relevant models developed in the 1990s offer relevant insights to understand the performance of technology collaborations are those proposed by Gibson and collaborators (Gibson and Smilor 1991, Sung and Gibson 2000), by Rebentisch and Ferretti (1995) and by Cummings and Teng (2003). These three models are described below.

Gibson and collaborators' model

The model developed by Gibson and collaborators (Gibson and Smilor 1991, Sung and Gibson 2000) comprises four levels of technology transfer (Figure 2.4): knowledge and technology creation (*Level I*), sharing (*Level II*), implementation (*Level III*), and commercialization (*Level IV*). At *Level I* individuals produce knowledge and announce their results through a variety of channels such as journal articles, videotapes and teleconferences. At this level, the transference of technology knowledge is largely passive and requires limited interaction between developers and users. At *Level II*, the interaction between developer and user becomes more active. Success occurs when technology knowledge is transferred across personal or organizational borders and it is

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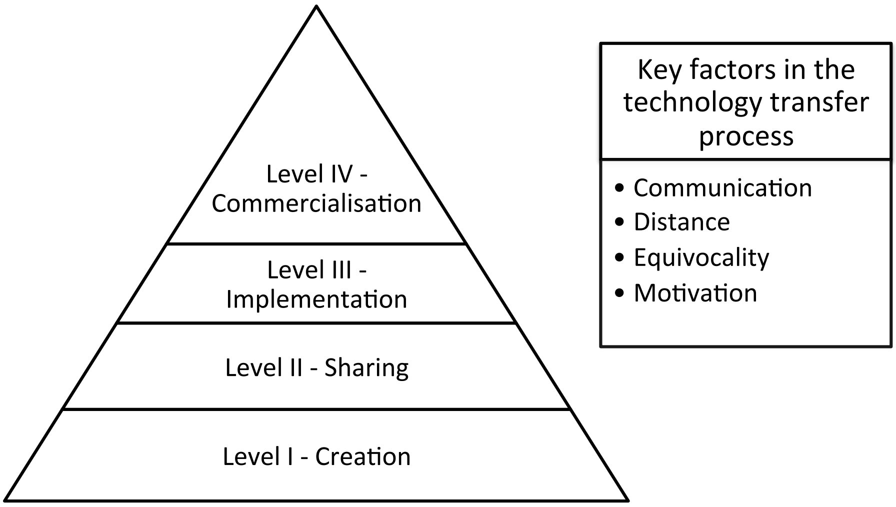
[1] The underlying proposition of the *appropiability model* is that the technology transfer occurs either when there is a user for the technology or the technology has been announced in the market (Wahab et al. 2009)..

[2] The *dissemination model* suggests that experts are the means by which the specialized knowledge is transferred to the willing user (Wahab et al. 2009).

[3] The *knowledge utilization model* represents an evolution of the previous two models. In this model, two elements are emphasized: (1) the role of communication between the technology developers and the users; and (2) the existence of organizational barriers and facilitators in the transfer process (Wahab et al. 2009).P

[4] The *communication model* adds an additional perspective to the previous three models. This model stresses that the interaction between developer and user is characterized by a two-way communication (Wahab et al. 2009). Technology transfer is recognised as a complex process that is magnified when crossing organisational limits (Gibson and Smilor 1991).

accepted and understood by a particular group of users. At *Level III*, success is achieved by the timely and efficient implementation of the transferred knowledge within the user organization in terms of manufacturing or other processes, services or best practices. At *Level IV*, the target of the transfer process is commercialisation.



Source: the author. Adapted from Sung and Gibson 2000

Figure 2-4 Gibson and collaborators' model

This model recognises four key factors in the technology transfer process: 1) *communication*, 2) *distance*, 3) *equivocality*, and 4) *motivation*.

Communication refers to "the degree to which a medium is able to efficiently and accurately convey task-relevant information and media richness" (Sung and Gibson 2000). Passive communications are media-based while interactive communications are basically person-to-person based. Passive communications target many receptors, but frequently the sender is unaware of whether the receptors receive and use the information. In contrast, interactive communications involve intensive communication between senders and receptors (Sung and Gibson 2000).

Distance comprises both cultural and geographical proximity (Gibson and Smilor 1991), however Sung and Gibson (2000) suggest that cultural differences are more important than geographical separation. Cultural proximity is a relevant predictor of whether communications between technology developers and users will be facilitated or discouraged. They point out “the more developers and users understand the values, attitudes, and ways of doing things each other, the greater the chance of successful transfer of knowledge and technology” (Sung and Gibson 2000).

Equivocality indicates “the degree of concreteness of knowledge and technology to be transferred” (Sung and Gibson 2000). Sung and Gibson (2000) argue that “highly equivocal knowledge is harder to understand, more difficult to demonstrate, and more ambiguous in its potential applications” (Sung and Gibson 2000).

Motivation, on the other hand, concerns individuals’ motivations to participate and supporting knowledge and technology transfer processes. This factor comprises the incentives that organizations give to their members who engage in transfer activities. Sung and Gibson (2000) indicate that motivations become critical when the target of the transfer process is closer to commercialisation.

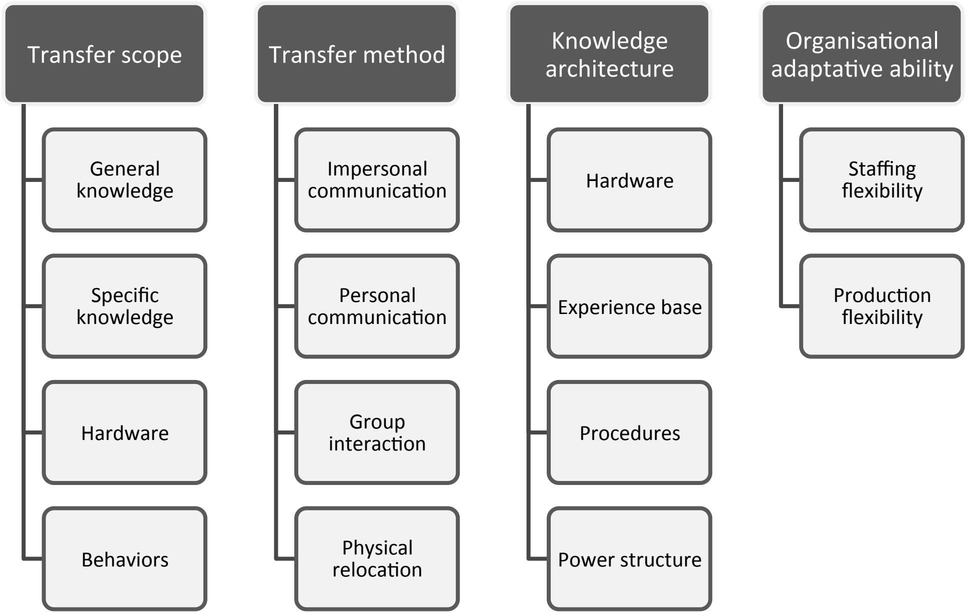
Rebentisch and Ferretti’s model

Rebentish and Ferretti (1995) propose a technology transfer framework that features four dimensions (Figure 2.5):

1. Transfer scope.
2. Transfer method.
3. Knowledge architecture.
4. Organisational adaptive ability.

Transfer scope describes the level of embodiment of the technology that is going to be transferred. Two sub-dimensions are covered in this dimension: how much information is embodied in the technology and the type of technology. These two sub-dimensions are combined to form four categories: (1) general knowledge, (2) specific knowledge, (3) hardware and (4) behaviours.

General knowledge is the simplest form of knowledge transferred between organisations. This kind of knowledge, although easy to transfer, does not allow the recipient to reproduce the capabilities of its partner. *Specific knowledge*, on the contrary, provides the recipient firm with enough information to reproduce its partner’s capabilities. *Hardware* embodies knowledge or experience into a physical device, and the last category, *behaviours*, comprises knowledge that is embodied in people’s actions and interactions. This last category of knowledge is commonly referred to as tacit knowledge and comprises a greater amount and richer type of embodied knowledge than the previous three (Rebentish and Ferretti 1995).



Source: the author. Adapted from Rebentish and Ferretti 1995

Figure 2-5 Rebentisch and Ferretti's model

Transfer method refers to the way or mechanism to transfer the technology. This dimension of the framework includes four methods: (1) impersonal communication, (2) personal communication, (3) group interaction, and (4) physical relocation.

The first method, *impersonal communication*, takes place through documents, graphic representations or material objects. This method is able to transfer relatively more information, but provides no immediate feedback to determine whether the receiver understands what is being communicated. *Personal communication* is performed by verbal communication, and it may include telephonic conversations or videoconferences. It occurs in real time between distant individuals and allows for immediate feedback. *Group interaction*, on the other hand, is also performed in real time by verbal communication, but it occurs through face-to-face meetings or organisational structures intended to facilitate the flow of information between individuals. *Physical relocation* comprises multiple forms of communication; it includes combinations of face-to-face interactions with documents and field observations. This method brings the people involved in the transference to the site where they can observe the technology in the context in which it operates (Rebentish and Ferretti 1995).

Knowledge architecture indicates the structure and interdependencies of the knowledge assets of the firm. This dimension specifies the way by which an organisation stores and process information. Rebentish and Ferretti (1995) argue that technologies are part of an organisation's overall knowledge architecture, and therefore they may have interdependent relationships with other elements in that architecture. This argument implies that it is critical to understand the interdependence of such knowledge with other assets in the providing organisation that could impede the transference of technology.

Knowledge architecture considers four components: (1) technology hardware, (2) experience base, (3) procedures, and (4) organisational power structure. The first component, *technology hardware*, comprises the physical and operational systems that allow the technology to provide a specific service. Thus, technology is easily transferred between sites if the technology hardware systems at the receiver site are relatively similar to the providing site.

The second component, *experience base*, refers to the technical, operational and product-related knowledge that the members of an organisation possess. Rebentish and Ferretti (1995) stress that technology transfer may not be successful if the receiving organisation does not have prior experience or knowledge about the technology. Indeed, the receiver organisation may not be aware of the existence of such technology.

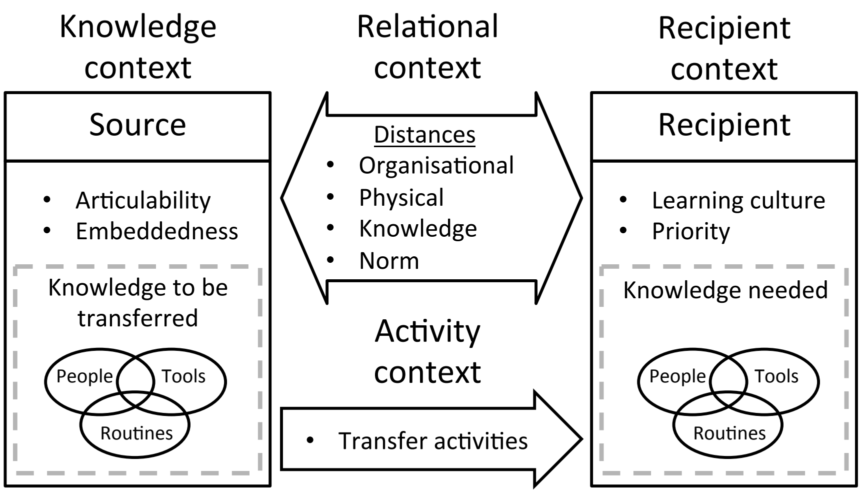
The third component, *procedures*, comprises the formal and informal operational rules that coordinate the activities and responsibilities of the members of an organisation. Procedures are dynamic and grow around an organisation's technologies, experience base, and power structure; therefore procedures are an integral part of the knowledge architecture.

Finally, the last component is the *power structure of the organisation*. This component determines what knowledge is valued and who will use it and how it will be used. Changes in the technology base of an organisation can raise shifts in the relative power of internal groups. Consequently, technology transfer initiatives may be interfered with, or facilitated, by a person, group or power coalition within the receiver organisation (Rebentish and Ferretti 1995).

The last dimension of the model, ***organisational adaptive ability***, refers to the ability of an organisation to modify its knowledge architecture over time to assimilate a new technology. This element of the framework denotes two characteristics of organisations: staffing flexibility and production flexibility. The former refers to an organisations' ability to use their members to fulfil the gap between its existing knowledge architecture and the architecture demanded by the new technology. The second characteristic, production flexibility, expresses the availability of additional resources or productive capacity to respond to non-routine events such as engineering-problem solving, modifications to existing equipment, or pilot trials (Rebentish and Ferretti 1995).

Cummings and Teng's model

Cummings and Teng (2003) explore the factors affecting the transfer of R&D knowledge. They argue that knowledge transfer occurs across four contextual domains: *knowledge context*, *relational context*, *recipient context* and *activity context* (Figure 2.6).



Source: Cummings and Teng 2003

Figure 2-6 Cummings and Teng's model

Knowledge context comprises two key factors: (1) knowledge's embeddedness and (2) articulability. *Embeddedness* refers to the extent to which the knowledge resides in individuals, in physical products, organizational routines or sub-networks. Cummings and Teng (2003) argue that transferring knowledge is more difficult when the knowledge resides in multiple knowledge reservoirs and sub-networks. *Knowledge articulability* is the extent to which knowledge can be verbalised, written, drawn or otherwise articulated. They point out that tacit knowledge is hard to communicate because it is non-verbalized, intuitive and unarticulated; and the only way to communicate it is through actions, involvement and commitment within a specific context. In contrast, product-based knowledge is codifiable, therefore, more articulable than tacit knowledge. They argue that poorly articulated knowledge is difficult to transfer within the members of an organisation (Cummings and Teng 2003).

Relational context comprises four variables: (1) organisational distance, (2) physical distance, (3) knowledge distance and (4) norm distance. *Organisational distance* refers to the degree of organisational integration between the participant units in the transfer initiative. *Physical distance* makes communication between developers and users more difficult, increases expenses and requires more time. Face-to-face interactions have been found superior to other communication formats in knowledge transfer. *Knowledge distance* refers to the degree to which the developer and user possess similar knowledge. Finally, *norm distance* refers to the degree to which participating organisations share the same organisational culture and value systems (Cummings and Teng 2003).

Recipient context comprises project priority and predisposition for learning. It is proposed that a greater motivation to support the transference occurs when the recipient organisation sees the knowledge transfer project as highly important (Cummings and Teng 2003). In addition, a culture of learning in an organisation facilitates knowledge transfer. Cummings and Teng (2003) point out that a willing recipient is not enough; knowledge must be retained to achieve effective technology transfer.

Activity context includes three interdependent types of knowledge transfer activities: (1) assessment of the form and embeddedness of the knowledge, (2) management of the administrative structure to solve any issue between participating organisations, and (3) those activities focused on transferring the knowledge (Cummings and Teng 2003).

2.2.2 Knowledge-based view of the firm

The knowledge-based view (KBV) of the firm offers another perspective of factors that affect the performance of technology collaborations. This theoretical perspective considers knowledge as a key resource to build competitive advantage (Grant 1996, Szulanski 1996). The main focus of KBV is the transfer (Szulanski 1996) and application (Grant 1996) of knowledge within an organisation. The models proposed by Gabriel Szulanski and by Robert Grant propose internal barriers to transfer and apply knowledge. Their models offer concepts needed to identify the inter-organisational factors that may limit the internalisation of new knowledge. The core elements in their models are described below.

Szulanski's model

Szulanski (1996) argues that a critical component in a firm's ability to build competitive advantage is the ability to transfer practices internally. He explores a series of factors that could become barriers to transfer knowledge within the firm. He distinguishes four stages in the transfer process: (1) initiation, (2) implementation, (3) ramp-up, and (4) integration.

The first stage, *initiation*, comprises activities and events that lead to the decision to transfer. A necessary condition in this stage is that both the need and the knowledge to meet that need coexist within the organization.

The next stage, *implementation*, begins with the decision to proceed and finishes when knowledge has been transferred to the recipient or potential user. In this stage the knowledge flow is enabled by transfer-specific social ties.

The *ramp-up* stage starts as soon as the recipient applies the knowledge. This stage is characterized by the emergence of unexpected problems to apply the knowledge and by the gradual improvement in the use of the knowledge.

The last phase, *integration*, starts when the recipient achieves a satisfactory command of the transferred knowledge. In this phase, the knowledge use is gradually routinized and subsequently incorporated in the meanings and behaviours of the members of the organisation that participate in its application.

Szulanski (1996) also observes that four factors can affect the difficulty of transferring knowledge within an organisation:

1. Characteristics of the knowledge transferred.
2. Characteristics of the source.
3. Characteristics of the recipient.
4. Context of the knowledge transfer.

Characteristics of the knowledge transferred

Szulanski (1996) stresses two characteristics of the knowledge that influence the difficulty of its transfer: causal ambiguity and unproveness. *Causal ambiguity* is present when the precise reasons for failure or success to replicate a capability in a new setting cannot be determined. Knowledge tacitness and idiosyncratic features of the new context contribute to causal ambiguity. *Unproveness* indicates whether or not the knowledge has been proven to be useful in the past. Knowledge without a proven record of past usefulness is more difficult to transfer (Szulanski 1996).

Characteristics of the source of knowledge

Lack of motivation and reliability of the source are two features of the source of the knowledge highlighted in Szulanski's model. On the one hand, knowledge transfer is more difficult when the source is unwilling to share it. The source may not be interested in sharing critical knowledge for several reasons, including fear of losing ownership, inadequate rewards or unwillingness to dedicate time and resources to support the transfer. On the other hand, knowledge recipients may resist accepting information and advice from a source that is not perceived as reliable. A trustworthy and knowledgeable source is more likely to influence the behaviour of a recipient (Szulanski 1996).

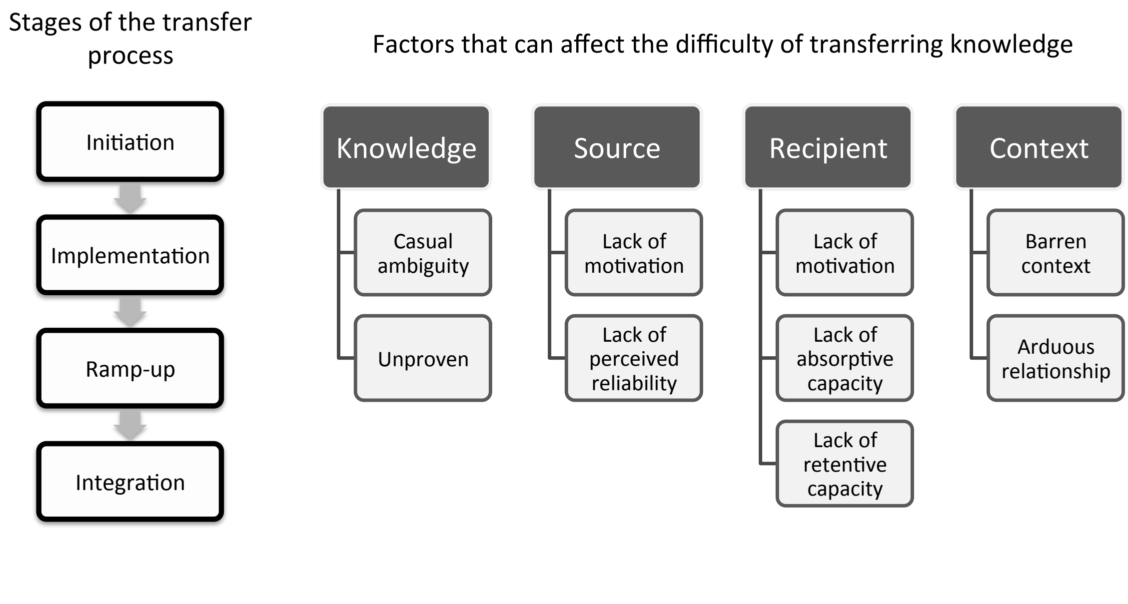
Characteristics of the recipient

Szulanski's model states three features of the recipient that affect the transfer process: (1) lack of motivation, (2) lack of absorptive capacity, and (3) lack of retentive capacity. The *lack of motivation* results in a rejection in the implementation and use of new knowledge; *lack of absorptive capacity* results in the inability to value, assimilate and apply new knowledge, and; *lack of retentive capacity* reflects the ability of the recipient to internalize (Cumming and Teng 2003) the use of new knowledge (Szulanski 1996).

Characteristics of the context

Two characteristics of the context are pointed out in Szulanski's model: barren organisational context and arduous relationship. The *organisational context* includes for example systems, formal structures and behaviour-framing attributes. The organisational context affects the number of attempts and outcomes of knowledge transfer initiatives. The second characteristic, *arduous relationship*, regards to the relationships between individuals. These relationships are particularly important to enable communication and transfer the tacit components of the knowledge (Szulanski 1996).

Figure 2.7 shows the stages of the transfer process and the factors that affect the difficulty of transferring the knowledge within an organisation.



Source: the author. Adapted from Szulanski 1996

Figure 2-7 Szulanski's model

Grant's model

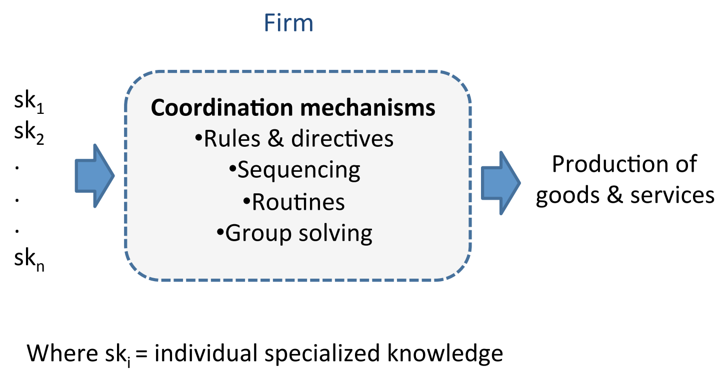
There are two main distinctive propositions in Grant's model (Grant 1996). First, knowledge creation is an individual activity, therefore each person possesses different knowledge. The assumption is based upon the principle of "bounded rationality" which proposes that the human brain has limited capacity to acquire, store and process knowledge. Consequently, individuals tend to specialize in particular areas of knowledge. Second, the primary function of firms is the integration and application of existing knowledge to the production of goods and services. The underlying assumption is that knowledge is a critical input in production and a primary source of value (Grant 1996). Grant (1996) stresses that firms achieve efficiency through effective knowledge integration and not by effective technology transfer.

Grant's knowledge-based theory points out that firms are able to offer products and services because they provide the conditions under which multiple individuals integrate their specialist knowledge. Efficient value creation results through systemic application of individuals' knowledge, but it is often problematic to achieve cooperation and effective coordination (Grant 1996). Grant (1996) suggests that the mechanisms that facilitate the systemic integration of knowledge across different 'specialized organizational units' are divided in four categories (Figure 2.8):

1. Rules and directives.
2. Sequencing.
3. Routines.
4. Group problem solving.

The ***rules and directives*** category involves plans, schedules, forecasts, rules, policies, and procedures among others. ***Sequencing*** considers organization of production activities in time-patterned progression. ***Routines*** may be simple sequences; nevertheless their distinctive feature is their ability to support complex patterns of interactions between individuals in the absence of rules, directives, or even significant verbal communication. ***Group problem solving*** is the more personal and communication-intensive form of knowledge integration (Grant 1996).

The effective operation of mechanisms described above depends on the existence of common knowledge, which includes the elements of knowledge that are common to all the members of the organisation (Grant 1996). The elements of the common knowledge include language, symbolic communications, commonality of specialized knowledge, shared meaning, and recognition of individual knowledge domains (Grant 1996). Grant (1996) argues that a more efficient integration is achieved when it is higher the level of common knowledge between the members of an organisation.



Source: the author based on Grant 1996.

Figure 2-8 The knowledge-based view of the firm

2.2.3 External technology integration in the development of new products

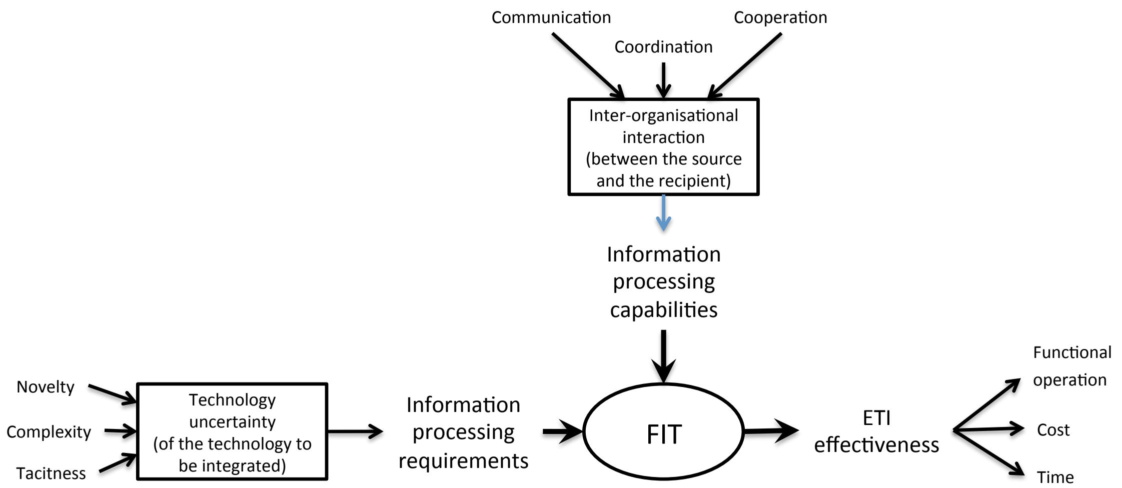
To close Section 2.2, the perspective of the external technology integration (ETI) in the context of the new product development process is described. Tatikonda and Stock are the main supporters of this perspective, having explored the conditions that enable the integration of external technologies into a new product (Tatikonda and Stock 2003, Stock and Tatikonda 2004). They built a conceptual framework upon the combination of two theoretical approaches: information processing theory and the interdependence theory. Their framework combines two key elements: *technology uncertainty* and *inter-organisational interaction* (Figure 2.9). They suggest that technology transfer effectiveness is greatest when participant companies match the type of technology with the appropriate design, implementation and management of the inter-organisational interaction between supplier and recipient (Tatikonda and Stock 2003).

Technology uncertainty is characterised by three dimensions: technology novelty, complexity and tacitness. Technology *novelty* refers to both the degree of experience of the recipient company with the technology and the degree of change of the technology in relation to prior technologies. Technology *complexity* refers to the interdependence level among the elements of the technology within a system and its operating environment, as well as the scope of the technology[5]. *Tacitness* refers to the degree to

[5] The scope of the technology comprises the number of people working on and the functional areas represented in the development effort (Tatikonda and Stock 2003).

which the technology is embodied in a physical device, textually or graphically codified and complete[6].

The second element of the model, ***inter-organisational interaction***, is described by three dimensions: communication, coordination and cooperation between the developer and recipient organisations. Tatikonda and Stock (2003) point out that despite these dimensions being conceptually different, in practice they can overlap somewhat. They observe that the higher levels of *communication*, *coordination* and *cooperation*, the higher interaction between technology developer and recipient. Under such a context of higher levels of interaction, both developer and recipient practically become a single temporary organisation (Tatikonda and Stock 2003).



Source: Stock and Tatikonda 2004.

Figure 2-9 Tatikonda and Stock's analytical framework

Tatikonda and Stock (2003) stress that the main focus of their framework is to highlight the technical dimensions that are related to the challenges associated with transferring product technology in the context of new product development. They argue that an accurate assessment of the technology uncertainty of the product technology that is transferred would lead to a better design, implementation and management of the inter-organisational interaction between the developer and recipient. They observe that the performance of a new product development project depends also on other project

[6] Technology completeness indicates the level of predictability of its functional performance or, in other words, the maturity of the technology (Tatikonda and Stock 2003).

management factors, but the identification of these factors was out of the scope of their research.

Recently, Cui et al. (2012) published a paper that explores the factors that influence the effective integration of external technologies in the new product development process. Based on the analysis of 31 projects, they identified success drivers in development collaborations that are related to the maturity of the technology. They observe that successful integration of embryonic technologies is characterised by trust and communication, organisational stability of the supplier and defined goals. In the case of mature technologies, they found that project success also depends on compatibility of the technology with existing systems architecture and flexibility of the supplier to adjust components to accommodate broader systems requirements.

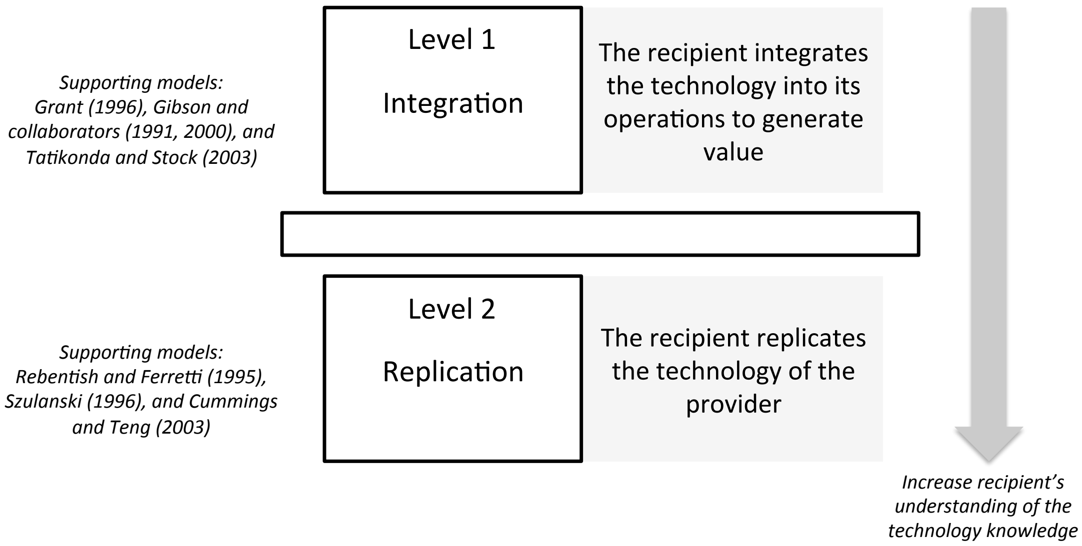
2.2.4 Summary

The three theoretical approaches presented in this section emphasize that technology characteristics, ease of communication and the transfer context influence how effectively a technology is moved from the provider to the recipient. Nevertheless, this perspective does not explain the motivations that drive the provider and receiver to engage in a technology transfer project, which seems to be important to understand the factors that affect TA by collaboration.

In addition, it is worth mentioning that the knowledge and technology transfer perspective suggests that there are two levels of internalization of technology from the perspective of the recipient. The first level is more superficial and it is achieved when the recipient understands how to integrate the technology to their daily operations. The models proposed by Grant, Gibson and collaborators, as well as Tatikonda and Stock support this level of transference[7]. The second, and deepest, level of internalisation is achieved when the recipient absorbs all the technology knowledge that is behind a particular technology and it is able to replicate it. The models proposed by Rebentish and Ferretti, Szulanski, and Cummings and Teng seem to support this level of

[7] Grant's model suggests that firms get value through the effective integration of technology and specialised knowledge. Gibson's model identifies four levels of transference, which span from passive communications between provider and receiver to intensive interactions aimed at applying the technology for commercial purposes. Tatikonda and Stock, likewise, argue that providers help receivers to incorporate the technology into their operations. These three models do not indicate that the receivers should be able to replicate the technology but rather understand the technology and how it adds value to their operations.

transference. Their models provide a series of conditions that affect how effectively a particular technology or knowledge is moved from the provider to the receiver. Figure 2.10 shows a representation of the levels of internalisation of technology suggested by the knowledge and technology transfer models discussed in this subsection. This research concerns the level where the technology is integrated into the operations of the recipient to generate value (level 1).



Source: the author

Figure 2-10 Dimensions of internalisation of technology

2.3 Managerial and organisational barriers

This section explores the organizational and managerial barriers that affect communication and coordination between independent organisations. The barriers are explored from the perspective of the organisation that receives the technology. This section comprises three subsections, each one describes organisational and managerial barriers from different bodies of literature. Section 2.3.1 presents the factors that affect the performance of collaborations reported in the new product development management literature. Section 2.3.2 presents the conditions that allow for effective collaboration described in the body of literature concerning collaboration and strategic alliance management. Finally, section 2.3.3 provides an overview of the organisational culture literature and the dimensions of culture that are relevant to explain communication barriers between independent organisations.

2.3.1 New product development management

New Product Development (NPD) is the part of the innovation process where activities are typically known and structured. Traditional NPD begins with the selection of business ideas and finishes with the launching of a new product[8]. NPD is a project screening process. Business ideas are matured and their success viability is defined by technical and economic evaluations. Figure 2.11 shows a generic NPD process, which is linked to a technology development process. This model indicates that the outcomes of technology development projects can go into a NP process at gate 1, 2 or 3 (Cooper 2006). Before each stage there is a decision point where the progress of the project is evaluated. Gates are predefined and described by a set of deliverables, a list of criteria for assessment and an output (Cooper 2001). Those projects that do not meet the evaluation criteria are discarded.

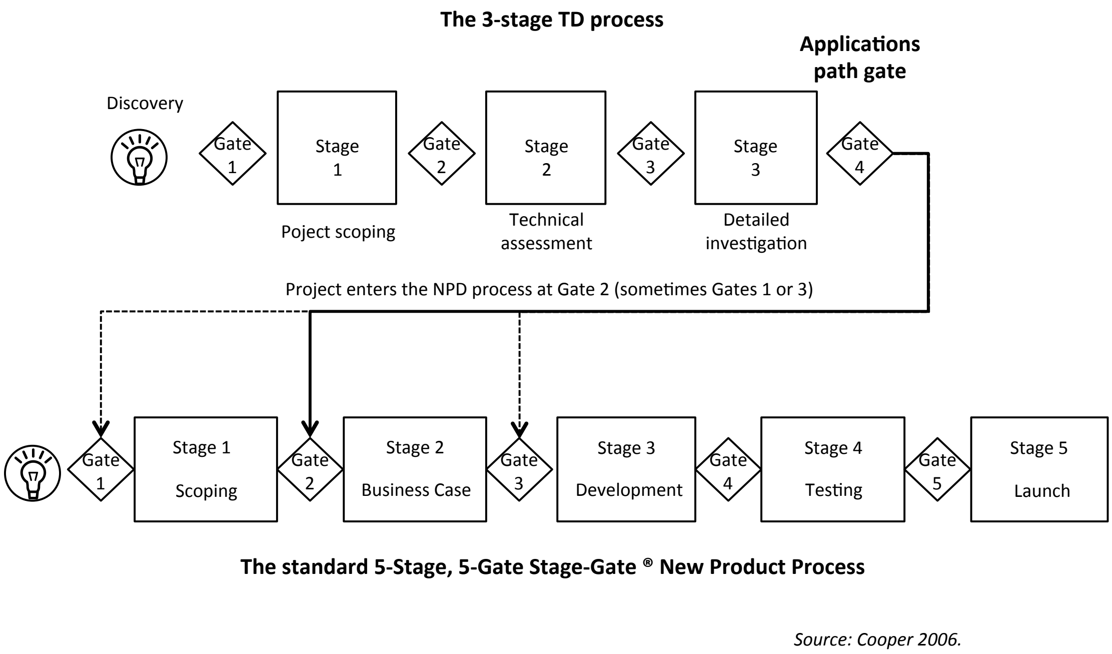


Figure 2-11 Generic stage-gate new product process

[8] Cooper (2001) defines newness in two senses: 1) New to the technology receiver, in the sense that the firm has never made or sold this type before, but other firms might have; 2) New to the market, when there is not any similar product available in the market.

Fraser et al. (2003) argue that product development is inherently a collaborative activity because it involves both internal groups and external partners. External partners can be broadly divided in two types: (1) suppliers, which comprise for instance technology or material/component providers; and (2) customers, which include for example final users and manufacturers. External partners may join the development process at different stages (Handfield et al. 1999). In radical and complex development projects, partners are frequently involved at early stages of the development process (Rothwell 1994, Ragatz et al. 2002, Petersen, et al. 2005).

Supplier involvement

The benefits of involving suppliers in product development projects are often associated with cost reductions, shorter concept-to-customer development time, quality improvements and incorporation of new technologies (Cuthill et al. 1997, Handfield et al. 1999, Petersen et al. 2005). Suppliers can join the development process at different points depending on, for instance, the complexity of the project (Wagner and Hoegl 2006). Figure 2.12 shows possible supplier integration points (Handfield et al. 1999).

Authors have pointed out a number of issues in supplier integration, such as timing to involve suppliers in the process, inter-firm communication, intellectual property agreements and alignment of organisational objectives (Handfield et al. 1999). Some of the factors that seem to facilitate collaborative working with suppliers are a favourable past experience, business compatibility, probability of success of the new product, and

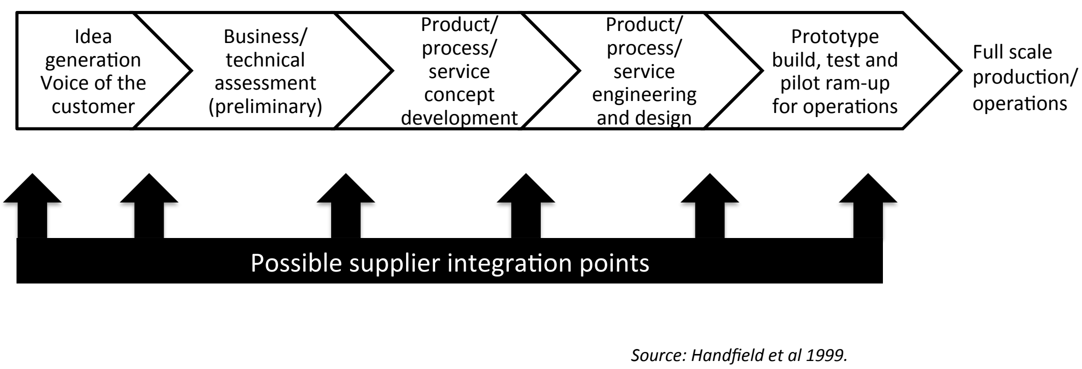


Figure 2-12 Possible supplier integration points in the new product development process

demonstrable financial stability (Cuthill et al. 1997). In addition, Monczka et al. (1998) observe that the following attributes of supplier collaborations are related to success: trust and coordination, interdependence, information sharing, joint problem solving as well as avoiding the use of severe tactics to solve conflicts.

However, involving suppliers in the development process may have some disadvantages. For example: selecting one supplier may limit the access to other technologies; having one single source may not be the cheapest option to cut production costs; and, technical capabilities may be lost in activities allocated to the supplier (Cuthill et al. 1997, Handfield et al. 1999). These circumstances make supplier selection a critical issue (Handfield 1999).

Customer involvement

Several authors have explored customers' involvement in development projects, in particular because they are considered a key source of innovation (Gales and Mansour-Cole 1995, Von Hippel 2005, Goffin et al. 2010). Customer involvement is frequently addressed in innovation literature (e.g. Goffin and Mitchell 2005, Ettlie and Pavlou 2006), where changes in the customer or user preferences are a key trigger to develop new products. In innovation projects, the customer is generally seen as the primary source of ideas to achieve commercial success.

There is a series of potential benefits of involving customers and users in the development of new products. These benefits include reducing time to market of new products, sharing development costs, reducing risks of new product failure and enabling the implementation of new technologies (Gales and Mansour-Cole 1995, Cuthill et al. 1997). Goffin et al. (2010) distinguish four points of customer involvement in the NPD process:

1. Ideation.
2. Design and development.
3. Market launch.
4. Modification and novel use.

In the ideation phase the customer or user generate ideas for new products and services. In the design and development phase, the product is co-developed in close cooperation with the sponsoring firm[9]. Just before launching a new product, customers can be involved in tests to define the final features of the product and marketing strategy. Finally, when a product is already in the market, customers can provide insights on new uses of the product or modifications to add functionality (Goffin et al. 2010).

However, despite the potential benefits of customer involvement, firms may face particular challenges to determine the appropriate level of involvement of the user (Gales and Mansour-Cole 1995). For example, in co-development projects that are initiated by a firm willing to explore new technologies for new products (Neale and Corkindale 199, Kim and Lee 2003), the relationship with the customer may depend greatly upon the success/failure of the new product (Cuthill et al. 1997). The firm may also become too dependent on one customer and it is possible that proprietary technology may be divulged (Cuthill et al. 1997). Some of the factors that allow for sustainable relationships with customers are positive impact on sales and profit, development of trust, risk sharing and financial support (Cuthill et al. 1997).

Influential factors

Literature on NPD has discussed a number of factors that can affect the outcomes of collaborative developments. Table 2.3 presents the factors that have been reported as relevant. For simplicity, these factors have been divided into four categories: partners alignment, partnership management, project execution and contextual factors. From Table 2.3 it can be observed that a significant proportion of factors are related to project execution.

[9] Goffin et al. (2010) point out that the involvement of customer or user at this phase of the development process result in *user-led innovations*.

Table 2-3 Factors affecting the outcomes of collaborative developments explored in NPD literature

Type of factor	Factor	Reference *See note at end.*
Partners alignment	Commitment	2
	Development cost sharing	18
	Motivations	2
	Mutual benefits	2
	Trust	2
Partnership management	Buyer-supplier relationship	13
	Collaboration management	6, 11, 14
	Partner selection	10, 13, 19
	Type of agreement	19
Project execution	Coordination	12
	Development team	3, 10, 13
	Development work sharing	18
	Project management	2, 9,16
	Establishment of clear goals	10
	Knowledge base overlap	15
	Product champion	1
	Product performance	7
	Supplier involvement	4, 12, 13
Contextual factors	Characteristics of the acquiring firm	17
	Product novelty	18
	Project characteristics	5, 8
	Technology novelty	5
	Technology uncertainty	7
	Type of partner	15, 19

References: [1] Chakrabarti 1974; [2] Littler et al. 1995; [3] Jassawalla and Sashittal 1998; [4] Handfield et al. 1999; [5] Tatikonda and Rosenthal 2000; [6] Deck and Strom 2002; [7] Ragatz 2002; [8] Tidd and Bodley 2002; [9] Fraser et al. 2003; [10] Petersen et al. 2005; [11] Emden et al. 2006; [12] Fliess and Becker 2006; [13] Wagner and Hoegl 2006; [14] Cooper 2006; [15] Knudsen 2007; [16] Cañez et al. 2007; [17] Barczak et al. 2009; [18] Bhaskaran and Krishnan 2009; [19] Faria et al. 2010.

2.3.2 Collaboration and strategic alliance management

Managing collaborations is a challenging activity (Ireland et al. 2002, Hacklin et al. 2006). Scholars and managers have reported that collaborations do not always meet the original expectations; for instance, some studies have found that more than half of collaborations fail (Duysters et al. 1999). Literature on management of strategic alliances has explored inter-organizational factors that ultimately influence the

Table 2-4 Factors explored in literature concerning collaborations and strategic alliance management.

Category	Factor	References *See note at end.*
Partners alignment	Alliance strategy	32, 48
	Importance of the project	9
	Managing of IPR	30
	Motivations	33, 39, 44, 55
	Problem definition	7
	Skills and resources in exchange	20, 39, 41
	Trust	7, 39
Partnership management	Type of agreement	1, 8, 24, 27, 37, 41, 47, 48, 50
	Collaboration management	5, 11, 13, 17, 25, 28
	Incentive alignment	7
	Involvement level	19, 22, 39
	Partner selection	3, 12, 16, 54
	Success factors	14, 18, 40
Project execution	Communication	7, 39
	Compatibility of operations	39, 43
	Coordination	35, 39, 56
	Cultural distance	43
	Knowledge and technology transfer	6, 42, 44
	Knowledge spill overs	49
	Organisational learning	42
	Performance of the project	58
Contextual factors	Characteristics of the acquiring firm	1, 7, 26, 29, 39, 44, 50
	Competitive environment	1, 24, 31, 33, 38, 46, 50, 57
	Experience in collaborative projects	10, 34, 43, 50
	Availability of financial resources	39
	Previous relationship	10
	Project characteristics	1, 4, 10, 17, 21, 43, 59
	Characteristics of the providing firm	1, 7, 10, 17, 29, 39, 43, 44, 48, 53
	Technology characteristics	2, 22, 43, 44
	Technology dynamism of industry	31
	Technology policy	45, 51
	Type of partner	2, 4, 15, 23, 36, 50, 52, 60

References: [1] Buse and Armonaitis 2011; [2] Cui et al. 2012; [3] Lee et al. 2010; [4] Paixao-Garcez et al. 2010; [5] Slowinski et al 2009; [6] Spivey et al. 2009; [7] Cui et al. 2009; [8] Baloh et al. 2008; [9] Lunnan and Haugland 2008; [10] McCutchen Jr et al. 2008; [11] Chesbrough and Schwartz 2007; [12] Hacklin et al. 2006; [13] Piachaud 2005; [14] Campione 2003; [15] Miotti and Sachwald 2003; [16] Das and Teng 2003; [17] Kim and Lee 2003; [18] Marxt and Link 2002; [19] McCutcheon and Stuart 2000; [20] Das and Teng 2000; [21] Cagliano et al. 2000; [22] Steensma and Corley 2000; [23] Kaufman et al 2000; [24] Narula and Hagedorn 1999; [25] Duysters et al. 1999; [26] Robertson and Gatignon 1998; [27] Chiesa and Manzini 1998; [28] Bronder and Pritzl 1992; [29] Minshall et al. 2010; [30] Mehlman et al. 2010; [31] Ang 2008; [32] Yasuad and Iijima 2005; [33] Yasuda 2005; [34] Reurer and Zollo 2005; [35] Gerwin 2004; [36] Belderbos et al. 2004; [37] Colombo 2003; [38] Vilkamo and Keil 2003; [39] Williams and Lilley 1993; [40] Barnes et al. 2006; [41] Lin et al. 2009; [42] Inkpen 1998; [43] Simonin 1999; [44] Simonin 2004; [45] Hagedoorn et al. 2000; [46] Hagedoorn 1995; [47] Hagedoorn 1996; [48] Hipkin and Naude 2006; [49] Jordan and Lowe 2004; [50] Lhuillery and Pfister 2009; [51] MacKinnon 1989; [52] Thuriaux-alemán et al. 2010; [53] Varis et al. 2004; [54] Caetano and Amaral 2011; [55] Hagedoorn 1993; [56] Enberg 2012; [57] Wu 2012; [58] Lin et al. 2012; [59] Lager and Frishammar 2010; [60] Un et al. 2010.

performance of alliances. A detailed list of factors addressed in this literature is shown in Table 2.4. The factors have been also divided into four categories: partners alignment, partnership management, project execution and contractual factors.

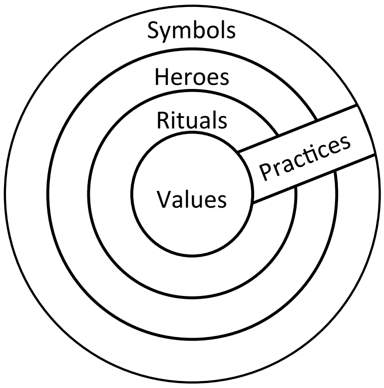
This body of literature points out factors such as acquiring firm characteristics (e.g. Cui et al. 2009, Buse and Armonaitis, 2011), providing firm characteristics (e.g. Kim and Lee 2003, McCutchen Jr et al. 2008), type of partner (e.g. Miotti and Sachwald 2003, Cui et al. 2012), type of agreement (e.g.Colombo 2003, Baloh et al. 2008), and competitive environment (e.g.Yasuda 2005, Ang 2008) amongst others as influential in the outcomes of strategic alliances.

2.3.3 Organisational culture

Culture can influence the quality of the communication between independent organisations. Culture is often referred to as "the collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede G. 1991, p.5). However, many scholars agree that culture is something difficult to define. It comprises a pattern of beliefs and values that are manifested in practices, behaviours, and various artefacts shared by members of an organisation or a nation (Hofstede 1980).

Differences in culture are manifested in several ways. Hofstede (1991) considers that culture can be described by four elements: symbols, heroes, rituals and values. The first three are visible to an outside observer and they can be summarised as practices. In contrast, values are unconscious feelings therefore they cannot be observed and they are only manifested through peoples' behaviour. Figure 2.13 shows that "symbols represent the most superficial and values the deepest manifestations of culture, with heroes and rituals in between" (Hofstede 1991, p.7).

Scholars suggest that there are many ways to compare cultural differences between organisations. Table 2.5 shows some of the dimensions that have been proposed by different authors. Each of these dimensions comprises a number of practices and organisation characteristics. These dimensions are useful to examine the critical differences between independent organisations.



Source: Hofstede 1991.

Figure 2-13 Manifestations of culture at different levels of depth

Table 2-5 Dimensions of organizational culture suggested by different authors

Author	Dimensions of organisational culture
O'Reilly et al. 1991	• Innovation. • Outcome orientation. • Respect for people. • Team orientation. • Stability. • Aggressiveness. • Attention to detail.
Denison and Mishre 1995	• Adaptability of the organisation. • Mission/goal orientation. • Employee involvement and participation.
Cunha and Cooper 2002	• Organisational orientation. • Performance orientation. • People orientation. • Market orientation.
Khan et al. 2010	• Support orientation. • Innovation orientation. • Co-ordination. • Rules orientation.
Waisfisz and Hofstede §	• Means oriented vs goal oriented. • Internally driven vs externally driven. • Easy going work discipline vs strict work discipline. • Local vs professional. • Open system vs closed system. • Employee oriented vs work oriented. • Degree of acceptance of leadership style. • Degree of identification with the organisation.

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In short, firms' culture is expressed by means of their practices and values. Thus, differences in practices between partnering firms may lead to communication and coordination problems, while differences in values may lead to disagreements in negotiations and decision making during joint projects.

2.3.4 Summary

This section has presented an overview of influential factors on inter-firm collaborations that have been reported in three strands of literature: new product development, management of strategic alliances and organisational culture. On the one hand, literatures on NPD and strategic alliances have reported a very large number of factors that affect the outcome of inter-firm relationships. Those factors were broadly divided into four categories: partners alignment, partnership management, project execution and contextual factors. On the other hand, literature on organisational culture suggests that the differences in practices and values between partnering firms may become a barrier for communication and decision-making in collaborative projects.

2.4 Strategic management perspective

This section presents two theoretical concepts that address how firms build competitive advantage by exploiting external technologies. One of the main drivers to enter into collaborative agreements is to obtain access to resources required to build and sustain competitive advantages (Bruce et al. 1995). According to Michael Porter (1980) there are three main generic strategies that firms can follow to outperform other firms in their industry: overall cost leadership, differentiation and focus. Quite frequently, firms follow more than one of these strategies (Porter 1980). However, none of these generic strategies is effective if a firm's competitors can replicate it; thus, the sustainability of a generic strategy requires that a firm develops barriers to prevent their competitors from imitating it (Porter 1985). These competitive barriers are explained by well-known theoretical approaches such as the resource-based view, transaction cost economics (TCE), absorptive capacity, agency theory and transaction value theory. In this section the resource based view and absorptive capacity are described because they offer relevant elements to understand how firm develop new competences by means of technology collaborations[10].

2.4.1 Resource based view

The Resource Based View (RBV) contends that firms are collection of tangible and intangible resources (Das and Teng 2000). When these resources are valuable, rare, inimitable and nonsubstitutable they lead to unique capabilities (Barney 1991) and, therefore, to creating competitive advantages.

The RBV has been used within the last decade to explain the formation, structure and performance of strategic alliances (Das and Teng 2000, Tsang 1998). It is appropriate for explaining the formation of strategic alliances because firms enter into collaborative ventures with the purpose of gaining access to external resources to achieve or sustain a competitive advantage.

The basic proposition of the RBV is that firms are a set of tangible and intangible resources that in combination yield productive services (or capabilities). A productive service is the result of the way in which such resources are used in the firm and defines its capability of achieving a specific job function or activity. Thus, firms' capabilities are embedded in their organizational resources rather than in individuals (Tsang 1998).

There are different ways to classify the resources of a firm. For example, Barney (1991) suggests three categories, namely physical resources, human resources and organizational resources.

- *Physical resources* include tangible assets such as land, plant, equipment, finished and semi-finished goods, as well as intangible resources such as brand name, copyrights and patents.
- *Human resources* include training, experience, relationships, skills and intelligence of the firm's staff.

[10] Despite TCE, agency theory and transaction value theory offer a very good basis to explain inter-firm collaborations and contractual modes for governing the relationship, they are not described in the literature review because their contribution to our understanding of building competitive advantage from technology collaborations is marginal compared to RBV and absorptive capacity. However, the relevant elements of these theories will be referred to when useful in this document.

- *Organizational resources* refer to corporate culture, organizational structure, rules, procedures, management and information systems, as well as a firm's relationships with external institutions (Barney 1991).

On the other hand, Das and Teng (2000) propose that the resources of a firm may also be classified into two wide categories: property-based resources and knowledge-based resources. The former are resources legally owned by firms, including financial capital, physical resources and human resources. The latter refers to firm's intangible know-how, skills, as well as technical and managerial systems.

In the case of property-based resources, owners enjoy clear property rights of these resources, or rights to use the resources, so that others cannot take them away without the owners' consent. Thus, *property-based resources* may be imitable but they cannot be easily obtained, because they are legally protected through property rights in such forms as patents or contracts. In contrast, *knowledge-based resources* are not easily imitable because of knowledge and information barriers and, in consequence, are much more difficult to transfer (Das and Teng 2000).

RBV suggests that valuable firm's resources are scarce, imperfectly imitable or mobile, and lacking in direct substitutes (Barney 1991). Therefore, certain resources are not perfectly tradable, as they are either mixed with other resources or embedded in organizational structures (Das and Teng 2000). In addition, some resources can yield only one productive service at a time and the amount of service given by a resource in a predetermined period of time is generally limited. Other resources are able to offer one or more productive services simultaneously in virtually unlimited amounts. Technology and brands are two examples of this type of resources (Tsang 1998). This attribute of a resource is referred to as flexibility.

Table 2.6 summarizes the types of resources and their attributes suggested by the RBV. As mentioned above, combination of resources yields productive services. Due their attributes, productive services can be imperfectly imitable, imperfectly mobile, without substitutes and limited, either because of availability or flexibility of the associated resources. These characteristics are relevant to understand why firms enter into a collaboration agreement.

Table 2-6 Types of resources and their attributes suggested in the RBV

Types of resources	
Barney (1991)	Das and Teng (2000)
• Physical resources • Human resources • Organizational resources	• Property-based resources • Knowledge-based resources
Resources attributes	
• Availability • Imitability • Mobility • Substitutability • Flexibility	

2.4.2 Absorptive capacity

Absorptive capacity (ACAP) is a theoretical concept that has evolved over the last 20 years. Originally Cohen and Levinthal (1990) defined ACAP as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends…". Later Zahra and George (2002) reviewed the concept and proposed a new definition. They defined ACAP as a "set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (Zahra and George 2002). Recently Jiménez-Barrionuevo et al. (2011) pointed out that ACAP is "the organisation's relative ability to develop a set of organisational routines and strategic processes through which it acquires, assimilates, transforms and exploits knowledge acquired from outside the organisation to create value".

The last two definitions stress that ACAP is dynamic and they indicate that it is not only about acquiring and using knowledge generated outside. ACAP is about the ability to continuously improve routines and processes to exploit external knowledge. Indeed, ACAP has been found to be a strong predictor of innovation output (Hurmelinna-Laukkanen et al. 2012) and it is considered an ability that firms develop in order to build and sustain competitive advantage (Zahra and George 2002, Jiménez-Barrionuevo et al. 2011).

The definition proposed by Jiménez-Barrionuevo et al. (2011) distinguishes four dimensions in ACAP: (1) acquisition, (2) assimilation, (3) transformation and (4) exploitation of external knowledge.

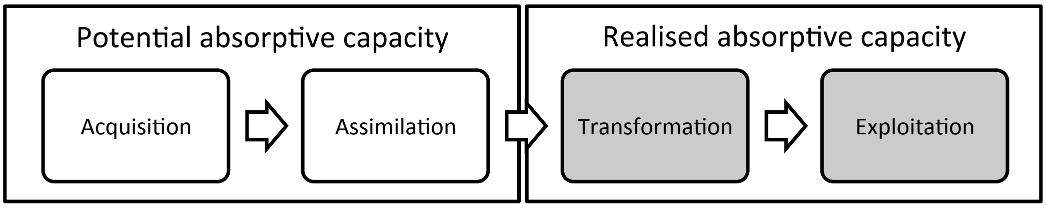
The *first* dimension refers to a firm's ability to locate, identify, evaluate and acquire externally generated knowledge that is critical to its operations. The *second* dimension is the ability to comprehend external knowledge. This ability includes the capacity to analyse, classify, process, interpret and ultimately understand the knowledge brought from outside the organisation. The *third* dimension refers to the ability to facilitate the transfer and combination of prior knowledge with newly assimilated knowledge. This ability comprises the capacity to combine new and existing knowledge in a different way. The *last* dimension is the ability to incorporate the external knowledge into the operations and routines of the focal firm. This is the ability through which a firm improves and creates new goods, systems, processes, organisational forms and also competences (Jiménez-Barrionuevo et al. 2011).

ACAP is described by two independent and complementary components: (1) potential and (2) realized absorptive capacity (Zahra and George 2002, Jiménez-Barrionuevo et al. 2011). The difference between these two components is the ability of a firm to generate value from the newly acquired knowledge.

Potential absorptive capacity reflects the ability of a firm to acquire and assimilate external knowledge. Such knowledge can be internalized and disseminated within the firm, but the firm might not have the technical capacities required to transform and exploit the knowledge that has been absorbed (Zahra and George 2002).

Realized absorptive capacity denotes a firm's ability to transform and exploit external knowledge. This ability largely depends on the firm's technical capacities (Jiménez-Barrionuevo et al. 2011). Realized absorptive capacity is therefore the ability to incorporate new knowledge into firm's operations.

Therefore, potential and realised absorptive capacities indicate that this theoretical concept goes beyond merely the ability to understand external knowledge. ACAP is fully developed when firms apply the knowledge that is brought in from outside (George et al. 2001). Figure 2.14 graphically shows the relationship between the dimensions and components of ACAP.



Source: the author.

Figure 2-14 Dimensions and components of absorptive capacity

It is argued that ACAP is enabled by two elements: accumulated knowledge and possession of related knowledge (Cohen and Levinthal 1990). Thus, ACAP seems to be related with the intensity of investment on research or other capability-building activities (Fabrizio 2009). Indeed, several publications have explored different dimensions to measure ACAP. Typically, R&D spending (Cohen and Levinthal 1990, George et al. 2001, de Faria et al. 2010) and investment on personnel training (Escribano et al. 2009, de Faria et al. 2010) are two of the most common variables to measure the ACAP of a firm. However, scholars have suggested that ACAP is still an ambiguous concept since there is not a set of measures to determine the ACAP of a firm. Jiménez-Barrionuevo et al. (2011) recognise that there is a flow of knowledge from the organisation that creates the knowledge to the acquiring organisation. Consequently, ACAP also can be affected by inter-organisational factors such as trust, reciprocity, compatibility of cultures and management styles between the providing and acquiring organisations (Jimenez-Barrionuevo et al. 2011).

2.4.3 Summary

The two theoretical concepts discussed in this section provide a context to explain why firms are motivated to work in collaboration with industry partners. The resource-based view suggests that firms are likely to join a collaborative effort when another firm possesses resources or capabilities that, in combination with its resources and capabilities, can yield a new capability. Given the unique combination of the resources and capabilities of the partnering firms, the outcome potentially can lead to a new source of competitive advantage for the participating firms. Thus, if the competitive advantage is equally attractive for the partnering firms, the RBV seems to explain why firms are willing to enter into a collaborative agreement. Indeed, from this particular point of view, the value that a firm sees in a collaborative agreement seems to be narrowly linked to the extent to which the outcome of the collaboration can yield a new source of competitive advantage.

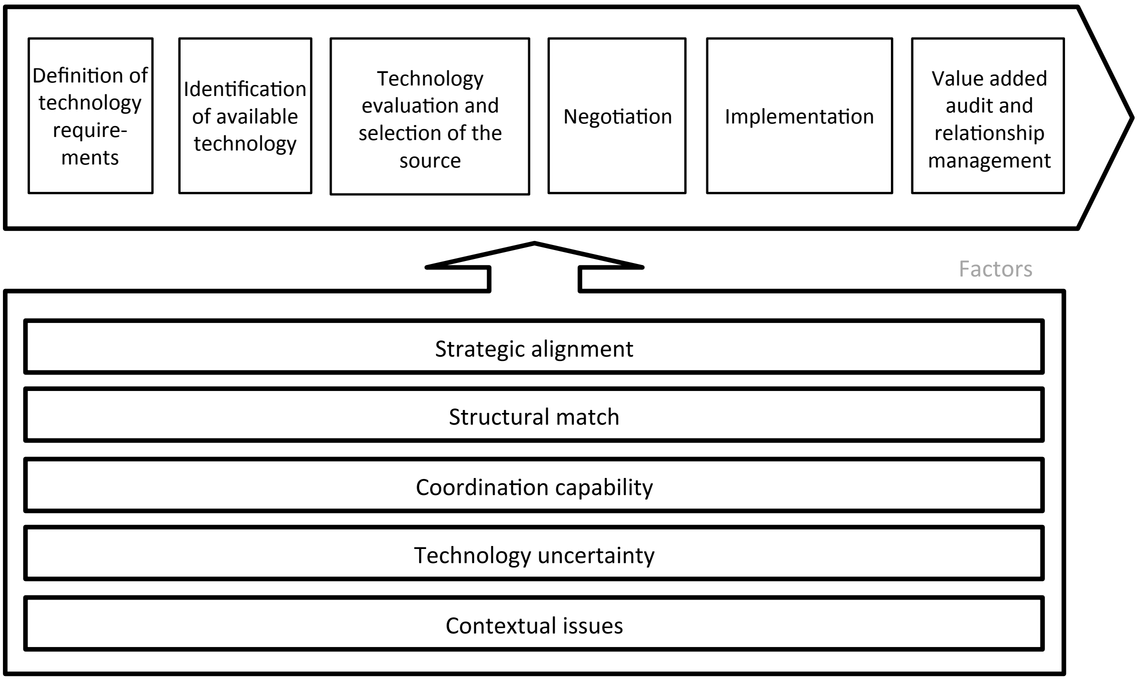
ACAP, on the other hand, suggests that firms achieve competitive advantage by the continuous and systematic assimilation and exploitation of externally generated knowledge. This theoretical approach points out that successful use of external knowledge requires the focal firm to possess a certain level of awareness about the characteristics and technical requirements of the knowledge to be assimilated and exploited. However, when firms do not have an appropriate level of ACAP to acquire a particular technology knowledge they may opt for starting an alliance with a partner in order to get access to its expertise to accelerate its acquisition.

In some sense, ACAP is closely connected to TA. Both concepts refer to incorporating and using new technology knowledge within a firm. Nevertheless, these two concepts seem to have a difference. ACAP concerns the conditions that define how fast a given company can exploit new knowledge while TA is interested in exploring the processes that allow companies to obtain the technology that they need. Thus, these two concepts seem to be complementary rather than equivalent.

2.5 Framework v0.0

The four perspectives explored in the previous sections provide complementary insights to understand the motivations to acquire technology by collaboration and the conditions that may affect the effective acquisition of technology. Literature on TA describes the key activities and factors that affect the incorporation and use of technology that is new to a firm. Literature on knowledge and technology transfer suggests that there are two levels of internalisation of technology from the viewpoint of the receiving partner, namely integration and replication. Literature addressing inter-firm collaborations offers insights on factors that may affect the outcomes of inter-firm relationships. Finally, RBV and ACAP provide two different perspectives to understand how firms' build competitive advantage by exploiting externally developed technologies.

Combining the activities in the TA process summarised in Section 2.1.1 and the factors that affect the process, it is possible to depict a conceptual framework (Figure 2.15).



Source: the author.

Figure 2-15 Technology acquisition by collaboration – Conceptual framework (v0.0)

The framework comprises two dimensions: activities and factors. The framework indicates that technologies are incorporated and exploited through a process that covers the following activities: definition of technology requirements, identification of available technology, technology evaluation and selection of the source, negotiation, implementation and value added audit and relationship management. Literature also provides a large number of factors that potentially can affect the outcomes of inter-organisational interactions. In a general approach, factors can be allocated into five groups: strategic alignment, structural match, coordination capability, technology uncertainty, and contextual issues. Table 2.7 shows a consolidated list of the factors that may affect the effective acquisition of technology by collaboration found in the core literature. This table also indicates the body of literature where each factor comes from. Each group is described below.

Strategic alignment comprises factors that allow partners to set up a collaboration agreement. Academic literature points out that strategic alignment is crucial to set up a collaborative agreement (Bronder and Pritzl 1992, Emden et al. 2006, Hacklin et al. 2006). Strategic alignment comprises factors that influence the establishment of a common vision and understanding of the benefits to each participant. Incentive alignment, motivations, importance of the project and management of resulting intellectual property amongst others seem to be influential factors to set up collaborations.

Structural match is reported as a condition for any collaborative project (Marxt and Link 2002, Kim and Lee 2003, Hacklin et al. 2006). Structural match comprises factors that define the quality and availability of resources and skills required to develop an intended product. It seems to be a driver for establishing collaborative efforts and selecting a partner to work with. According to RBV, organisations are likely to enter into a collaborative agreement when another entity possesses complementary resources. This group of factors includes for instance availability of financial resources, partner selection, skills and resources in exchange, as well as knowledge base overlap.

Table 2-7 Factors that may affect effective acquisition of technology by means of collaboration

Literature Category	Factor	NPD	C&SAM	TA
Strategic alignment	Type of agreement	x	x	x
	Trust	x	x	x
	Motivations	x	x	x
	Agreement terms			x
	Bargaining power of the source of technology			x
	Business strategy			x
	Fit with corporative objectives			x
	Providing firm support			x
	Importance of the project		x	x
	Alliance strategy		x	
	Incentive alignment		x	
	Managing of IPR		x	
	Development cost sharing	x		
	Mutual benefits	x		

Table 2-7 Factors that may affect effective acquisition of technology by means of collaboration (cont.)

Literature Category	Factor	NPD	C&SAM	TA
Structural match	Availability of financial resources		x	x
	Partner selection	x	x	
	Ability to identify emerging technologies			x
	Access to patents and literature information			x
	Access to technology intelligence reports			x
	Design/ manufacturing capacity			x
	Hiring individuals who know the technology			x
	In-house R&D capabilities			x
	Skills and resources in exchange		x	
	Development team	x		
	Knowledge base overlap	x		
Coordination capability	Coordination	x	x	x
	Communication		x	x
	Experience in collaborative projects		x	x
	Ability to control project expenses			x
	Decision making autonomy			x
	Collaboration management	x	x	
	Cultural distance		x	
	Performance of the project		x	
	Development work sharing	x		
	Product champion	x		
	Establishment of clear goals	x		
	Project management	x		
Technology uncertainty	Technology characteristics	x	x	x
	Evaluators of the technology			x
	Further development to adapt the technology			x
	Lack of information			x
	Lack of understanding of the technology			x
	Reliance on highly specialized skills and expertise			x
	Technical risks			x
	Technology familiarity			x
	Product novelty	x		
Contextual issues	Characteristics of the acquiring firm	x	x	x
	Characteristics of the providing firm		x	x
	Compatibility of operations		x	x
	Previous relationship with provider		x	x
	Technology dynamism of industry		x	x
	Competitive environment		x	x
	Type of partner	x	x	
	Project characteristics	x	x	
	Industry competition basis			x
	Market risks			x
	Opportunity cost			x
	Protection scope of intellectual property rights			x

Key: NPD: New product development literature; C&SAM: Collaboration and strategic alliances management literature; TA: Technology acquisition literature.

Coordination capability includes factors that influence the quality of the inter-organisational interaction across the co-development project. Factors included in this group are communication, project management, experience in collaborative projects, collaboration management, cultural distance, and establishment of clear goals.

Technology uncertainty comprises the characteristics of the technology and the availability of technical information. Technology characteristics such as novelty, maturity and complexity have been recognized as important aspects to consider in the effective implementation of technologies. Other factors such as lack of information, technical risks and technology familiarity seem to contribute to technology uncertainty in acquisition projects. These factors seem to be related to the time, resources and amount of development work required to bring the technology to the point where it can be implemented into a product or process.

Finally ***Contextual issues*** comprise external circumstances that may influence the interaction between partners. Those external events or settings eventually are not under the control of the partnering firms. This group of factors includes characteristics of acquiring firm, project characteristics, competitive environment and type of partner. These factors may have direct influence on the stability of the relationship and ultimately on the effective implementation of the technology.

2.6 Concluding remarks

1. TM literature suggests that acquisition of technology is characterised by a sequential series of activities.
2. As pointed out in section 2.1.4, literature on technology management has not yet provided a comprehensive description of how the acquisition process changes when technology is sourced by means of collaborative development and the relevance of certain factors over the TA process.
3. Literature on technology and knowledge transfer suggests two levels of internalisation of technology, which have been identified in this research as integration and replication.

4. Different bodies of literature offer relevant insights about the factors that may affect TA when a third party is involved; however none of the bodies of literature explored in this chapter seems to be sufficient by itself to explain the conditions that affect technology acquisition by collaboration in its entirety.
5. From a theoretical perspective, technology acquisition by collaboration may be influenced by a number of factors that can be divided in five groups: strategic alignment, structural match, coordination capability, technology uncertainty and contextual issues.
6. The conceptual framework presented in this chapter provides a starting point to understand the conditions that affect TA by collaboration.

3 PRACTICE REVIEW AND KNOWLEDGE GAPS

Contents

In addition to literature review, the research included a review of practice to understand TA by collaboration better. This chapter presents an account for the key activities and influential factors from a practical perspective. This chapter also highlights knowledge gaps, which result from the comparison of literature and practice.

3.1 Information sources and analysis

A practice review was conducted through discussions with practitioners that have been involved in collaborations either as technology receivers or providers, or both. These interviews provided a practical perspective of the activities and factors that affect technology transactions. In these interviews the perspectives of the acquiring and providing firms were captured.

The main source of contact data was the members' directory of the Society of Petroleum Engineers (SPE)[1]. Access to this directory was possible because the researcher is member of this community. Other sources of contact data comprised personal contacts of the researcher and electronic publications. Participants were principally selected on the basis of their role in their company. Thus people in the role of Director or Manager were initially invited to participate[2]. Potential interviewees were contacted via e-mail.

Through an introductory email, the researcher explained the purpose of the research and requested a telephonic discussion. The e-mail was sent to 36 persons of which 13 accepted the invitation to share their experience. Table 3.1 contains the roles of participants as well as the industry they work for and their position in technology collaborations.

Semi-structured interviews were undertaken aiming to capture the general experience of the practitioner in technology collaborations, success factors and examples of acquisition projects that had involved the participation of an external partner. The interviews protocol was built on the insights obtained through the literature review.

Interviews were conducted by telephone, lasting on average 40 minutes. Interviews aimed at discussing the general experience of participants in technology collaborations (in some cases participants provided specific examples of projects carried out by their companies).

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[1] This online directory contains a brief profile of professionals in the oil and gas industry and their contact details. The search engine allows the user to find people based on multiple criteria.

[2] Some of the people contacted redirected the researcher to the person in their company that had been involved in technology collaborations.

Table 3-1 Profile of participants

Identifier	Industry	Role	Perspective TAF	Perspective TPF
Expert_01	Chemical products	Director, Research and Technology Centre	X	X
Expert_02	Oil & Gas Industry	Director, Petroleum and Geothermal Research		X
Expert_03	Oil & Gas Industry	Field development-Subsea systems		X
Expert_04	Oil & Gas Industry	VP and Managing Executive	X	
Expert_05	Chemical products	Business Research Associate	X	X
Expert_06	Consumer products	Technology and Product Development		X
Expert_07	Oil & Gas Industry	Vice Manager - Regional Planning	X	
Expert_08	Oil & Gas Industry	Vice Manager - Field development	X	
Expert_09	Oil & Gas Industry	Research Fellow	X	X
Expert_10	Industry processes	Group leader		X
Expert_11	Chemical products	Technology and Operations Director		X
Expert_12	Industry processes	Product Technology and Innovation Manager	X	X
Expert_13	Oil & Gas Industry	Facilities Team Leader	X	

Key: TAF- Technology acquiring firm; TPF- Technology providing firm.

The interviews covered topics such as[3]:

- Motivations
- Inter-organisational challenges
- Recurrent issues in collaborations and examples
- Key success factors in managing technology collaborations and examples

The interviews were recorded to complement the notes that the researcher took during the interviews. Thereafter, data collected from interviews were analysed following a grounded approach to identify key activities and factors[4].

[3] See Appendix A for details of the interview protocol.

[4] See Section 4.9.1 for details of the data analysis process.

3.2 Key activities

This section presents the key activities that firms perform when acquiring technologies by collaboration. Managing technology collaborations seems to be a complex task from both perspectives. The practice review suggests that acquiring and providing firms perceive different activities in technology collaborations, despite the fact that they work together to achieve a common goal. The relevant activities from each perspective are presented below.

3.2.1 Acquiring firm perspective

The analysis of the interviews led to the identification of 25 tasks that may become problematic in TA by collaboration. The tasks were allocated into seven activities[5]:

1. Technology requirements
2. Technology scouting
3. Technology evaluation
4. Partner selection
5. Negotiation
6. Development
7. Exploitation

Table 3.2 presents the tasks identified through the interviews with practitioners and corresponding activities. The activities are presented in terms of their links to the stages of the TA process in the conceptual framework (v0.0). As it can be noticed, some stages embraces two activities. Firstly, the stage *technology evaluation and selection of the source* comprise two key activities: *technology evaluation* and *partner selection*; and secondly, the stage *implementation* comprises two activities: *development* and *exploitation*. None of the tasks mentioned by interviewees fell in the stage *value added audit and relationship management*.

[5] Appendix D shows the activities highlighted by each interviewee from the acquiring firm's perspective.

Table 3-2 Relevant activities in acquisition of technologies by collaboration – Acquiring firm's perspective

TA stages in the conceptual framework (v0.0)	Activity	Task
Definition of technology requirements	1. Technology requirements	Foresee industry's future requirements
		Foresee client's future needs
		Estimate resources required to accomplish the business objectives
		Identify alternatives to address an operational issue
Identification of available technology	2. Technology scouting	Identify new technologies and potential applications
		Understand the new technology
Technology evaluation and selection of the source	3. Technology evaluation	Estimate the cost of the technology
		Decide whether to make, buy or collaborate
		Estimate potential economic benefits
		Estimate the feasibility of use of the new technology for a particular application
	4. Partner selection	Identify potential partners
		Evaluate capabilities of potential partners
		Keep confidentiality of development intentions
		Select a partner to work with
		Keep confidentiality of samples/prototypes/information
Negotiation	5. Negotiation	Manage emerging intellectual property
		Define the project's scope and outcomes
		Build trust between partners
		Make decisions timely
Implementation	6. Development	Keep track of the project and evaluation of partial outcomes
		Make decisions about resources allocation
		Scale up the production process
		Develop the technology
	7. Exploitation	Implement the technology across the whole company
		Manage manufacturing cost
Value added audit and relationship management	-	-

3.2.2 Providing firm perspective

From the providing firm perspective, analysis of conversations led to the identification of 19 tasks[6] (Table 3.3). The tasks can be divided into six activities:

1. Technology concept development.
2. Building business reputation.
3. Demonstration of technology capabilities.
4. Negotiation.
5. Development.
6. Technology transfer.

The three last activities (negotiation, development and technology transfer) are equivalent to the last three activities identified from the perspective of the acquiring firm (negotiation, development and exploitation). It is relevant to note that the activities labelled as *technology transfer* and *exploitation* are equivalent. Their name is different to due to the direction of the flow of the technology.

Table 3-3 Activities in acquisition of technologies by collaboration – Providing firm's perspective

Activity	Task
1. Technology concept development	Identify technologies that meets clients' future needs
	Identify technology that meets future industry needs
2. Building business reputation	Advertise technologies and technical capabilities
	Build technology/Market reputation
	Publicize the technology concept
3. Demonstration of technology capabilities	Keep confidentiality of samples/prototypes/information
	Demonstrate the technology
	Estimate the cost of development of the technology
4. Negotiation	Manage emerging intellectual property
	Build trust between partners
	Share value of the technology
	Understand the needs of the partner
5. Development	Keep the schedule running on time
	Keep track of the project and evaluation of partial outcomes
	Scale up the production process
	Share decision making
	Estimation of technology risks
6. Technology transfer	Manage expectations
	Manage manufacturing cost

[6] Appendix E shows the activities highlighted by each interviewee from the providing firm's perspective.

3.2.3 Activities perceived as problematic by each partner

The results suggest that acquiring and providing firms perceive different key activities in collaborations. Table 3.4 shows the activities that both acquiring and providing firms perceive problematic in negotiations, development and technology transfer/exploitation, which are the activities that emerge during the collaborative work.

Firstly, during negotiations, providing firms seem to struggle with understanding the needs of the partner and sharing the value of technology, while acquiring firms seems to find it difficult to define the project's scope, outcomes, and make timely decisions. Secondly, during the development stage, the providing firm seems to be more concerned with estimating technology risks, sharing decision making, and keeping the schedule running on time. In contrast, the acquiring firm seems to struggle to make decisions about resource allocation and making the product perform as required. Finally, in technology transfer/exploitation, managing expectations become a challenging activity from the perspective of the providing partner, while the acquiring firm sometimes seems to find difficult implementing the technology across the whole company.

Table 3-4 Comparison of the problematic activities perceived by each partner in technology collaborations

Group name	Perspective		Issue
	TAF	TPF	
Negotiation	X		Define project's scope and outcomes
	X		Make decisions timely
	X	X	Manage emerging intellectual property
	X	X	Build trust between partners
		X	Share value of the technology
		X	Understand the needs of the partner
Development	X		Make decisions about resources allocation
	X		Develop the technology
	X	X	Keep track of the project and evaluation of partial outcomes
	X	X	Scale up the production process
		X	Keep the schedule running on time
		X	Share decision making
		X	Estimation of technology risks
Exploitation/ Technology transfer	X		Implement the technology across the whole company
	X	X	Manage manufacturing cost
		X	Manage expectations

Key: TAF- Technology acquiring firm; TPF- Technology providing firm.

To sum up, the results of the analysis of activities perceived by the partnering firms suggest the following two points:

1. The process to acquire external technologies reported in the conceptual framework (v0.0) may not reflect the relevant activities in technology acquisitions by means of collaboration. Practice review suggests that the TA process may require an explicit recognition of certain activities. For example, it should indicate that a development process takes place.
2. The providing and acquiring firms perceive different critical activities in technology collaborations. There is some agreement on problematic activities, such as building trust and management of IPR, but there are other problematic activities contingent on the role of each partner.

3.3 Influential factors

The analysis of influential factors also suggests that partnering firms perceive different issues depending on their role. Table 3.5 presents a list of the factors identified through the interviews. Those factors are distributed within the groups comprised in the conceptual framework (v0.0).

Trust and effective communication are factors seen from both perspectives as paramount. Regarding other influential factors, acquiring firms perceive factors such as *availability of testing facilities*, *capital availability to acquire the technology* and *final cost of the product* as influential. Technology providers, on the other hand, point out factors such as *requirement of additional technologies to meet customer requirements*, and *mismatch of the way in which both partners evaluate the outcomes of the project* as relevant factors in the outcomes of technology collaborations.

The analysis of influential factors provides additional elements to support the observation that both acquiring and providing firms perceive technology acquisitions differently.

Table 3-5 Comparison of influential factors perceived by each partner in technology acquisitions

Influential factor	Type of factor					Related factor in literature review	Perspective	
	SA	SM	CC	TU	CF		TAF	TPF
Trust	X					Trust	X	X
Availability of testing facilities		X				In-house R&D capabilities	X	
Capital availability to acquire the technology		X				Availability of financial resources	X	
Availability of resources (materials, infrastructure, experts)		X				In-house R&D capabilities	X	
Mismatch of the way in which both partners evaluate the outcomes of the project			X			Performance of the project		X
Effective communication			X			Communication	X	X
Customers do not understand the technology				X		Technology familiarity		X
Final cost of the product					X	Performance of the project	X	
Governmental regulations about business relationships					X	None	X	
Opportunity to implement the technology in the value chain					X	None	X	
Risk of implementing the new technology					X	None	X	
Requirement of additional technologies					X	None		X

Key: SA- Strategic alignment; SM- Structural match; CC- Coordination capability; TU- Technology uncertainty; CF- Contextual factors. Key: TAF- Technology acquiring firm; TPF- Technology providing firm.

As mentioned above, the only common factor from both perspectives is ‘effective communication’, which is widely reported in extant literature. Some of the other factors were not identified in the core literature. Particularly, ‘opportunity to implement the technology’ is a factor that is not reported explicitly in technology acquisition literature. Although some scholars may consider this factor as obvious, it might be a determinant factor in TA projects. Let’s consider the words of one of the interviewees:

> “The results look good in terms of technology performance, but the problems are in the final cost of the product, chances to implement it and continuity of the project, as sometimes an equipment is developed and later it is forgotten {…} if there is a technology that applies for particular products, a development is carried out in parallel to what it is already in the market and then some trials are performed but we wait until the end of useful life of extant equipment to implement the new technology.” [Expert_12]

As noted by Expert_12, the implementation of a new technology may not take place immediately after the end of the development work. This suggests that the final decision regarding when a technology should be implemented may depend on other circumstances not reported yet in extant literature.

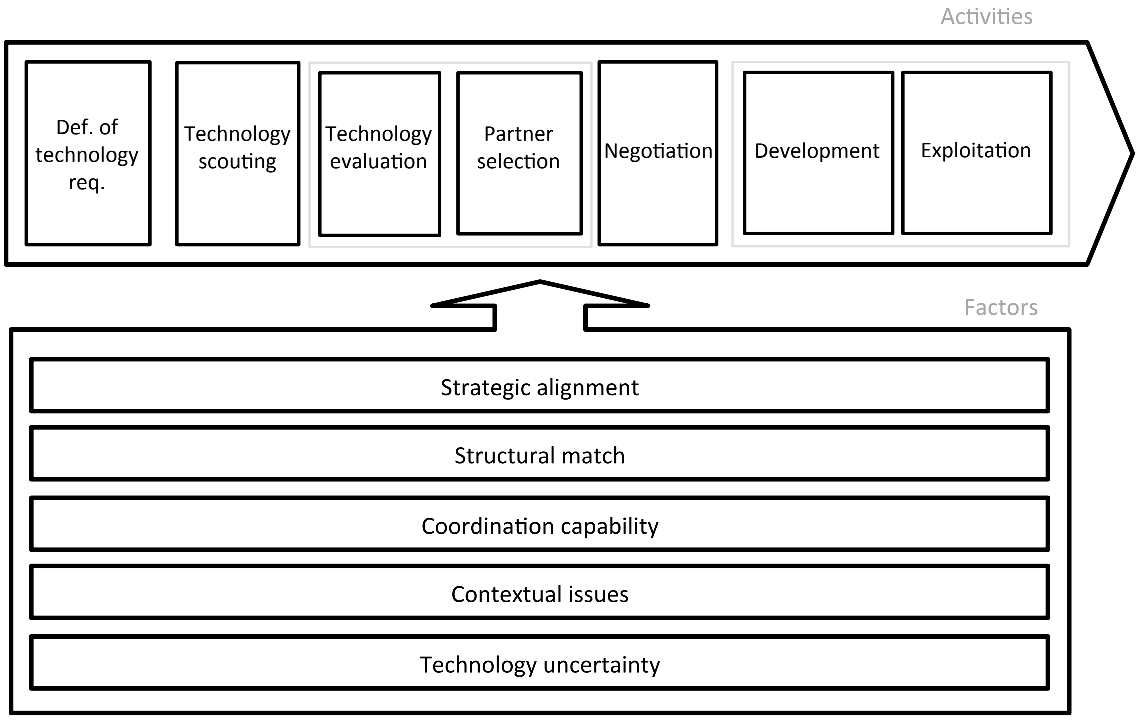
Other factors that were not found in the core literature were: governmental regulations about business relationships, risk of implementing the new technology and requirement of additional technologies. The rest of the influential factors mentioned by the interviewees seem to be related to factors already reported in literature. However, these factors appear to be generic and often scholars do not give details about their coverage. For example, from the interviews two factors were identified: *availability of testing facilities* and *availability of resources*. These two factors can be linked to the factor 'in-house R&D capabilities' already reported in literature. Nevertheless, factors reported in literature can be interpreted in different ways when they are not properly described. Thus, the factors reported in literature could be ambiguous and do not provide an appropriate description of the conditions that affect the effective acquisition of technology by collaboration, which is the focus of this research.

To sum up, the analysis of the factors that affect the technology acquisition process suggest the following points:

1. Effective communication and trust seems to be relevant factors for the partnering firms.
2. Each partner seems to perceive different influential factors in technology collaborations.
3. Some factors identified through practice review seems that have not been explored in the core literature, particularly the factor named 'opportunity to implement the technology'.

3.4 Framework v1.0

The combination of the activities and factors drawn from the interviews led to some modifications to the conceptual framework. Figure 3.1 shows the new version of the framework, which includes insights from practice.



Source: the author.

Figure 3-1 Initial framework (v1.0)

The key difference between this framework (v1.0) and the conceptual framework (v0.0) concerns the activities in the acquisition process (discussed in section 3.2.1). The key activities in this framework include definition of technology requirements, technology scouting, technology evaluation, partner selection, negotiation, development and exploitation. The factors drawn from the interviews, on the other hand, seems to fit within the groups considered in the conceptual framework, therefore there is not a substantial change in this regard.

So far this practice-based version of the framework does not reflect a relationship between the activities in he acquisition process and the influential factors, however it indicates the need for further research to understand the conditions that affect effective technology acquisition by means of collaboration.

3.5 Knowledge gaps

From the comparison of what is argued in literature and what was drawn from interviews with practitioners, a number of points can be mentioned.

Regarding the technology acquisition process, it seems that scholars have oversimplified the stages of the acquisition process. TA is a challenging activity, in particular when acquisition requires interaction between the providing and acquiring firm, and this is not explicitly reflected in extant literature. Practice review, therefore, suggests that describing the acquisition of technology by collaboration is a potential area for research.

The practice review provided evidence to infer that providing and receiving firms perceive different activities and factors that affect the outcomes of TA. Although this observation may seem obvious, it challenges the factors currently reported in literature. The majority of relevant factors that may affect the outcomes of technology acquisition by collaboration are reported in technology transfer literature and in literature related to management of collaborations and strategic alliances.

On the one hand, technology transfer literature has explored technology transactions but mainly from the perspective of the providing firm (e.g Cummings and Teng 2003) and at team level (e.g. Rebentish and Ferretti 1995). Therefore the strategic drivers of the acquiring partner, for example, are frequently ignored in this body of literature. On the other hand, literature on management of collaborations and strategic alliances reports a series of factors that affect technology collaborations mostly from the acquiring firm perspective; nevertheless, this literature does not put emphasis on how effective the transference of technology between partners is (e.g. Fliess and Becker 2006), as the main focus of this literature is describing the inter-organisational activities that may affect the stability of the relationship. Therefore, exploring technology collaborations from the acquiring firm perspective, with particular emphasis on technology acquisition, is a potential research opportunity.

Concerning factors affecting technology collaborations there are two key points. Firstly, the practice review suggests that there is an apparent mismatch with the factors reported in literature. Some of the influential factors mentioned by practitioners do not match with those factors reported in literature. This observation suggests that there is an opportunity to carry out research to identify further relevant factors that affect the acquisition of technology by means of collaboration.

Secondly, it seems that some of the factors reported in the literature emerge as result of the interaction between firms or performance of the project. For example, it is widely argued by scholars that trust is a factor that has an important influence on the outcomes of collaborations (e. g. Littler et al. 1995, Kim and Lee 2003, Wagner and Hoegl 2006). But, trust seems to be a result of the combination of effective communication and other context factors. Indeed, interviewees consider that building trust is important in technology collaborations.

To sum up, practice review provides a complementary perspective to select the methodological approach for the research project. There are three research opportunities based on the comparison between literature and practice:

1. Describing the TA by means of collaboration.
2. Exploring the activities and factors that affect technology collaborations from the perspective of the firm acquiring the technology.
3. Exploring the particular factors that affect TA by collaboration.

The gaps between theory and practice suggest that further research should aim to increase understanding of TA by collaboration by identifying the specific activities and factors that are relevant from the acquiring firm perspective.

3.6 Concluding remarks

1. A series of interviews led to the identification of relevant activities and factors from the practitioners' perspective.
2. The activities covered by the conceptual framework (v0.0) do not match with the key activities identified through the practice review.
3. Practice review included experiences about collaborations from both perspectives: technology receivers and providers. The results suggest that both partners perceive different activities and influential factors in technology collaborations.
4. Practice review suggests that some specific factors affecting technology acquisition by collaboration have not been explored yet in the core literature.

5. The activities and factors identified through practice review were compared with the conceptual framework. The observations emerged from this comparison suggest that exploring the specific activities and factors that affect TA by collaboration is a potential research opportunity.

4 METHODOLOGICAL APPROACH

Contents

The previous two chapters have provided a review of core literature and practice and discussed knowledge gaps. This chapter describes the elements of the research approach that was adopted to answer the research question.

4.1 Research purpose

This research was driven by the following question:

> How can the conditions that affect the effective acquisition of technology by collaboration be described?

Section 3.5 indicates that there is a gap between theory and practice regarding the specific activities and factors that affect TA by collaboration. Thus the purpose of this research is to build a theory that describes the specific circumstances that characterise TA when an industry partner is involved. Specifically, this research aims to contribute to knowledge regarding the conditions that affect the effective acquisition of technology by means of collaboration by identifying and describing the following variables and their relationship:

a) Key activities.
b) Influential factors.

4.2 Philosophical approach

As discussed in Chapter 2, there are a number of publications that report key success factors and common reasons for failure in technology collaborations. These publications seem to provide a broad perspective on the circumstances that may affect the outcomes and performance of technology collaborations. However, despite the vast quantity of research in this field, so far it seems that literature has not reported the specific activities and factors that affect TA by means of collaboration. There is no theoretical or empirical evidence in the core literature explored in this research indicating that the activities and factors already reported are applicable for explaining the effective acquisition of technology.

Scholars suggest that a qualitative approach is appropriate when the purpose of the inquiry is to understand "real-world" events (McCutcheon and Meredith 1993). Thus, in order to increase our understanding of technology acquisitions by collaboration, a qualitative research approach was adopted in this inquiry. The research has been built on the basis of the social constructivism as the researcher recognises that the *business world* is dominated by people interactions. In social constructivism, phenomena are analysed in their natural settings, so that this epistemological perspective is appropriate for understanding meanings, processes and it is good for theory generation (Easterby-Smith et al. 2008). Table 4.1 shows some common differences between positivism and social constructivism.

Table 4-1 Contrasting implications of positivism and social constructivism

	Positivism	Social constructionism
The observer	must be independent	is part of what it is being observed
Human interests	should be irrelevant	are the main drivers of science
Explanations	must demonstrate causality	aim to increase general understanding of the situation
Research progress through	hypotheses and deductions	gathering rich data from which ideas are induced
Concepts	need to be defined so that they can be measured	should incorporate stakeholder perspectives
Units of analysis	should be reduced to simplest terms	may include the complexity of 'whole situations'
Generalization through	statistical probability	theoretical abstraction
Sampling requires	large numbers selected randomly	small number of cases chosen for specific reasons

Source: Easterby-Smith et al 2008 p. 59

4.3 Research approach

Literature on research methods indicates that there are six approaches that can apply to constructionist research (Easterby-Smith et al. 2008):

1. Action research
2. Cooperative inquiry
3. Ethnography
4. Narrative methods
5. Case study
6. Grounded theory

Each approach has it own characteristics, and therefore they are appropriate under different contexts. Table 4.2 presents a summary of the main characteristics of constructionist research approaches.

Table 4-2 Constructionist research designs

Method	Main characteristic	Additional features
Action research	The researcher learns about and organization or social system by attempting to change it.	• The people most likely to be affected by the project take part in the research. • The results may not explain why the changes took place.
Cooperative inquiry	The researcher and the object of study become partners in the research process.	• The researcher gains access to understand how individuals decide. • This method aims to understand behaviours at individual level rather than at organisational level.
Ethnography	The researcher 'immerses' himself in a setting and become part of the group under study.	• Good for understanding meanings and significances that people give to their behaviour. • Data collection is likely to be prolonged over time.
Narrative methods	The researcher collects organizational stories. The researcher constructs and transmits stories.	• Stories are useful to examine relationships between individuals and the wider organisation.
Case studies	Looks in depth at one, or small number of, organisations, events, or individuals over time.	• Allows the combination of a number of data collection sources and analytical approaches. • Case studies are not necessarily studies of individuals.
Grounded theory	The researcher develops theory by looking at the same event or process in different settings or situations.	• Highly dependant on the judgement of the researcher. • Particularly useful in unexplored areas of research where the theoretical approach is not clear or non-existent.

Source: The author with information from Easterby-Smith et al. 2008, Gill and Johnson 2010 and Robson 2011.

The main purpose of three of the methods shown in Table 4.2 (cooperative inquiry, ethnography and narrative methods) is to understand individuals. Thus, since the objective of this research concerns organisations, these three methods are less appropriate. Also, action research is not appropriate since its main focus is to understand organisations through attempting to change it. In this particular research project, time is a limitation for applying this method since most of the collaborative developments may take more than three years, from the conceptualisation to completion. Such a time exceeds the time available to complete the research project. Thus, only case studies and grounded theory are the methods that seem to be suitable to meet the purpose of this research project.

The case method was chosen as a main research approach in this project. In comparison to grounded theory, the case method offers more flexibility in the ways to collect and analyse data. Indeed, case method is acknowledged as a research approach that "involves an in-depth examination of a single instance" (Gill and Johnson 2010:225). Case method permits the use and combination of different data collection methods and analytical approaches to understand as fully as possible the phenomenon under study (Meredith 1998). The combination of methods increases the reliability and validity of the results as allows for methodological triangulation (Gill and Johnson 2010). This research combines different methods to collect and analyse data. These methods are described later in this chapter.

It is also important to mention that the case research method adopted in this research follows a relativist position. Easterby-Smith et al. (2008) distinguish three ontological positions in case method: realist, relativist and constructionist (Table 4.3). Compared to the other two positions, the relativist position, developed by Eisenhardt (1989), is concerned with building theory from case studies (Easterby-Smith et al. 2008).

Table 4-3 Key features of case method informed by different ontologies

	Realist (Yin[1])	Relativist (Eisenhard[2])	Constructionism (Stake[3])
Design	Prior	Flexible	Emergent
Sample	Up to 30	4-10	1 or more
Analysis	Across	Both	Within case
Theory	Testing	Generation	Action

[1] Yin (2002); [2] Eisenhardt (1989); [3] Stake (2006). Source: Easterby-Smith 2008 p. 99.

4.4 Candidate cases

Candidate cases for this research were co-development projects between industry partners, where the driver to collaborate for one of the partners was to acquire new technology. The outcomes of co-development projects usually are product concepts that meet the functional performance expected by the acquiring firm. Thus, effective acquisition is achieved when the technology is embedded into a product or process and implemented in the value chain of the acquiring firm.

Some of the collaborations studied were on going at the time when data was collected. This decision has advantages and disadvantages for the research. One positive point is that the interviewees were able to provide much more detail of the activities and influential factors in the project. Co-development projects can take at least two years to be completed and at the end of the project, participants may remember only few key activities and problematic situations. However, one of the disadvantages of including on-going projects is that interviewees may evaluate the project on the basis of the current state of the project and not on the implementation of the technology.

4.5 Measurement

It is important to clarify what *effective technology acquisition* means in this research. As literally suggested, effective technology acquisition refers to the successful incorporation of a new technology into the portfolio of products or operations of the acquiring firm. However, measuring success of TA is not a trivial task. Extant literature suggests that success can be evaluated through five indicators (Table 4.4):

1. Internalisation of the technology.
2. Performance of the project.
3. Satisfaction with the project.
4. Financial performance.
5. Partnership recurrence.

Each of the five indicators described above presents different evaluation focuses and implications for its measurement. Between the five alternatives to measure success, only two seem to be appropriate for the purposes of this research: *internalisation of technology knowledge* and *satisfaction with the project*. The other three alternatives only provide an indirect measurement of the acquisition of technology.

In this research, *satisfaction with the project* has been chosen as indicator of effective acquisition of technology. This indicator denotes the perception of satisfaction of acquiring firms' managers with the knowledge acquired and other particular aspects of the relationship with the provider (Mora-Valentin et al. 2004, Lunnan and Haugland, 2008, Cui et al. 2012). These particular aspects include satisfaction with the relationship and performance of the partner, satisfaction with the project results and accomplishment of the initial expectations (Mora-Valentin et al. 2004). Some authors have argued that this indicator is capable of coping with projects whose original objectives may change during its course, which is a frequent situation in R&D projects (Marxt and Link 2002, Mora-Valentin et al. 2004).

Table 4-4 Success indicators in collaborative projects

Indicator (Reference)	Evaluation focus	Implications
Internalisation of the technology (Rebentish and Ferretti 1995, Szulanski 1996, Cummings and Teng 2003)	Level of internalisation of the new technology into the acquiring firm.	Ideally the best alternative to measure success. This measurement is valid for completed projects.
Performance of the project (Szulanski 1996, Cummings and Teng 2003, Mora-Valentin et al. 2004, Stock and Tatikonda 2008)	Degree to which the costs, time and quality of the acquisition project approximate to the initial estimations.	The objectives of development projects cannot be always defined from the beginning. Quite frequently development projects are evaluated in terms of the benefits of the outcomes, therefore the performance of the project become contextual.
Satisfaction with the project (Szulanski 1996, Steensma and Corley 2000, Mora-Valentin et al. 2004, Lunnan and Haugland 2008, Cui et al. 2012)	Level of satisfaction of the managers in the acquiring firm with the outcomes of the collaborative development and implementation of the technology.	This measurement is capable of coping with projects whose original objectives change during its course but it lacks of objectivity.
Financial performance (Sivadas and Dwyer 2000, Steensma and Corley 2000, Sung and Gibson 2000, Marxt and Link 2002)	Benefits obtained trough the incorporation of the technology into the operations of the acquiring firm.	The economic benefits emerging from the acquisition of a new technology can be difficult to measure, since the economic success can be consequence of other factors such as commercialisation skills, which are out of the scope of this research.
Partnership recurrence (Cummings and Teng 2003, Mora-Valentin et al. 2004)	Signature of an additional co-development agreement between the partnering firms.	The signature of additional co-development agreements does not necessarily mean that that previous relationship succeeded. Conversely, eventually a collaboration agreement could be successful, but the partners are not obligated to sign a new one.

Source: the author based on the sources indicated in the table.

4.6 Data collection methods

Most of the information relevant in this research is contained in the mind of the people that have been involved in collaborative projects. Therefore, the most appropriate methods to collect information in this research are those that allow the researcher to get *natural language data* from organizational members (Easterby-Smith 2008). These methods include interviews, critical incident technique and focus groups. In this research, interviews and focus groups were the methods employed to collect data.

The major volume of data was collected through semi-structured interviews. Prior to start collecting data, the researcher prepared a set of questions that would be used to guide the conversation. Compared to other interview styles, semi-structured interviews combine structure and flexibility during the conversation with the interviewee (Robson 2011). Interviews were carried out through teleconferences and face-to-face. Interviews were recorded and subsequently transcribed for analysis.

4.7 Case selection

The researcher followed three routes to identify potential case studies.

Route A

The process began with the identification of companies operating in the UK. Once a large number of firms were identified, only those showing commitment or activities in the development of new product or innovations were considered as potential participants. This evaluation was performed with the information provided through company's websites.

Contact details of Directors or Technology managers at candidate firms were collected through on-line directories or websites. In those cases where contact details of relevant persons were not available, an email was sent to the public relations office to request them.

Once a group of potential participants was identified, the next step was to send a formal invitation in order to know whether they were interested in participating in the research. The invitations included a brief overview of the research project and an electronic file where the motivations, scope and expected outcomes of the project were described.

Route B

The second route took advantage of the personal relationships and professional networks of the researcher. In order to identify potential participants, the researcher asked his colleagues for contact details of persons working in industry that may be involved in co-development activities. In addition, a request for contact details of potential participants was posted in electronic research and development forums.

The profiles of the people whose contact details were gathered were analysed to define whether he/she would provide good access to further case studies. In most of the cases the main criterion when deciding whether to make contact was their position in their company.

An introductory e-mail was sent to those people whose profile seemed to be related to R&D or NPD activities in order to invite them to participate in the research project.

Route C

A third route explored the possibility of contacting people involved in co-development projects reported in industry news, conference proceedings, and press releases. Factiva, and other industry databases were the main sources of information.

In these sources, a scan for cases where two industry partners had collaborated was performed. The selection criterion for these cases was basically the exchanging of technology as main focus of the collaborative agreement. For relevant projects, the contact details of people involved were sought in electronic directories and on the Internet. Once the details of the potential participants were collected, an introductory email was sent to ask for a telephonic conversation.

Results

Route B was relatively more effective than the other routes, therefore most of the cases were selected on the basis of ease of access, which Easterby-Smith et al. (2008) refers to as convenience sampling.

4.8 Access

One of the biggest challenges during this research was getting access to the sources of information. The reason for this situation was that co-development projects frequently are carried out under non-disclosure agreements, therefore members of companies are not allowed to share information related to the collaborative project. Some participants were prepared to share the experiences of their companies, however they provided very limited information about the technology involved and their partner. In addition, they were not keen on providing the researcher with contact details of other people involved in the project. Therefore, in order to get full access to relevant cases, the researcher made use of his personal network to contact people at senior levels that could give authorization to interview participants in the projects. In this way, the researcher got access to the major number of case studies reported in this research.

4.9 Analytical approaches

Through the different phases of the research project, data was analysed by different methods, namely grounded analysis, narrative analysis and cross case analysis.

4.9.1 Grounded analysis

Grounded analysis is closely linked to grounded theory (Easterby-Smith 2008). This method produces themes, patterns and categories from texts, which can be either interviews transcriptions or reports. Grounded analysis is an inductive analytical approach that forms abstract concepts from observations and reflections. Therefore, this approach is useful when there is limited previous theory about the phenomena under study (Easterby-Smith 2008).

In this research, the analytical process suggested by Easterby-Smith et al. (2008) was taken. The process consists of seven steps: familiarization, conceptualization, cataloguing concepts, re-coding, linking and re-evaluation. This process resulted in the identification of activities and factors in each case. Figure 4.1 shows a diagram of the analytical process and the key tasks performed at each stage.

Data extracted from interviews were transferred into a spreadsheet to facilitate the analytical work. After classification categories, activities and factors were evaluated with practitioners. The purpose was to verify that the names of the categories were appropriate and representative of the factors and issues identified. Appendixes F and G show an example of the conceptualisation stage and an extract of the database generated in this analysis respectively.

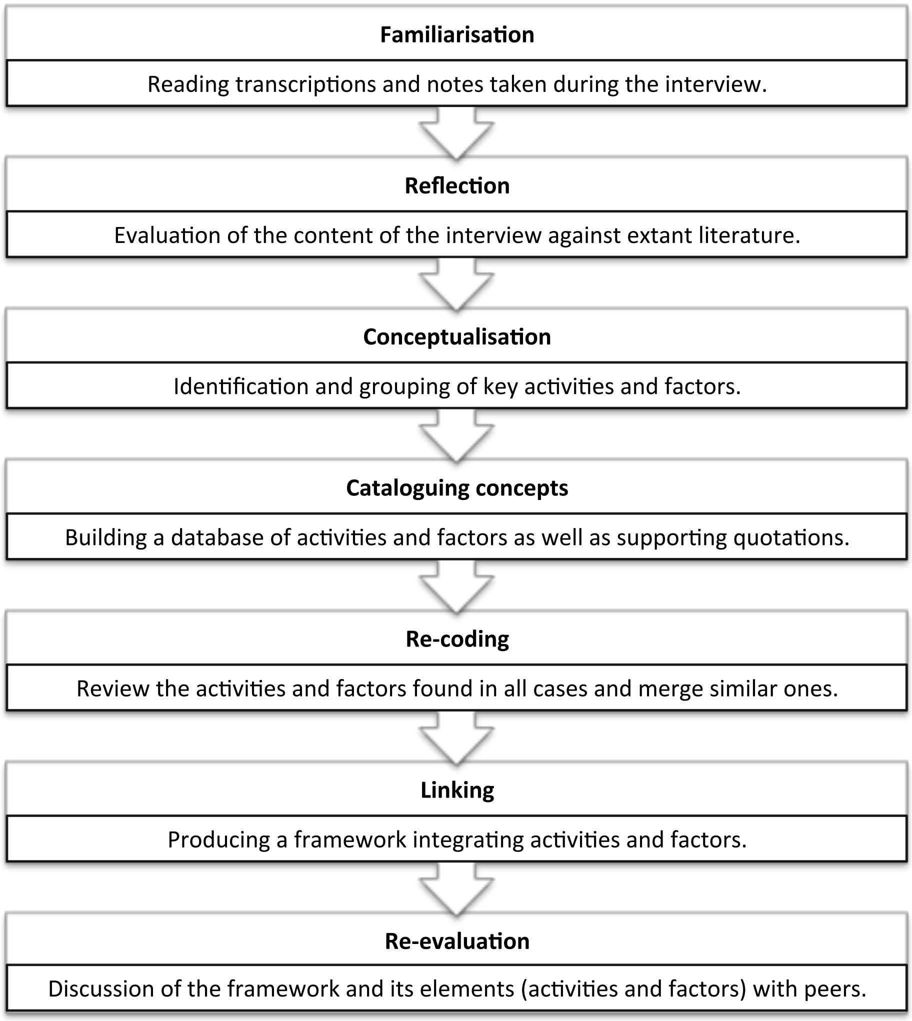


Figure 4-1 Stages of grounded analysis. Source: the author.

4.9.2 Narrative analysis

Narrative analysis is an approach to describe the sequence of events in a case study by building a story based on the temporal ordering of events and key participants (or actors). This method is an analytical approach to make sense of natural language data (Easterby-Smith et al. 2008). This method analyses how people describe events in order to create a story. It is useful to analyse transcriptions and text based media. It employs elements of storytelling to build the story.

The elements of storytelling comprised by this method are characters, conflicts, goal and struggles (Haven and Ducey 2007).

The **character** is the central element of any story (Haven 2000). In this research, the character in each case study is the organisation whose aim is acquiring the technology. The main features of characters are (Haven 2000):

1. *Core* – Core character information, values and particular motivations in the story.
2. *Personality* – How the character relates to, and acts within, the world.
3. *History* – What has happened to the character and what the character has done in the past.
4. *Activity* – What the character does.
5. *Sensory image* – Information available to the senses.

Conflicts are the situations or obstacles that block characters from their goals (Haven and Ducey 2007). Conflicts result from the combination of problems and flaws. Problems are external circumstances that the character cannot modify while flaws originate inside the character. Flaws are internal drives, feelings or motives that prevents a character from obtaining the goal. In this research, flaws are the values or internal forces that define how decisions are made inside the focal organisation. Basically, conflicts emerge each time that the focal organisation faces an unforeseen situation that affects the success of the acquisition project.

Goals tell the reader what the story is about and consequently indicate where the story ends (Haven 2000). In this research, the goal of the focal organisation is to achieve effective acquisition of technology.

Struggles describe how the characters react to conflicts and the risks that are involved. In story telling, characters must do something (Haven and Ducey 2007). It is during these struggles that risks and dangers are confronted. Thus, it is important to tell the reader what the character is willing to do and the risks to reach a goal. In this research struggles are equivalent to the actions that acquiring firms undertook to carry on forward the project.

The information for each case were analysed in order to identify the elements of the story. The elements were identified and ordered into a sequential order, and thereafter the researcher built the story. After building the story of each case study, the narrative was sent to the main contact in the participant company for feedback. Such a feedback allowed the researcher to amend possible misinterpretations of the project. Appendix H shows a story built from the information collected in one case study.

4.9.3 Cross case analysis

Cross case analysis is a technique that allows the researcher to find similar or distinctive features across case studies. The attributes of each case study are compared in order to find the recurrence of patterns or relationships. Cross case analysis can be used when the research involves two or more cases. Yin (2009) reports six methods to analyse data across cases:

1. Putting information into different arrays.
2. Placing data into matrices.
3. Creating data displays.
4. Tabulating frequency of events.
5. Calculating means and variances.
6. Ordering events into chronological order.

Placing data into matrices, creating data displays and ordering events in chronological order are the three techniques utilised to analyse data across cases in this research.

4.10 Research phases

The research was carried out through four phases (Figure 4.2): practice review, framework development, framework refinement, and framework verification.

First phase – Practice review

In the first step, a series of semi-structured interviews with 13 managers and CEOs (see Table 3.1 for details) provided an initial perspective of the relevance of the topic and the problematic issues that companies face when acquiring technologies by collaboration. In this initial set of interviews[1], the perspectives of firms that have either acquired or provided technology or both were included. Discussions aimed to capture the general experience of the interviewee about recurrent issues in technology

[1] See Appendix A for details of the interview protocol.

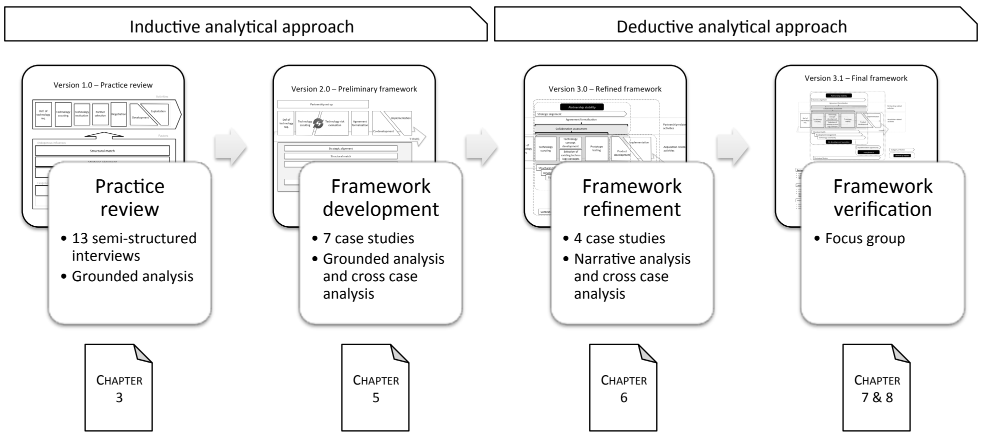


Figure 4-2 Phases of the research

collaborations, key success factors and examples of the projects carried out by their companies. The content of the interviews was analysed following a grounded approach. Chapter 3 presents the results of this phase and discusses gaps found between theory and practice. The outcomes of this phase were key to refining the focus and research design. As a result of this phase the conceptual framework was modified to reflect the insights gained through practice review.

Second phase – Framework development

The second phase aimed to explore deeper the acquisition process and to identify the particular factors that may be influential. In order to achieve these purposes, a set of seven co-development projects were analysed following an inductive approach. The units of analysis were co-development projects from different industries where the driver to collaborate of one of the partners was to acquire a new technology. Data was collected through telephone and face-to-face semi-structured interviews [2]. The interviews were transcribed and subsequently analysed through two methods: grounded analysis and cross-case analysis. Chapter 5 describes how this phase was carried out and presents the framework (v2.0) that emerged as a result of this phase.

Third phase – Framework refinement

The objective in the third phase was to verify whether the activities and factors comprised by the framework drawn in the previous phase would also be present in a

[2] See Appendix B for details of the interview protocol.

new set of case studies. In this phase four in-depth case studies were carried out. Case studies were selected following an ease of access approach, and the fundamental criteria was that more than one person involved in the co-development project from each partner could be interviewed. Data was collected through face-to-face semi structured interviews[3]. In this stage of the project, a deductive approach was taken. In this phase, data was analysed through two methods: narrative analysis and cross-case analysis. At the end of this phase, a more detailed version of the framework emerged (v3.0). Chapter 6 provides a detailed description of data collection and analysis carried out at this phase.

Fourth phase – Framework verification

In the fourth phase, a focus group session with practitioners was performed in order to validate the elements of the refined version of the framework. The focus group aimed to achieve the following objectives: (1) identifying possible limitations to the research outcomes, (2) verifying the terminology utilised to describe the dimensions of the framework; and (3) confirming practical implications of the outcomes. The six participants at the session were practitioners with experience in industries such as electronics, printing and chemicals. As result of feedback received during the workshop, minor modifications to the refined framework were required. Therefore, the session led to the last version of the framework (v3.1). Chapter 7 presents the details of the session and chapter 8 describes the final version of the framework.

4.11 Ethical considerations

The nature of the data collected required the researcher to ensure that the outcomes of the inquiry do not interfere with the business of the companies and people that contributed with information. Thus, all the communications that the researcher held with informants were treated with strict confidentiality. Therefore, all the real names of companies and persons were substituted to ensure their anonymity. In addition, any data that could reveal the identity of participants were intentionally omitted in this document.

[3] See Appendix C for details of the interview protocol.

4.12 Concluding remarks

1. This chapter presented the key features of the research design.
2. Case study was chosen as main research approach given the fact that it is a flexible method that allows for a combination of different methods to collect and analyse data to explore a particular instance in depth.
3. The research project comprised four phases: practice review, framework development, framework refinement and framework verification.
4. This research considers the use of interviewees as the main method to collect data and combination of grounded analysis, narrative analysis and cross case analysis to make sense of the information gathered through the four phases of the project.
5. The details of the data collection and analytical processes utilised at each phase are described in chapters 3, 5, 6 and 7.

5 FRAMEWORK DEVELOPMENT

Contents

This chapter presents a more detailed description of TA by collaboration, which is represented through an enriched version of the framework presented in Chapter 3. The results are based on the empirical evidence obtained through the analysis of seven collaborative projects.

5.1 Case studies overview

Case studies comprised joint development projects in industries such as biofuels, oil and gas, chemicals, and petrochemicals. Cases included experiences of projects carried out between companies of different sizes (Cases 1, 3, 4, 5 and 6). In all cases, the project involved two key partners: an acquiring firm and a technology partner. Table 5.1 provides a brief summary of the case studies carried out.

Table 5-1 Summary of case studies carried out

Case No. *Industry* Technology domain	Organizational form	Previous relationship between the partners	Interviewees perspective	Project objective (Project status at data collection)
Case 1 *Biofuels* Manufacturing technology	Technology joint venture	None	Acquiring firm / Providing firm	Developing a commercial process to produce cellulosic ethanol. (Scaling up)
Case 2 *Biofuels* Manufacturing technology	Technology joint venture	Joint research programme	Acquiring firm	Developing a commercial process to produce biofuels. (Scaling up)
Case 3 *Oil & Gas production* Information processing technology	Joint development agreement	None	Acquiring firm	Developing a tool for downhole monitoring. (Completed)
Case 4 *Gas transportation* Information processing technology	Joint development agreement	Technology supplier	Acquiring firm / Providing firm	Developing a system for monitoring the integrity of gas pipelines. (Completed)
Case 5 *Petrochemicals* Manufacturing technology	Strategic partnership	Technology supplier	Providing firm	Increasing the range of polyethylene grades of an existing commercial process. (Completed)
Case 6 *Construction industry* Manufacturing technology	Minor investment	None	Acquiring firm	Scaling up the production of an insulating material. (Scaling up)
Case 7 *Paint & Coatings* Product technology	Joint development agreement	None	Acquiring firm	Developing a new resin system for high performance coatings applications. (Cancelled)

Cases also comprise different technology domains such as process, materials and product technologies at different stages of maturity. In five cases the partners collaborated for the first time (Cases 1, 2, 3, 6 and 7). In addition, cases comprise projects at different completion stage: three cases were successfully completed (Cases 3, 4 and 5); three cases were at scaling up stage (Cases 1, 2 and 6); and one was cancelled before reaching the intended outcome (Case 7). Such heterogeneity of project characteristics was allowed in order to capture a broader number of factors and activities. Table 5.2 offers an overview of the case studies and participating companies.

Table 5-2 Case studies analysed to develop the emerging framework

Participant companies *Industry* Size	**Case description**
Case 1 **Alpha [TAF]** *Transport fuels* Large company **Theta [TPF]** *Biotechnology* Small	As part of its corporate strategy to get into the biofuels sector, Alpha, a large transport fuel producer, looked for potential technologies to enter in the biofuels market. Alpha found Theta, a small biotechnology firm, as a potential source of the technology. They signed a 50/50 technology joint venture to incorporate Theta's technology into a commercial-scale plant. Alpha would provide engineering expertise in building full-scale plants and commercialisation of transport fuels. At the middle of the development programme Theta sold their stake in the joint venture to Alpha because of a lack of financial resources to pay its part in the agreement. As a result, Theta's research staff and facilities were absorbed by Alpha. At the moment of collecting the data, Alpha was working on constructing the production facilities and scaling up the production process.
Case 2 **Alpha [TAF]** *Transport fuels* Large company **Iota [TPF]** *Chemicals* Large company	As part of its corporate strategy to get into the biofuels sector, Alpha, a large transport fuel producer, looked for potential technologies to enter in the biofuels market. Alpha approached to Iota, a large chemical company, to explore the potential application of Iota's biotechnology capabilities and technologies to produce biobutanol, a biofuel that presents better characteristics than bioethanol. Both firms signed a 50/50 technology joint venture to develop the technology, build production plants and commercialise the technology. They achieved successful results in the research phase so that they started the construction of the production facilities. At the moment of the interview, the development team was already working on some parts of the technology package to reduce the unitary cost of the biofuel.
Case 3 **Beta [TAF]** *Oil and Gas* Large company **Kappa [TPF]** *Defence* Start up company	Beta, a large oil and gas producer, began an R&D programme to explore the potential use of fibre optic technology for improving gas production operative processes. They approached Kappa in order to test the possible application of its technology for monitoring the movement of fluids inside oil and gas wells. Kappa was a start up company holding a promising technology to detect ground movement. At that time Kappa's technology had been applied only for security and defence purposes. The results of the tests were positive and both firms decided to sign a joint development agreement to develop a range of products for applications in the oil and gas industry. At the moment of data collection, the firms had achieved the development of the first product prototypes and they were about to move to the commercialisation phase.

Table 5-2 Case studies analysed to develop the emerging framework (cont.)

Participant companies Industry Size	**Case description**
Case 4 **Gamma [TAF]** *Oil and gas* Large company **Lambda [TPF]** *Oil and gas* Small company	Gamma, a subsidiary of a large oil and gas company, was running an R&D programme aimed at developing new solutions that may increase the safety and integrity of its gas pipelines. Thus, Gamma was looking for new technologies. At that time, the latest progress on fibre optic technology enabled this technology for a new range of applications. Gamma asked Lambda, a firm specialised with fibre optic technology, to carry out a state of the art and technical feasibility study to use fibre optics to monitoring the integrity of gas pipelines. The results of the study pointed out that additional research work was needed to determine the technical and economic feasibility of the technology. Therefore, Gamma and Lambda pushed the formation of a consortium to develop new technical knowledge on the technology. After some months the consortium provided such positive results that both firms became interested in developing prototypes. The prototypes worked so well that both companies signed a joint development agreement to develop products based on this technology for monitoring the integrity of gas pipelines.
Case 5 **Delta [TAF]** *Petrochemicals* Large company **Omega [TPF]** *Petrochemicals* Large company	Delta, a large producer of polyethylene, wanted to enter into the South America polyethylene market, however the technology that was used in its current plants did not meet the specifications of the customers of that region. Thus, Delta asked Omega, the provider of the process technology currently used in its plants, to develop the necessary changes to the technology to meet the requirements of the prospective market. Omega accepted the deal since it represented an opportunity to improve the technology and update its portfolio of products. Thus, Delta would advise Omega on the final specifications of the production process and Omega would keep the intellectual property rights of the process technology.
Case 6 **Epsilon [TAF]** *Construction* Large company **Omicron [TPF]** *Materials* Start up company	Epsilon, a large supplier of materials to the construction industry, decided to incorporate a new line of products based on a new insulating technology. Epsilon considered that acquiring this technology was an opportunity to gain a 'significant competitive advantage' as one key trend in the industry was to introduce materials with better characteristics. Epsilon found a couple of potential providers of new materials. After approaching these two companies, Omicron, a small start up company, was chosen because of the large range of potential applications of its insulating technology and terms of the relationship. Epsilon bought a stake in this small company to support its growth. The laboratory trials demonstrated that the material exceeded the expected performance, so Epsilon decided to incorporate this material into its portfolio of products. At the moment of the interview, Omicron had built a large-scale production facility and Epsilon was making the necessary changes to its manufacturing facilities to incorporate the new material into its production line.
Case 7 **Eta [TAF]** *Paint and coatings* Large company **Sigma [TPF]** *Chemicals* Large company	Eta is a large player in the paint and coatings industry. One of the key trends in this industry is the introduction of high performance coatings. Thus, in order to develop new and better products based on high performance coatings Eta looked around the globe for potential partners. Eta used to complement its internal R&D skills and infrastructure with external technology providers. From the list of possible partners, Eta picked Sigma, which showed good technical capabilities and was geographically close to its research facilities. Eta signed a joint development agreement with Sigma. The relationship and progress of the agreement between both companies ran well for the first half of the project, but after an internal restructuring programme, Sigma changed the development team and as a consequence the progress that Eta and Sigma had achieved was almost lost. Indeed, the new development staff did not show the same enthusiasm as the previous team. At the end Eta decided to cancel the agreement because it did not provide the expected results.

5.2 Data collection and analysis

Data was collected through semi-structured face-to-face and telephonic interviews with managers and project leaders that were involved in the acquisition project. This ensured that information in each case came from people with deep knowledge of the technology, as well as the managerial and organizational implications of the project for their company. In two cases (Cases 1 and 4), participants from both partners were interviewed. In the rest of the cases, the information came only from one informant. Conversations lasted about 40 to 50 minutes given the busy agenda of the interviewees. Participants were encouraged to describe the project covering the following aspects, which were based on the literature[1]:

- Specific motivations/objectives of the collaboration.
- Partnership set up.
- Resources allocated by each partner to the collaboration.
- Management of the development project.
- Management of emerging intellectual property rights.
- Problematic situations during the project.
- Results achieved.

Conversations were recorded and transcribed to facilitate further analysis. Data were analysed through two methods: grounded analysis and cross-case analysis. The combination of these methods led to the identification of key activities and influential factors in TA.

Grounded analysis was utilised to identify key activities and relevant factors that affected the acquisition process in each case. The grounded analysis followed the analytical process suggested by Easterby-Smith et al. (2008) (see section 4.9.1).

Cross-case analysis allowed the researcher to find similarities and differences between the cases. Through this method the most recurrent factors and two acquisitions patterns were identified. In addition, this method allowed the researcher to check whether the grounded analysis was carried out with the same level of detail in each case.

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[1] The protocols followed to conduct the interviews are in Appendix B.

In order to reduce the bias that the researcher could have introduced into the results, practitioners and academic peers were asked to give feedback on the emerging categories for each dimension. Their comments were considered to provide a better description of the activities, factors and categories of factors comprised in the new version of the framework.

5.3 Key activities

The analysis of the seven case studies indicates that acquisition of technology by collaboration involves seven key activities (Figure 5.1): definition of technology requirements, technology scouting, technology risk evaluation, agreement formalisation, co-development and implementation.

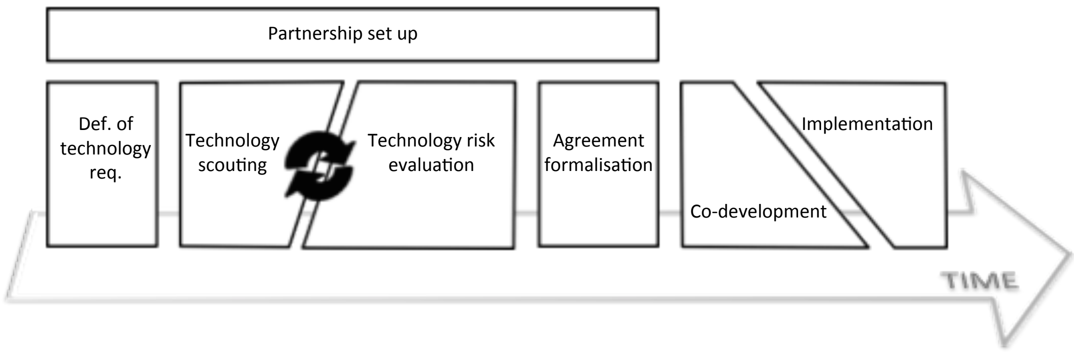


Figure 5-1 Key activities in the acquisition of technology through collaboration

5.3.1 Definition of technology requirements

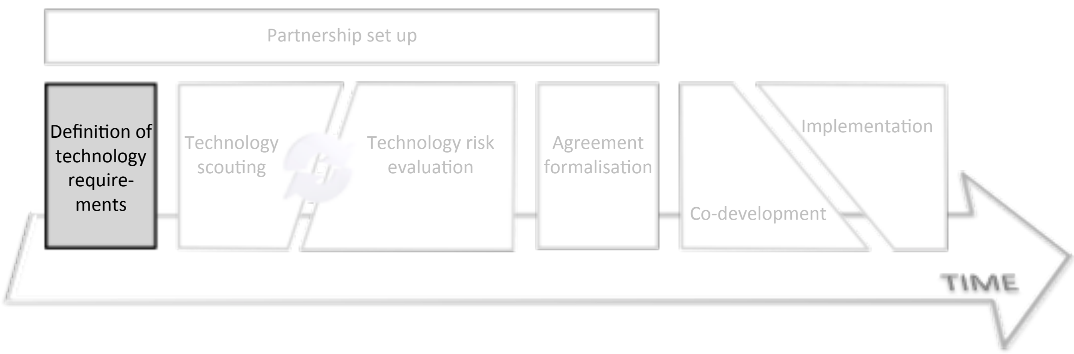


Figure 5-2 Definition of technology requirements

Definition of technology requirements (Figure 5.2) comprises a group of tasks that drive a firm to acquire a new technology. Identification of an emerging market, existing customer requirements, and company-wide R&D programmes were identified as the main triggers to start the acquisition process, as it is described below.

In cases 1, 2 and 6, the acquisition process began as a response to an emerging market as can be observed from interviewees' words:

> "We decided to invest in biofuels primarily for two reasons. Firstly we see it as a growing market, so it is a substantial market for transportation fuels; and secondly because it is part of our company core business, which is the transportation fuels value chain." Informant Company Alpha, Case 1 and 2.

> "By acquiring this technology we could immediately identify a great market opportunity" Informant Company Epsilon, Case 6.

In cases 5 and 7 the main driver was improving the product portfolio to meet the requirement of existing customers. On the one hand, in Case 5 the acquiring firm needed the technology to meet a new market driven by a new application of polyethylene. On the other hand, in Case 7 the acquiring firm wanted to improve their capabilities to produce high performance coatings to increase its portfolio of products. The words of one of the informants provide support for this trigger.

> "It turns out that our customer in South America wanted to target certain polyethylene grades for certain applications." Informant Company Omega, Case 5.

In cases 3 and 4 the acquisition process was triggered by company-wide R&D programmes aimed at improving the operational performance of the company or developing new sources of competitive advantage. In Case 3 the acquisition project was part of a wider programme to evaluate and incorporate the use of fibre optics to make more efficient operations in Oil and Gas exploration and production. Similarly, in Case 4 the acquisition project was part of a wider R&D programme whose main aim was to increase the efficiency and safety of operations in the Oil and Gas industry, from production of crude oil to delivery of refined fuels:

> "We had a very structured R&D programme which has addressed everything from what to do down holes in reservoirs and all the way through to delivery…" Informant Company Gamma, Case 4.

5.3.2 Technology scouting

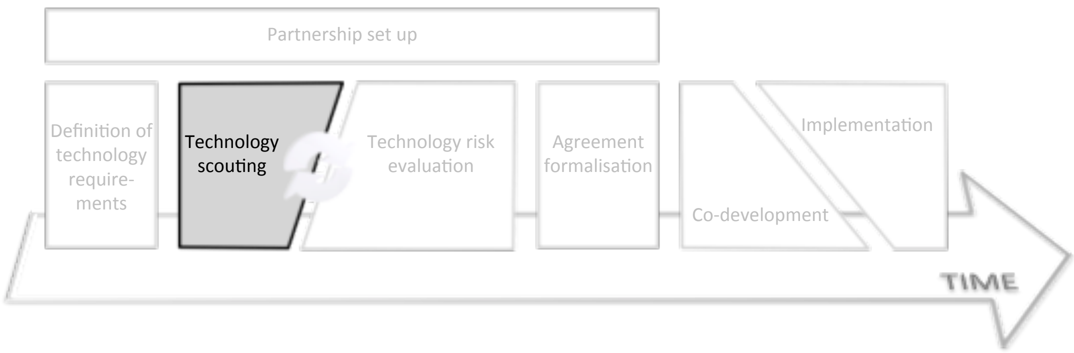


Figure 5-3 Technology scouting

Another key activity performed in all cases aimed at exploring the level of maturity and sources of alternative technologies to meet the application required by the acquiring firm (Figure 5.3). This activity particularly was stressed in the cases where the firms were looking for technologies that were mature enough to be acquired (Cases 1 and 6). For example, in case 1, Alpha, the acquiring firm, found that Theta possessed a technology that was at a higher level of development in relation to other technology options, as noted by the interviewee:

> "…we also found that they had the pilot plant facility, so they were beyond just laboratory demonstrations and started to demonstrate it at commercial scale…" Informant Company Alpha, Case 1.

In another case (Case 4), the partnering firms carried out a feasibility study in order to identify the latest progress in optoelectronics towards the use of optical fiber to monitoring the physical condition of gas pipelines. They found that there was some work done, but it was necessary to carry out additional research to verify whether optical fiber could be used for that purpose.

> "At the time the only measure that was really available commercially was temperature, so I spent three months working with one or two of guys here, I ran a feasibility study that looked at everything that was available in commercial, academic, blue skies, conceptual in terms of what was available for fibre sensing. And the conclusion of the report was that the majority of pipeline events and conditions of interest could or would most likely be possible to be monitored by two fibre sensing technologies which at that stage I would say were largely at the academic stage and we made a proposal to progress that work and to do some R&D work and start looking at prototypes." Informant Company Lambda, Case 4.

5.3.3 Technology risk evaluation

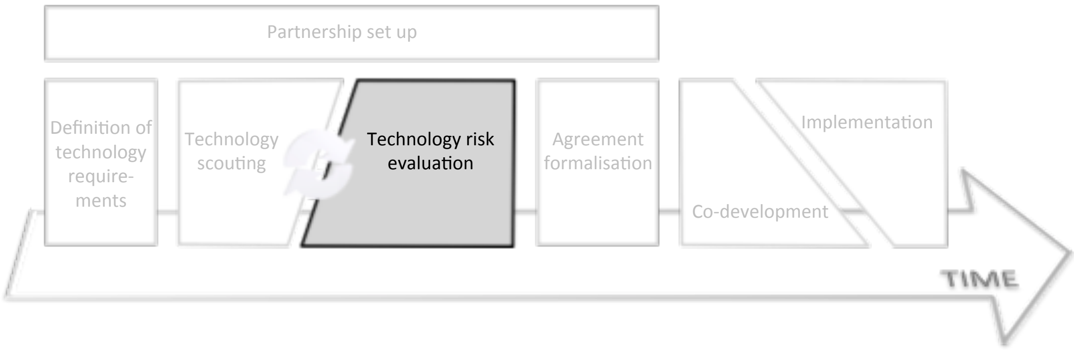


Figure 5-4 Technology risk evaluation

Case studies indicate that firms performed a technical and economic evaluation of the technology in order to determine whether it could provide the expected performance in a particular application and to evaluate whether it might add value to the business (Figure 5.4). This was observed in the cases where the technology had not been proven yet for the particular application required by the user firm (cases 2, 3, 4, 5 and 7). These evaluations included lab tests and field trials. These tests provided evidence to define whether the technology was suitable for the particular application:

> "The results from that were very encouraging but also showed that the existing gas technology, which you are probably aware came out of defence and intelligence application, was not yet mature for gas applications, so that we started a research collaboration and a product development agreement." Informant Company Beta, Case 3.

5.3.4 Partnership set up

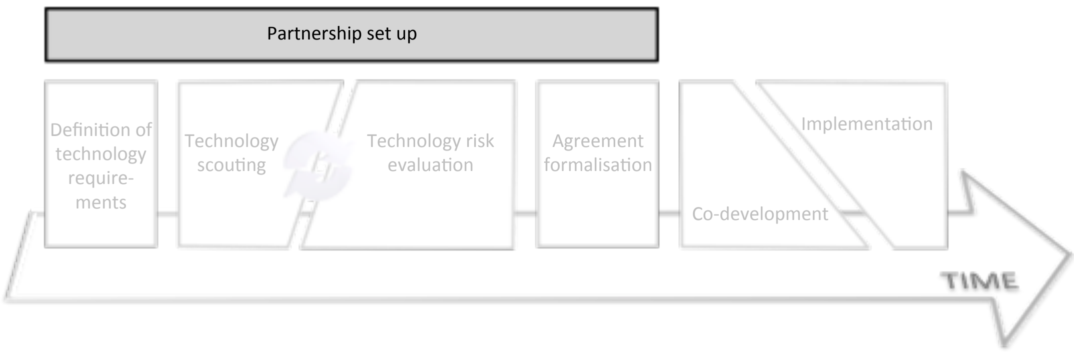


Figure 5-5 Partnership set up

Case studies also suggest that there is a period before formalising a collaborative agreement where the acquiring and providing partners interact and define whether they can work together. The acquiring and providing firms may start to interact at various times during the early stages of the acquisition project (Figure 5.5). In some cases, interaction between firms started during the evaluation of potential technologies (Cases 4 and 7). Indeed, before formalising a collaborative agreement, firms started to build a business relationship, for example by signing a research contract. In the cases where the technology had not been tested for a given application, the acquiring firm hired its partner to perform a technical assessment to determine whether the technology can be used for a particular application (Case 4). In this situation, the relationship was governed by a unilateral contract and the acquiring firm took all the risks:

> "At the early stages, particularly at this stage which we funded entirely, we signed a contract that said we own all the intellectual property." Informant Company Gamma, Case 4

Also, during their earliest interactions, firms may develop a common vision and willingness to participate in a collaborative project. It is the time when companies learn about each other's business objectives, capabilities and culture. For example, in Case 2, the informant explains that both companies complemented each other very well, that was why they decided to invest in the development of a process to produce biobutanol:

> "The reasons for going with Iota were that they are a great chemical company, and now biochemical innovators, they are very good technologists, so they brought that to the party and what we brought was the experience of transportation and fuel value chains" Informant Company Alpha, Case 2.

5.3.5 Agreement formalisation

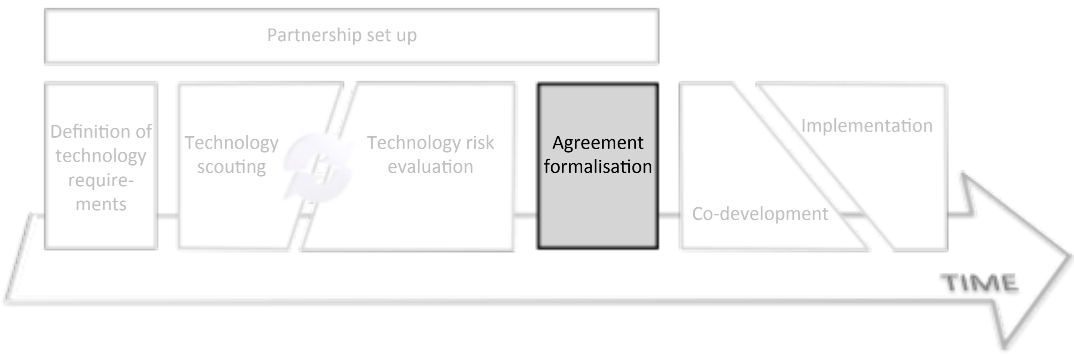


Figure 5-6 Agreement formalisation

Case studies also point out that there is a point when the acquiring firm formalises a collaborative agreement with its partner (Figure 5.6). This happens usually when the acquiring firm is convinced that the technology will provide the expected value and performance in a particular application.

The cases also showed that the outcomes of the project offer value in some way also to the providing partner, so that the acquisition project, which initially may have been a unilateral contract, becomes a bilateral contract. In this new agreement the partners negotiate the terms and conditions of the collaboration work. The partnering firms specify the scope of the collaborative work and who is doing what, who is responsible for what, who is paying for what, who will manage the emerging IPR, and set up a series of criteria to evaluate the overall performance of the development process.

Thus, the formalization of the collaboration is reached through the signature of a technology joint venture (Cases 1 and 2), joint development agreement (Cases 3, 4 and 7), strategic partnership (Case 5) or whatever other mechanism is chosen by the partnering firms. The following quote is an example of the agreement reached in one case:

> "We had Biofuels Co that was the entity that Alpha and Theta established and that would represent the overall technology-licensing package for the production of cellulosic ethanol. So Theta would contribute its intellectual property around cellulosic ethanol, and Alpha would contribute its engineering know-how to create an overall licensing package that we could use to license and build cellulosic ethanol facilities both for Alpha as well as licensing the technology to other companies." Informant Company Theta, Case 1.

5.3.6 Collaborative development

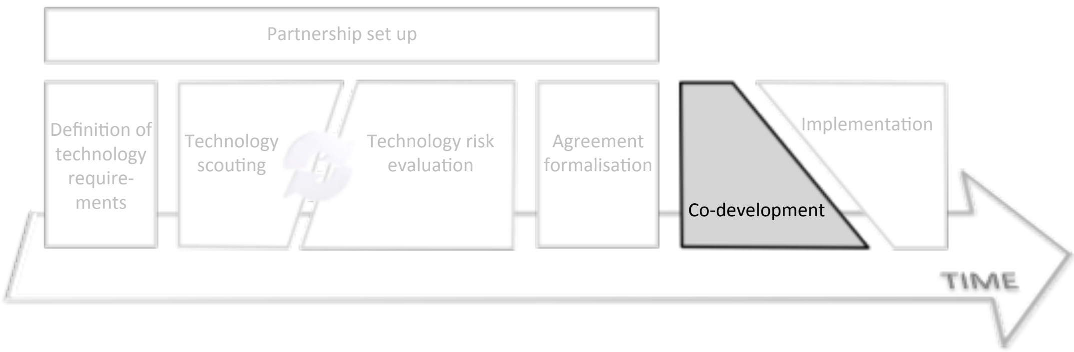


Figure 5-7 Collaborative development

Case studies also point out that the project, which began as an acquisition initiative driven by the acquiring firm, goes through a phase where the technology is further developed and integrated into a commercial product (Cases 3, 4, 6 and 7) or process (Cases 1, 2 and 5). Such a product or process must meet a particular set of specifications defined by the acquiring firm so that it can be implemented later into its operations or product portfolio. At this point the acquisition project turns into a collaborative new product development project (Figure 5.7). Thus, this phase of the acquisition project becomes intensive in activities related to development management such as project and resources management, pilot tests, and further field trials. The following quotes illustrate some of the situations during the execution of the development project:

> "…we have a series of very clear technology milestones which ultimately aim to get down to the cost of production of the new product. Ultimately the cost of production would allows us to determine whether things were successful in the project, so it is a crystal clear what represents success." Informant Company Alpha, Case 1.

> "We do have incurred in quite significant delays with the delivery. I would say Kappa staff was too optimistic because they were the only ones who could estimate the time of delivery, not us {…}. They had been optimistic on their side so we incurred about half a year's delay, and there is a cost to that of course." Informant Company Beta, Case 3.

> "…we are in the pilot phase and we are still confident that we will be ready to launch this technology next year." Informant Company Epsilon, Case 6.

5.3.7 Implementation

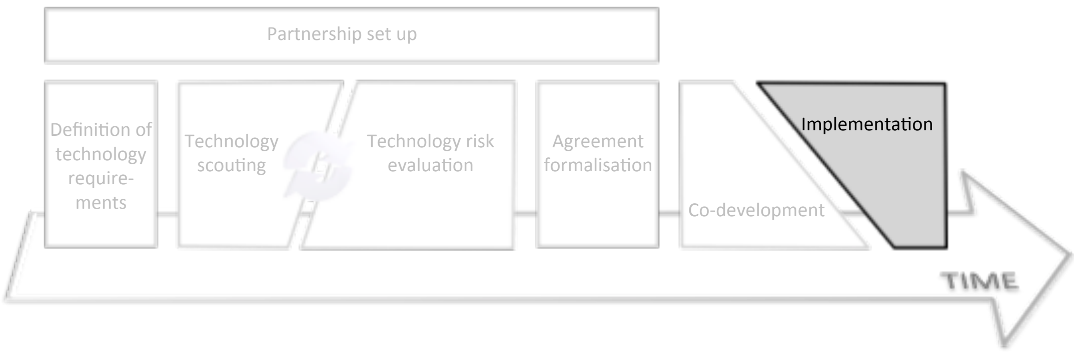


Figure 5-8 Implementation

The last key activity regards the implementation of the resulting product of the development project into the value chain of the user firm (Figure 5.8). Thus, the technology is incorporated into the value chain of the acquiring firm in the form of a product or process. Such a product or process is expected to be a means by which the acquiring firm will capture the value provided by the new technology.

> "We have 17 different application areas. We don't have detailed implementation plans for all of these, but for the one that we call technology package number 4 which is an application to hydraulic fracturing {…} The initial business implementation should start around the end of this year." Informant Company Beta, Case 3.

> "…what you now have to do is to transfer that into a manufacturing process, so we had the final stage which is commercialisation. That actually finished last year in 2009." Informant Company Lambda, Case 4.

> "We've developed with them the knowledge of how to make a particular grade of product that they want for their market place and what we have is an additional grade that we can now sell as part of our licencing package." Informant Company Omega, Case 5.

Sometimes the implementation activities can run in parallel to the development project (Cases 1 and 2). In particular this may happen when the technology is part of a broader investment plan. For example, firms may start looking at raw material suppliers:

> "…by and large you have to start with agricultural issues two or three years in advance to start constructing the plant so that you can be sure that agricultural stuff has been solved" Informant Company Alpha, Case 1.

5.4 Evaluation – key activities

Case studies suggest that TA comprises seven key activities: definition of technology requirements, technology scouting, technology risk evaluation, partnership set up, agreement formalization, co-development and implementation. These activities may not be sequential, for instance, technology scouting and technology risk evaluation seem to be very closely interrelated, depending on the existence of the technology in the market, its maturity for a particular application and the number of potential suppliers.

Partnership set up, on the other hand, covers the activities that allow the supplying and acquiring firms to realize whether they could collaborate and get a benefit out of the relationship. Such an interaction between firms may happen at any moment between the point when the acquiring firm defines the requirements of new technology to the point where both companies decide to initiate a co-development agreement. In large and complex acquisition projects where new infrastructure and developing the supplier chain is required, the implementation of the technology may run in parallel to co-development execution.

Compared to the activities in the acquisition process drawn from the literature and practice reviews, it is possible to see that by far the major difference in the sequence of activities in the emerging framework is located at the middle of the acquisition process, between the definition of technology requirements and implementation.

Literature review vs activities in the emerging framework

The sequence of activities in the emerging framework considers a number of distinctive elements in relation to the sequence of activities identified in the conceptual framework (v0.0). Figure 5.9 shows a graphic representation of the correspondence between the activities comprised in the conceptual framework (v0.0) and the activities comprised by the emerging framework (v2.0).

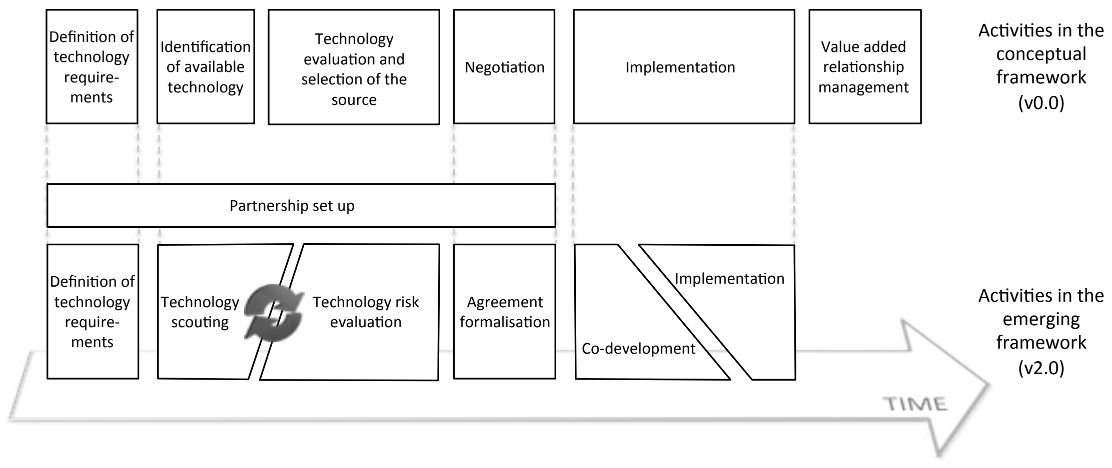


Figure 5-9 Correspondence of between activities in the conceptual framework and the emerging framework

The sequence of activities in the emerging framework highlights that there is a phase where the acquiring and providing firm know each other and demonstrate their interest to collaborate. This phase is labelled in the emerging framework as partnership set up and comprises from the point where the acquiring firm realises the value of the technology until the terms and conditions of the collaboration are agreed.

The sequence of activities in the emerging framework considers the presence of two independent activities after the formalisation of the collaboration agreement: co-development execution and implementation. In contrast, literature review suggests only one activity: implementation. Thus, literature review seems to miss the relevance of the partnership set up phase and do not provide a clear distinction of key activities at the implementation phase.

Literature review raises the presence of an additional activity in the process: value added relationship management. However, this activity it is out of the scope of this research. The reason for the exclusion of this activity is because the research focuses only on single TA projects and not on long-term relationships.

Practice review vs activities in the emerging framework.

The activities comprised in the emerging framework are relatively similar to the activities depicted in the practice-based framework (framework v1.0), the main difference lies on the sequence of the activities, particularly in the stage labelled as 'partner selection' in the framework v1.0. Figure 5.10 shows a graphic representation of the correspondence between activities in the initial framework and emerging framework.

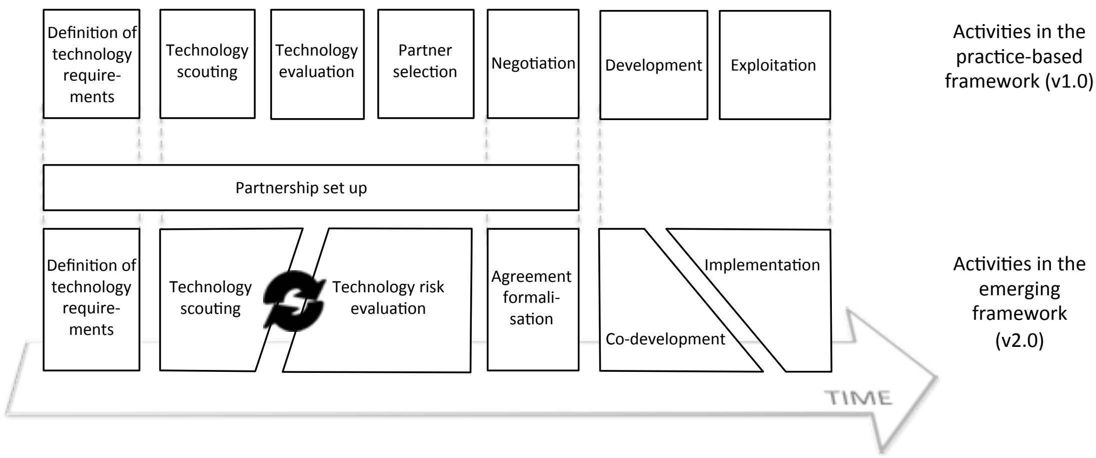


Figure 5-10 Correspondence of between activities in the initial framework and the emerging framework

Partner selection is included in the emerging framework within the phase *partnership set up*, which comprises from the identification of potential partners to the development of a common vision with the selected partner. The emerging framework suggests that the selection of a partner may occur even before the acquiring firm evaluates the technology alternatives and their risks. In particular, this situation may happen when the technology is not mature yet for the application required by the acquiring firm. For example, in Case 4 Company Gamma selected its partner before defining the technology that would be acquired. Due to the lack of expertise in fibre optics, Gamma hired Lambda, a company with expertise in optoelectronics, to carry out a feasibility analysis in order to know whether the fibre optics technology could be used to monitoring the physical conditions of gas pipelines. In this case, the selection of the partner was driven by the technical expertise of the company rather than by possessing a technology concept, and the companies began their relationship before any kind of evaluation of the performance of the technology. The rest of the differences between the activities in the practice-based framework and the emerging framework basically are changes in the names given to the activities.

5.5 Influential factors

The analysis of cases suggests that the factors that influence the outcomes of TA by means of collaboration can be divided into six categories: strategic alignment, structural match, development management, implementation opportunity, technology uncertainty and contextual factors (Figure 5.11).

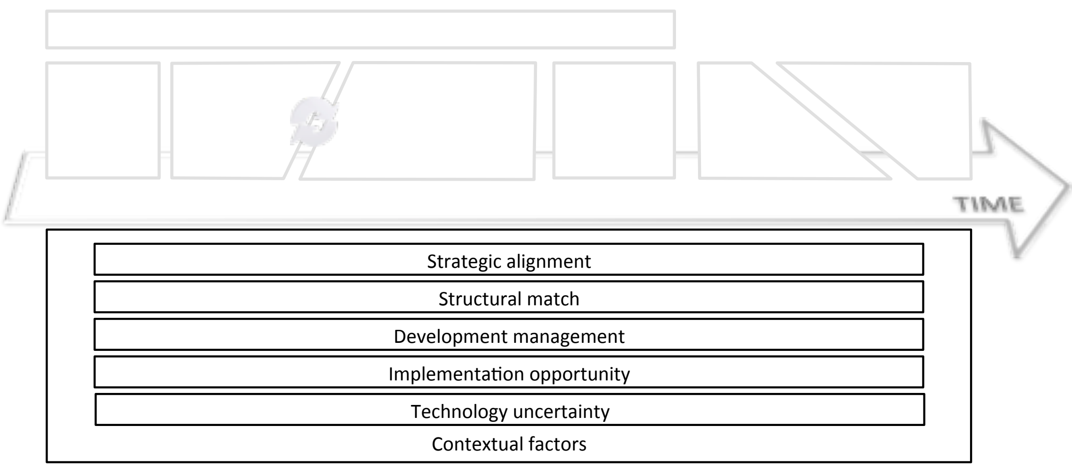


Figure 5-11 Categories of factors affecting the acquisition process

5.5.1 Strategic alignment

Strategic alignment comprises a number of factors that define the stability of the business relationship between the partnering firms. In the majority of the cases (Cases 1, 2, 3, 4, 5 and 6), a stable business relationship between partners was observed. The stability of the business relationship seems to be a condition to collaborate throughout the project. Except for Case 7, which failed as a result of an organisational change inside the technology partner, the partners in each case seemed to be committed to collaborate because of the benefits that the outcomes of the project would provide to both firms. Strategic alignment seems to be influenced by the following factors: business motivations, project relevance, risks and rewards, management of emerging IPR, vision alignment, wording of the contract and trust. Table 5.3 presents the cases where these factors were relevant.

Table 5-3 Strategic alignment

Case no.	1	2	3	4	5	6	7
Business alignment							
Business motivations	✓	✓	✓	✓	✓	✓	✓
Wording of the contract			✓				
Management of emerging IPR	✓	✓	✓	✓	✓	✓	✓
Project relevance	✓	✓	✓	✓		✓	✓
Risks and rewards	✓		✓	✓	✓	✓	
Trust			✓			✓	
Vision alignment	✓	✓	✓		✓		✓

Business motivations

Empirical evidence suggests that firms are motivated to participate in a joint project if they perceive value in the project and the benefits they can take out of the collaboration are compatible. For example, in Case 1, Theta considered that a partnership with a large company would be a means to grow. The collaborative agreement with Alpha would allow Theta to access additional capital, market, and business recognition. On the other hand, Alpha was very keen on the collaborative agreement because it was a means to acquire a new technology to get into the growing biofuels market.

> "They were aligned with us because they thought Alpha would bring a financial muscle and ability to take the product to the market and they would bring the technology." Informant Company Alpha, Case 1.

Wording of the contract

Another factor that arises when companies work together for the first time is wording of the contract, which may become a barrier to achieving a collaboration agreement. This would be a particular issue when a large company works with a small one and there is a possible overlap in their business scope. As example, consider the following quotation from one of the interviewees:

> "[What was written in the contract] could be interpreted differently by one party and then the other; but, it's mostly about other uses, other applications of inventions that were not foreseen at contract signing. That is particularly important for the smaller party here because they were afraid that some of the inventions that we could claim might push them out of certain businesses that they are already thinking about. For instance underground bunker detection is something that [our company] is not at all interested in." Informant Company Beta, Case 3.

Management of emerging IPR

One factor that appeared to be relevant to keep the strategic alignment between partners was agreement on how to manage the intellectual property rights emerging from the joint work. In Case 5 for example, the technology partner asked for the ownership of the resulting intellectual property rights, as pointed out by the interviewee:

> "...we asked for all the IP rights so that we can keep our whole platform under our IP control because of we're a licencing company." Informant Company Omega, Case 5.

Project relevance

The relevance of the project for each partner is another important factor. Commitment seems to be greater when the outcomes of the project fit the business strategy of the partners. The words of one of the interviewees provide an example of this factor:

> "The main advantage actually was that there was a very good fit to our strategy. Second point was that this technology would allow us to leverage the capabilities we already had. So it was a perfect fit, and last but not least, I would say upon acquiring this technology we could immediately identify a great market opportunity." Informant Company Epsilon, Case 6.

Risks and rewards

Risks and rewards refer to the commitments and benefits for each partner in the development project. The following quotation provides an example of the agreement between the firms:

> "So we said 'we will do a collaboration with you. We will develop in our pilot plant the grades that you need to meet this end use and what you will provide is the knowledge of a good product that meets this end use. So you have all of the applications, people who are your customers, so you can help us to find what grade you need and we can try to make it for you. You can tell us whether we've made it to meet all of the specifications or not and we will keep on doing that until we finally figure out the conditions on this polyethylene plant we licence to you that will make the grade'." Informant Company Omega, Case 5.

Trust

Trust was pointed out as an influential factor in achieving a strategic alignment between the partners. Trust is necessary to make joint decisions throughout the collaborative work. Honest discussions during the early stages of the partnership and avoiding overreliance on lawyers to lead contract negotiations seemed to encourage trust building between partners as noted by one of the interviewees:

> "I'd say building trust between the two sides by clear and upfront communication is very important as well, next to what the lawyers are putting down on paper in their language." Informant Company Beta, Case 3.

Vision alignment

Vision alignment seems to be another relevant factor contributing to the strategic alignment between partners. When companies work for the first time, it is likely that they do not know each other's business and real motivations to join the project. These circumstances may be a barrier to negotiate partnership terms and to manage the intellectual property that may emerge from the project, so that both partners should manifest their expectations from the collaboration. As one of the interviewees pointed out:

> "I mean it just worked out that Theta's approach to cellulosic ethanol and the way we were going to run the process and the feed stocks we were going to use was actually much more aligned with the independent thinking that Alpha was already doing. So from that standpoint there was very good alignment between Theta and Alpha about strategy and technology paths forward, so I think that was one of the main reasons why the discussions progressed so quickly and why we were able to set up the relationship with Alpha." Informant Company Theta, Case 1.

5.5.2 Structural match

Structural match comprises the factors that affect the complementarity and stability of the resources and skills required to develop the technology and incorporate it into a useful product. The factors that seem to contribute to the structural match of the partners are match of resources and expertise, access to relevant IP exploitation rights, access to testing facilities, internal stability of the partners and access to funding. Table 5.4 presents the cases where these factors were relevant.

Table 5-4 Structural match

Case no.	1	2	3	4	5	6	7
Structural match							
Access to testing facilities				✓	✓		
Access to relevant IP exploitation rights	✓	✓	✓	✓		✓	✓
Access to funding	✓			✓		✓	
Internal stability of partners	✓		✓	✓			✓
Match of resources and expertise	✓	✓	✓				

Access to testing facilities

Developing activities require not only specific technology knowledge, but also access to testing and to other facilities. In cases 4 and 5 having access to testing and to manufacturing facilities was key to verifying the specifications of the final product.

> "In this case I selected the Alaska gas pipeline, which is 5,000 km of 52 inch pipe, it is a huge project with permafrost and everything, and ground movement and leaks, interference, an so on. All that is part of the project, so we use that as our base case. {…} the tests were done not as a demonstration of the final product, but as a means to get field data to allow us to complete the design of the product." Informant Company Gamma, Case 4.

Access to relevant IP exploitation rights

Another relevant factor to achieve structural match is access to the IP exploitation rights of the core or auxiliary technologies. In particular this seems to be a fundamental criterion to chose a partner.

> "Theta was going to contribute its IP around cellulosic ethanol, and Alpha was going to contribute its engineering know-how to create an overall licensing package that we could use to licence and build cellulosic ethanol facilities." Informant Company Theta, Case 1.

Access to funding

Access to funding seems to have influence on the structural match of the partners. In particular it may be critical for the partners to get access to the funding required to carry out the development activities. For example, in Case 1 the financial stability of Theta depended on governmental funding:

> "[Theta] had been looking at getting financial support from the Department of Energy in the US, but that has been extremely slow. Although the DOE has said that they are going to offer loan guarantees for the building of commercial facilities in the US, they have been extremely slow to release that money and actually a lot of companies have suffered as a result of that." Informant Company Alpha, Case 1.

Internal stability of partners

Structural match is also influenced by the organisational and financial stability of the partners. During the partnership, firms may experience internal reorganisations or may be acquired by another company. The following quotation illustrates the effect of an organisational change on the collaboration in Case 7.

> "About half way through, this was a 3 year joint development agreement, a year or a year and a half, this company changed their people involved on their side, and new people didn't know very much about what the project was about. Their enthusiasm for doing it was greatly reduced compared to the previous team. There was no other change, just the people involved. So there were different people on the team, there was a rapid drop in enthusiasm, partly because of their lack of motivation, I think more than anything. The new guys didn't have any background in coating work." Informant Company Eta, Case 7.

Match of resources and expertise

The match of partners' resources and expertise is one of the influential factors. This factor refers to the possession of the key resources and expertise that is required to achieve the purposes of the collaboration agreement. Companies are encouraged to enter into a collaborative project when they do not have all the resources and knowledge required to develop a product or to solve a problem by their own. Firms are willing to collaborate with partners that have complementary assets as well as the knowledge and skills needed to develop and implement a given technology into a useful application. Indeed, the most common trigger to look around for potential partners is the lack of certain resources and expertise. The following quotation provide an example of this factor:

> "The reason that we choose Iota {…} was because Iota has real expertise in this kind of research and development, particularly around chemicals and also moving increasingly to biochemicals and biofuels." Informant Company Alpha, Case 2.

5.5.3 Development management

Another category of factors includes those factors that affect the ability of the partners to manage the development project effectively. The empirical evidence suggests that the factors influencing the ability of the partnering firms to develop and implement the technology into a commercial product or process also are relevant. Partners' ability to develop the new product in collaboration is influenced by factors such as existence of a project manager, ease of decision-making, project management practices, ease of communication, scope definition and development team. Table 5.5 presents the cases where these factors were relevant.

Table 5-5 Development management

Case no.	1	2	3	4	5	6	7
Development management							
Ease of communication	✓			✓			✓
Ease of decision-making	✓	✓	✓	✓	✓		✓
Enthusiasm of the development team				✓	✓	✓	✓
Project management practices				✓	✓	✓	
Project manager				✓	✓	✓	✓
Scope definition	✓		✓	✓	✓	✓	✓

Ease of communication

In cases 1, 4 and 7, ease of communication was an influential factor in the outcomes of the collaboration. Particularly, in cases 1 and 4, communication between the people involved was relevant to achieve the desired outcome as noted by the informant from Lambda:

> "…if there was bad news, he (Gamma's project leader) knew all about it {…} open communication worked very well. It was a partnership actually rather than a kind of standard client customer relationship." Informant Company Lambda, Case 4.

Ease of decision-making

Ease of decision-making seems to be an influential factor affecting the ability of the partnering firms to manage the development process. In some cases (1, 3 and 7) a steering committee, made up of members from both partners, met periodically to discuss the progress of the project. As noted by one of the interviewees:

> "We had a research committee, so there were members from Alpha, and members from Theta that met on a quarterly basis to discuss how things were progressing and how resources were." Informant from Company Alpha, Case 1.

Enthusiasm of the development team

Another relevant factor influencing the effectiveness of collaboration projects is the enthusiasm of the people involved in the project. Informant in Case 4, for example, indicated that the enthusiasm of the people is key to success:

> "…you need identifying the right contact, the discipline expert who's excited, and one of the things that Norman brought personally was the foresight and also, one thing he is very good at is getting funding and bringing funded projects to success. That's his reputation at Gamma. So it's putting together the right people and the right companies with common, shared goals. That for me was key to success." Informant Company Lambda, Case 4.

Project management practices

The way the project is managed is another relevant factor. In cases 4, 5 and 6 the project was conducted through a stage-gate process. In this approach, the probabilities of technical and commercial success of the product were assessed as the development team moved through the technology maturity stages. In both situations, the time and ease to make decisions were different.

> "[we] established a stage gate process whereby either partner can say 'stop, we're not meeting our targets, we want out.' we always make sure that either partner has the ability to stop if the project is not having the required technical success." Informant Company Omega, Case 5.

Project manager

In cases 4, 5, 6 and 7, each partner allocated a project manager to facilitate communication between teams and to coordinate the development work. The project manager was usually in charge of keeping the development team focused on the outcome. When a technical problem emerged, the project manager assisted the development teams to make timely decisions. In addition, the project manager in Case 6 was also responsible for dealing with regulatory issues. The following quotation points out the responsibilities of the project manager in Case 6:

> "…on our side we implemented a dedicated project manager assigned to this activity full time and who organised everything around the cooperation starting from the regulatory issues and then of course organising work packages and organising regular meetings." Informant from firm Epsilon, Case 6.

Scope definition

The definition of the scope of the development work seems to be also a relevant factor. In some cases, the partners defined a series of technology milestones that help them to have a clear vision of the progress and scope of the development work. For example, in Case 3 the technology would be used in a large number of applications, however the acquiring firm decided to get concentrated into few applications at the initial phases of the collaboration with its technology partner:

> "We identified 17 application areas. We identified 4 of these as high priority items which is high priority both in terms of fast implication and fast evaluation and also in terms of technical success." Informant Company Beta, Case 3.

5.5.4 Implementation opportunity

This category comprises those factors that affect the likelihood of implementing the technology into the operations of the acquiring firm. The chances to implement the technology are influenced by factors such as the overall performance of the project, familiarity of the application of the technology to the acquiring firm, implementation plan, participation of the end user, compatibility of the resulting product or process with existing systems as well as market uncertainty. Table 5.6 presents the cases where these factors were relevant.

Table 5-6 Implementation opportunity

Case no.	1	2	3	4	5	6	7
Implementation opportunity							
Implementation plan	✓	✓	✓		✓		
Participation of the end user				✓		✓	
Performance of the project	✓				✓	✓	✓
Compatibility with existing systems	✓	✓		✓			
Market uncertainty	✓		✓				✓
Familiarity with the final product			✓			✓	✓

Implementation plan

In order to achieve the acquisition of the technology, the company should have an implementation plan. In the cases 1, 2, 3 and 5 the acquiring firm had an implementation plan defined before formalising the relationship with their technology partners.

> "What we want to do is establish the new brand in the market which potentially, as we go forward into the market, we'd market biobutanol under the Butabiofuel umbrella." Informant Company Alpha, Case 2.

On the contrary, in the rest of the cases, acquiring firms did not have an implementation plan when they formalised the collaborative agreement. For example, in Case 4 Gamma supported the development of a system to monitor the integrity of gas pipelines but at the time they signed up the development agreement with Lambda, there was not a clear plan to implement the product in the operations of the company:

> "… the outcome is inevitably that although Gamma does benefit from this product, Gamma isn't necessarily their main customer. The main customer may be in a completely different industry. So what we are investing in, is we are investing in a piece of work, and the product that will benefit us and will benefit us not in selling the product because there may be some risk in increasing safety of our operation for example, it may reduce costs in our operations. But you appreciate at the start that we may not be their main customers." Informant Company Gamma, Case 4.

Participation of the end user

It seems that involving end users since the early stages of the development may help to change their attitude towards adopting the new technology. In cases 4 and 6, which did not have an implementation plan from the beginning, informants mentioned that it was difficult to convince other areas within the firm that the new product had advantages over current products.

> "…we were shooting for a very future oriented technology and we found within our company a lot of conservatism. For many people said, hey you shouldn't do this. This is wasted time, effort and money..." Informant Company Epsilon, Case 6.

Performance of the project

The overall performance of the co-development project is one influential factor. The cases analysed suggest that eventually firms may achieve success in developing a technology prototype, whose performance would be proved in a simulated or real operational environment. However, turning a prototype into a final product, or process, and implementing it into current operations may encounter not only technology challenges, but also business challenges. This situation is illustrated by one of the interviewees:

> "We would be making a very clear decision on go or not go next year. That would attempt to be the decision to go the first commercial plant, or whether we say no it is too risky or go ahead. So until that time we can put our hands up to say yes this may happen..." Informant Company Alpha, Case 1.

Compatibility with existing systems

Another factor that contributes to increase the chances to implement the technology is compatibility of the final product with existing systems. For example, new to the world products seem to be more difficult to implement, not because of market uncertainties, but because of the lack of standards or a value chain that may support mass production.

> "Elsewhere in pipelines in particular, it's early days. We're still at very low volumes. There is a lot of conservatism. There are no standards for example, {…} there aren't many projects around. There's interest but people are not yet convinced. You've got an ageing population in the pipeline world in particular, which will take a lot of convincing that this is a technology that is worth specifying." Informant Company Gamma Case 4

Market uncertainty

Market uncertainty is another factor influencing the opportunity to implement the resulting product. At the end of a development project, changes in the market may create barriers to implementing the technology. This factor is illustrated by one of the interviewees who pointed out that when they decided to begin the development project they were expecting higher gas prices.

> "…then you see gas prices now are much lower than they were a couple of years ago {…} so the business volume that we had estimated may actually in the foreseeable future be smaller." Informant Company Beta, Case 3.

Familiarity with the final product to the acquiring firm

It seems that the chances to implement the technology are influenced by the extent to which the acquiring firm is familiar with the final product or process that contains the technology. This factor seems to affect the amount of effort and resources that the acquiring company would require to successfully incorporate the technology into its operations.

> "We acquired {…} a new technology for a totally new kind of insulation material, so something totally unfamiliar for someone in engineering. You know we are in construction industry and in nowadays insulating is especially important in materials {…} the main challenges were internal within our company. Because first of all we were shooting for a very future oriented technology and you meet within your own company a lot of conservatism." Informant Company Epsilon, Case 6.

5.5.5 Technology uncertainty

The technology uncertainty category includes factors that define how challenging it may be for the partnering firms to develop and implement the technology. Technology uncertainty can be influenced by factors such as technology familiarity, technology performance, ease of scaling up, application novelty and maturity of the final product. Table 5.7 presents the cases where these factors were relevant.

Table 5-7 Technology uncertainty

Case no.	1	2	3	4	5	6	7
Technology uncertainty							
Technology maturity		✓	✓	✓	✓	✓	
Ease of scaling up	✓	✓				✓	
Product novelty	✓			✓			✓
Technology performance	✓	✓	✓	✓	✓	✓	✓
Technology familiarity	✓	✓				✓	✓

Technology maturity

In a broad approach, TA projects that involve immature technologies are more uncertain. Immature technologies frequently are present in two circumstances: 1) when a novel technology knowledge is combined with a novel application (Case 6); and 2) when an existing technology knowledge is combined with a novel application (Case 2, 3, 4 and 5). In either case, the technical challenge of the acquisition project is stressed by the degree of difficulty of maturing the technology. As an example the following quotation:

> "We modelled mathematically the performance of these products, but there is obviously a high degree of uncertainty when you do that so, we didn't know for example whether we would be able to achieve the optical range, the measurement range required. We didn't know even if we had a perfect measurement whether some of the events that we wanted to monitor, like gas leaks for example, would then generate enough temperature change or enough noise that we could detect them." Informant Company Gamma, Case 4.

Ease of scaling up

One of the factors that led to delays in the implementation of the final outcome was scaling up the manufacturing process (Cases 1, 2 and 6). Despite the fact that the technology worked well at small scale, scaling up of the manufacturing process was challenging. The following quotation illustrates this issue:

> "I think there was a technical challenge to make sure that the organisms were robust enough and that they could be scaled up in to an industrial process. And that was one of the things that we were really working on, making sure we had the right organisms." Informant Company Alpha, Case 1.

Product novelty

Product novelty refers to the level of existence of previous knowledge and availability of auxiliary components to make the product or process containing the technology perform as required. Technologies that are implemented into a well known product or process may require less effort than technologies that are implemented in new-to-the-world products. In Case 1 for example, the partnering firms had to sort out some issues related to the auxiliary components required to scale up the process to produce cellulosic ethanol:

> "The largest issue was associated with the early pre-treatment process. There is a large piece of equipment that has been used in the pulp and paper industry for a while, it's called a hydrolyser, and the hydrolyser used in pulp and paper has a different set of performance criteria than we need to have in cellulosic ethanol. And so getting that hydrolyser to operate efficiently and robustly was quite a challenge and I think that was one of the main technical issues we faced in that JV. And that's where we actually pulled together a series of workshops with Theta and Alpha's experts to really figure out how we were going to make that hydrolyser work more efficiently and effectively for our process." Informant Company Alpha, Case 1.

Technology performance

Technology performance generally is a key criterion to decide whether or not the technology should be acquired. In Case 4 the partnering firms decided to carry out the development project because they found that the technology could provide the functionality and performance required. The words of one of the informants exemplifies this situation:

> "…very quickly made very good progress and by about half-way through the project, about 18 months, it was very clear by mid 2006, probably slightly earlier than that, when we had prototypes working very nicely. We had demonstrated the extended range, we demonstrated new measurements." Informant Company Lambda, Case 4.

Technology familiarity

Technology familiarity refers to the level of novelty of the technology to the partnering firms. The relevance of this factor becomes evident when the potential risks and pitfalls of the development project have to be foreseen (e.g. Case1, 2, 6 and 7).

> "We have technology expertise in house. That enable us to make a judgment on the quality of this technology versus other cellulosic technologies, so I would say, it was not perfect, we are still on our way to learning because is not Alpha's core business, but we had enough technology capability to know what is a good technology, from what is more challenging and difficult to scale up." Informant Company Alpha, Case 1.

5.5.6 Contextual factors

The contextual factors category comprises the circumstances that describe the external context of each collaborative project. These factors seem to have influence on the other five categories of factors. Contextual factors include partners' characteristics, project's characteristics, previous relationship and affinity between partners. **Table 5.8** presents the cases where these factors were relevant.

Table 5-8 Contextual factors

Case no.	1	2	3	4	5	6	7
Contextual factors							
Partners' affinity	✓			✓			
Partners' characteristics	✓		✓	✓		✓	✓
Previous relationship			✓	✓	✓		
Project's characteristics			✓				✓

Partners' affinity

This factor may affect communication at both technical and business levels. For example, the compatibility of working and business cultures may affect how effective the communication is between the people involved in the collaboration project and ultimately how likely is that the partners achieve the desired outcome.

> "Gamma is very open. We get on very well, I think actually culturally they fit very well with Lambda." Informant Company Lambda, Case 4.

Partner characteristics

Some companies may show particular characteristics such as openness to outsource R&D activities (firms Alpha and Gamma) or possession of capital venture units to explore new technologies (firms Alpha and Epsilon). The relative size of the partnering firms is also an influential factor, as noted by one of the interviewees:

> "When you are working with a very small start up company, which is just growing heavily because it has an interest in technology for a whole range of different applications, the biggest issue you have is that these companies are absolutely chaotic because they only have a very small number of people. Everybody is doing everything basically. So, to structure the relationship in a way that you can actually work towards a common goal in a structured way is a challenge." Informant Company Epsilon, Case 6.

Previous relationship

A previous relationship between partners is also a relevant factor in co-development projects. Indeed, this would be a determinant criterion to choose a partner, as it can be perceived from the words of one of the interviewees:

> "…they are our customers, so we have interests in making them happy because they are buying services from us on a regular basis." Informant Company Omega, Case5.

Project's characteristics

The characteristics of the project seem to be also relevant. For example while in the electronics industry developing a product may take two years, in the chemistry industry a product may take a decade. The following quotation illustrates this situation:

> "So the problem with the paint industry, is that it can take many years for looking at a central new technology route, it could take anywhere between 8 and 10 years for a product from the start to actually getting a final product, because of all the testing that needs to be done." Informant Company Eta, Case 7.

5.6 Evaluation – influential factors

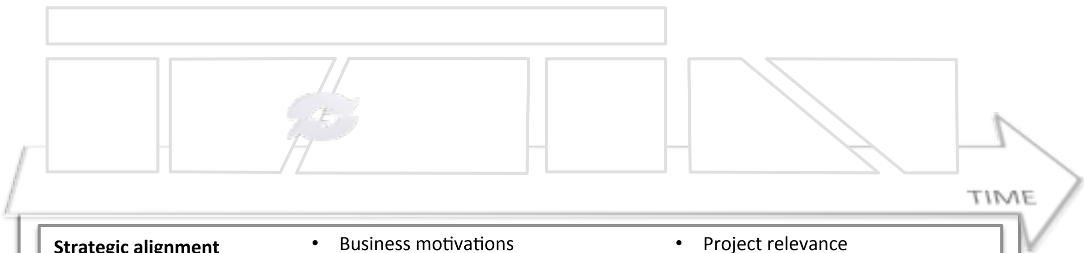
In short, case studies suggest that there are six categories of factors that affect acquisition projects carried out in collaboration. These factors are strategic alignment, structural match, development management, implementation opportunity, technology uncertainty and contextual factors. These categories of factors are graphically represented in Figure 5.12.

Based on the analysis of seven case studies the following observations can be drawn:

1. The types of influential factors found as relevant are six rather than five, as observed in the previous versions of the framework. The sixth category covers those factors that affect the implementation of the technology into the value chain of the acquiring firm. This group of factors is not reported in the core literature while in the practice review one of the interviewees stressed that the chance to implement the technology was a key factor in TA projects.
2. The category labelled as *development management* is equivalent to the category previously labelled as *coordination capability* in the previous frameworks. The reason for this change is to highlight that the acquisition process by collaboration implies the joint development of a product or process.
3. An analysis of the theoretical saturation reached through the grounded analysis reveals that 22 out of the 33 factors (67%) were found in Case 1. Cases 2, 3 and 4 contributed 1, 5 and 5 distinct factors respectively. Cases 5, 6 and 7 did not contribute new factors. This is an indicator that there is a high probability that most

of the relevant factors had been identified in the analysis of these seven cases. Figure 5.13 shows a graphic representation of the total number of distinct factors identified in the analysis of the seven case studies.

4. Most of the factors found through the analysis of case studies have been already reported in the core literature; however there are four particular factors that have not been explored: wording of the contract, enthusiasm of the development team, implementation plan and ease of scaling up.



Strategic alignment	• Business motivations • Vision alignment • Management of emerging IPR • Trust	• Project relevance • Wording of the contract • Risks and rewards
Structural match	• Match of resources and expertise • Access to testing facilities • Access to relevant IP exploitation rights	• Internal stability of partners • Access to funding
Development management	• Ease of communication • Ease of decision-making • Project management practices	• Scope definition • Enthusiasm of the dev. team • Project manager
Implementation opportunity	• Performance of the project • Compatibility with existing systems • Familiarity with the final product	• Implementation plan • Participation of the end user • Market uncertainty
Technology uncertainty	• Technology familiarity • Product novelty • Ease of scaling up	• Technology performance • Technology maturity
Contextual factors	• Partners' affinity • Project's characteristics	• Previous relationship • Partners' characteristics

Figure 5-12 Factors affecting technology acquisition by means of collaboration

To sum up, the factors identified through the seven case studies seem to offer a comprehensive picture of the specific factors that affect the acquisition of technology by means of collaboration.

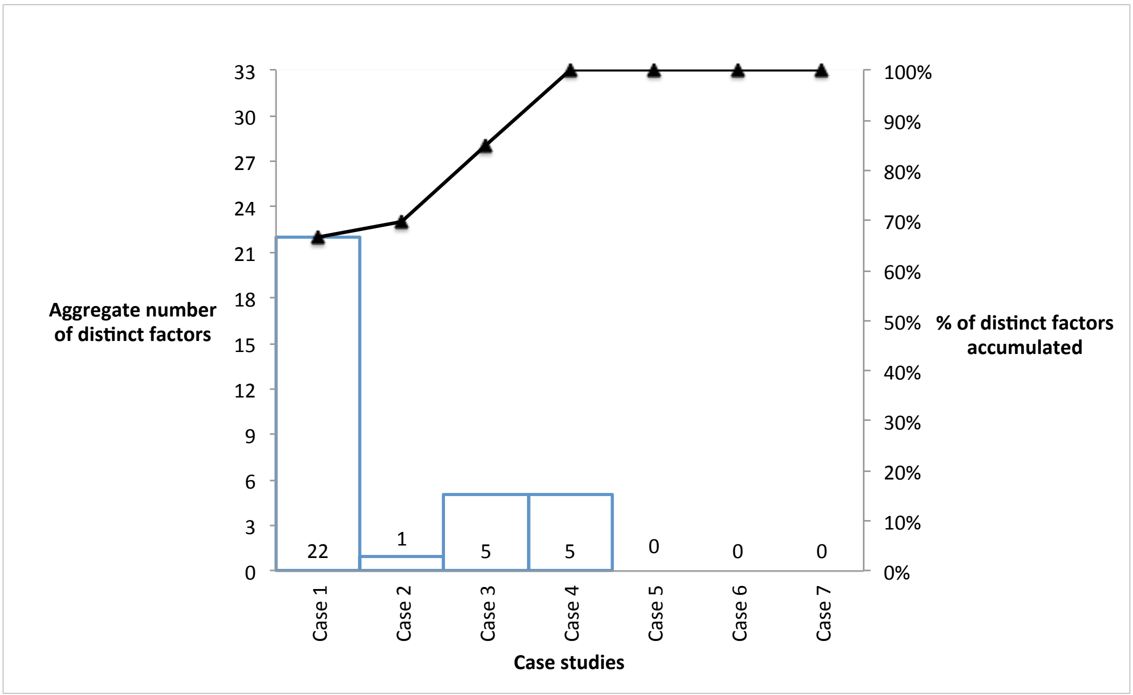


Figure 5-13 Number of distinct factors identified in case studies

5.7 Framework v2.0

The key activities and relevant factors identified in the case studies have been described above. This framework provides further details of the activities and factors that are relevant in TA projects that involve an industry partner.

Figure 5.14 shows the activities and categories of factors observed through the empirical analysis. At the top of the figure, the key activities are represented as a sequence of events. The acquiring firm may start to interact with its technology partner at any moment before starting the execution of the project. Partnership set up may run at the same time as project value recognition, technology scouting and technology risks evaluation. The early involvement of technology partners seems to increase their commitment to participate in the development project and to build a common vision. These two conditions are key to sorting out problems during the development work and to achieve the results expected by all partners. The implementation of the product or process may start before the development work has finished.

At the bottom of Figure 5.14 the six categories of influential factors are represented. These groups of factors may have influence over all the activities, but their relevance may be different over each activity in the acquisition process. The information collected for the set of case studies discussed in this chapter does not provide enough evidence to propose a clear correlation between the relevance of each factor and key activities in the acquisition project, yet some general thoughts can be drawn. In relation to the categories of factors, *strategic alignment*, *structural match*, *development management*, and *technology uncertainty* may be more relevant during the first activities of the acquisition project. During these activities partners require higher levels of communication and interaction in order to overcome technology challenges that are critical to ensure that the technology will provide the expected benefits to the acquiring company. On the other hand, the factors comprised in *implementation opportunity* may be more relevant during the later activities of the acquisition project, when the emerging product or process is implemented into the operations of the acquiring firm. As indicated in section 5.5.6, *contextual factors* have influence over the entire acquisition project.

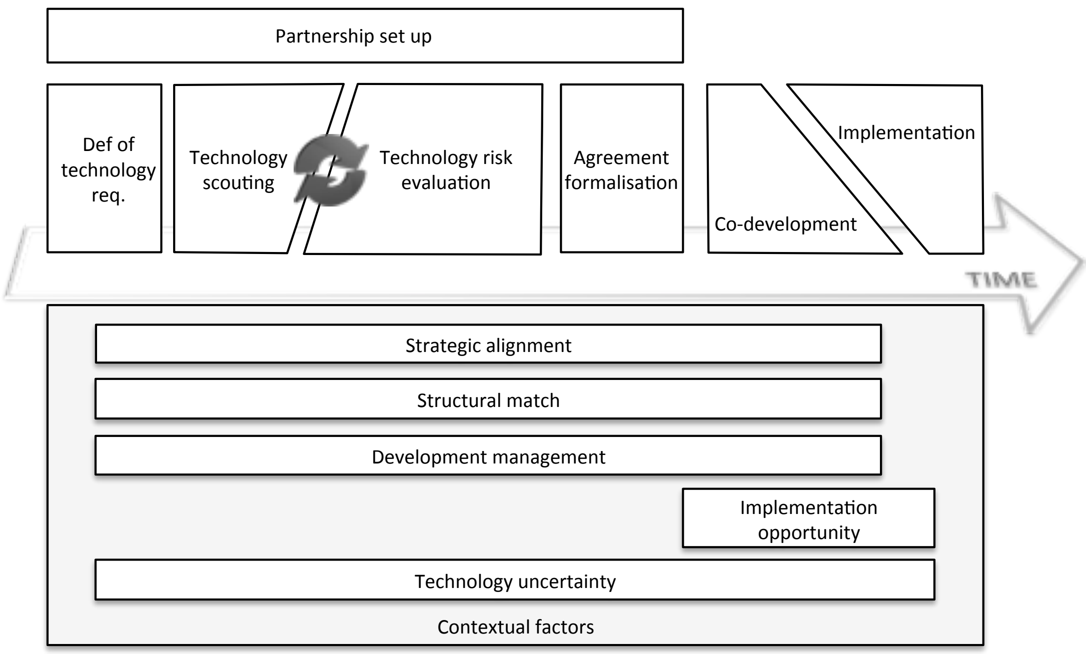


Figure 5-14 Emerging framework (v2.0)

5.8 Concluding remarks

1. The level of detail obtained through the analysis of seven acquisition projects led to a better understanding of the activities and influential factors in TA by collaboration.
2. The framework (v2.0) presented in this chapter offers a better description of the activities and specific factors that affect the technology acquisition process that involves a technology partner.
3. The acquisition process by means of collaboration comprises the following key activities: definition of technology requirements, technology scouting, technology risk evaluation, partnership set up, agreement formalisation, co-development and implementation.
4. The factors that affect TA by collaboration can be divided into six groups: strategic alignment, structural match, developed management, implementation opportunity, technology uncertainty and contextual factors.
5. Each group of factors seems to have different impact over the acquisition project.

6 FRAMEWORK REFINEMENT

Contents

This chapter presents the results of the next stage in the research project, which aimed at evaluating whether the framework was able to describe the conditions that affect effective acquisition of technology by collaboration. The results are based on empirical evidence obtained from four case studies.

6.1 Case studies overview

This phase of the research project comprised the analysis of a set of four case studies. Case studies included experiences of companies that acquired a new technology supported by an industry partner, which either provided the technology concept or the relevant technology knowledge. Table 6.1 shows a summary of the case studies analysed.

Table 6-1 Summary of case studies carried out to refine the emerging framework

Case No. Partners involved Industry Technology domain	Government of the relationship	Previous relationship between the partners	Project objective (Project status)
Case 8 Power Co/ Vegetal Oil Co. Chemical industry Manufacturing technology	Three different agreements were signed: 1) Intellectual property agreement. 2) Brand management agreement. 3) Commercialisation agreement.	None	To develop a process to produce biodegradable oil. (Finished)
Case 9 MyASA/ CNDT Tooling manufacturing Product technology	Three different contracts were signed: 1) Feasibility analysis and concept development. 2) Conceptual model and specifications of the thermal cutting module. 3) Prototype building and testing.	None	To develop a flexible steel cutting machine. (Product concept has been developed, implementation expected in 2014)
Case 10 PGSA/ CIP Oil and Gas production Product technology	One contract was signed: Service contract for wells intervention.	Technology supplier	To test and refine a downhole tool to boost gas production. (Finished)
Case 11 PGSA/ OT Oil and gas production Manufacturing technology	One contract was signed: Engineering and equipment supplying contract.	Technology supplier	To design and build an offshore crude oil dehydration and desalination plant. (Plant construction)

6.1.1 Case 8

Participating organisations

Acquiring firm – Power Co.

Main business – Manufacturing of electrical transformers to the power generation, transmission and distribution industry.

Industry partner – Vegetal Oil Inc.

Main business – Manufacturing of vegetable oil for the food industry.

Case overview

This is a co-development project carried out by two large independent firms. The purpose of this collaboration was to develop a manufacturing process to produce biodegradable dielectric oil for electric transformers. This project was important to Power Co. since through this project production costs of environmentally friendly electric transformers might be cut down. Power Co. persuaded Vegetal Oil Inc. − a large vegetable oil manufacturer − to join this project. Vegetal Oil Inc. was unfamiliar with the application of vegetable oil in electric transformers but if the project succeeded, Vegetal Oil Inc. would have access to a new market. There were many other potential customers for biodegradable oil in the industry, and Power Co. would be the channel to bring it into the market. Power Co., as consumer of the oil, defined the chemical specifications of the product and tested the performance of oil samples into electric transformers. Vegetal Oil Inc. provided the infrastructure and production expertise to scale up the process.

Data sources

The data in this case came from face-to face and telephonic interviews with key people involved in the project, including people from the partnering firm. The roles of the people interviewed were:

- R&D engineer, Power Co.
- Implementation coordinator, Power Co.
- Technology manager, Power Co.
- Strategic Technology Planning Manager, Power Co.

- Operations engineer, Vegetal Oil Inc.

Relevance of the project to the acquiring firm

This project aimed at acquiring the process technology to produce biodegradable dielectric oil for insulating applications in power transformers. The acquiring firm was interested in this technology because of the following drivers:

- A growing demand in the power generation, transmission and distribution industry for environmentally friendly and safer products.
- Power Co. wanted to increase participation and profits margins in the segment of environmentally friendly products.

Focus of the collaborative work

The R&D team at Power Co. had formulated a range of options to produce vegetable oil with dielectric properties at laboratory scale, but they needed further advice and support to scale up the processes. Vegetal Oil contributed with the facilities and expertise needed to meet Power Co.'s requirements.

Outcomes

Power Co. achieved success in developing a proprietary production process for biodegradable oil with dielectric capabilities. Without Vegetal Oil Inc.'s experience in manufacturing, Power Co. probably has never met this objective.

As a result of this project a patent request to protect the production process developed by both companies was submitted. At the time when data was collected, the partners were waiting for the approval of such a patent. They were optimistic that the patent would be granted because an external patent advisor had certified that no intellectual property was infringed. Such a report allowed Power Co. to start commercialising electrical transformers with proprietary biodegradable oil in some markets.

Both companies considered this project as a success. At the end of this joint research and development project, Power Co. obtained a proprietary process to produce its own biodegradable oil. Indeed, the technical properties of the resulting oil made it to perform better than existing commercial products without invading any intellectual property right. What is more, the resulting oil proved to be compatible with other electrical equipment within Power Co's portfolio of products. Vegetal Oil Inc., on the other hand, achieved the development of a new production process and a new product, which opened a new business window. Power Co.'s vision and perseverance was fundamental to encourage Vegetal Oil Inc. to join this venture and take the risks.

6.1.2 Case 9

Participating organisations

Acquiring firm - Metales y Aceros SA (MyASA).

Main business - Supplier of structural components to the automotive industry.

Industry partner- Centro Nacional de Desarrollo Tecnológico (CNDT).

Main business - National laboratory specialised in manufacturing.

Case overview

This is a co-development project carried out by a large firm and a national research centre. The purpose of this collaboration was to develop an adaptable machine to cut steel bars. This project was important to MyASA because the resulting process would reduce dependence on external equipment providers. Initially MyASA had considered leading the project and outsourcing only particular activities. Nevertheless, CNDT proposed to MyASA to work from the beginning by developing a conceptual model in collaboration. Developing the conceptual model in collaboration ensured that the final product would include the most appropriate technology. MyASA accepted CNDT's proposal. MyASA and CNDT shared their expertise and resources to develop the cutting machine from scratch. MyASA provided the specifications of the final product and CNDT provided technology development skills and infrastructure to develop the machine.

Data sources

The major sources of data in this case were face-to face and telephonic interviews. The researcher had also access to other documents such as business presentations and technology intelligence reports as well as to the physical prototype of the manufacturing equipment. The roles of the people interviewed were:

- R&D engineer, MyA SA.

- Product Technology and Innovation Manager, MyA SA.
- Project leader, CNDT.

Relevance of the project to the acquiring firm

The purpose of this project was to acquire a flexible manufacturing technology required to cut steel bars for the production of customised components. The acquiring firm was interested in this technology because of the following reasons:

- A growing trend in the structural components industry towards the use of small scale and flexible manufacturing processes.
- MyASA wanted to decrease investments and increase flexibility of manufacturing process for future plants.

Focus of the collaborative work

MyASA had a group of skilled people with technical experience in repairing manufacturing equipment, but they had never before developed equipment on their own. At the very beginning of the project, the staff had only a broad idea about what they wanted to obtain. CNDT contributed with facilities, technical expertise and management practices to develop the manufacturing process required by MyASA.

Outcomes

MyASA and CNDT achieved success in developing an adaptable machine to cut steel bars. The machine proved to work as expected. In particular, it was validated that the different components were able to communicate effectively. Nevertheless, due to inappropriate foundations of the place where tests were performed, the clamping system did not work correctly. However, the development teams considered this situation as irrelevant, since reinforcing the foundations could solve this problem. Beyond this issue, the cutting machine worked as expected. The machine incorporates an optical scanning technology, which is a technology that is being incorporated into the most advanced manufacturing systems in the tooling manufacturing industry. Thus, as a result of the collaboration, MyASA not only achieved the development of a proprietary cutting machine as expected, but also the acquisition of an optical scanning technology that can be applied in other manufacturing processes.

At the moment of the interviews, the cutting machine had not been implemented yet in any manufacturing facility, MyASA is planning to use it in a forthcoming plant in 2014. The resulting equipment remains in CNDT's laboratories. It has been converted into experimental equipment where new concepts and possible improvements are tested.

6.1.3 Case 10

Participating organisations

Acquiring firm - Petróleo y Gas SA (PGSA).

Main business - Exploration and production of gas and crude oil.

Industry partner- Centro de Investigación en Petróleo (CIP).

Main business - National laboratory specialised in services and technology for the oil and gas industry.

Case overview

This is a co-development project accomplished by a large Oil and Gas company and a national research centre. The purpose of this collaboration was to test and enhance a downhole tool developed by CIP to boost gas production. Having identified a critical problem to produce gas from wells with liquid loads, CIP developed a prototype tool to boost gas production. PGSA had explored different options and commercial tools to boost gas production from mature gas fields, but these tools were only contingent solutions to stabilise gas production. These technologies did not solve the problem since liquids persisted inside the well. CIP developed a prototype but it needed to be validated in a real operative environment. Therefore, CIP contacted PGSA to request access to some gas wells in order to test the prototype. The results of the field trials were very encouraging so that PGSA contracted CIP to install the downhole tool into problematic wells. This contract allowed CIP to refine the tool by getting feedback from the customer and gaining expertise in well interventions.

Data sources

The major source of data in this case was semi-structured interviews. The researcher also had access to other documents including business presentations, technical reports and technology intelligence reports. The roles of the people interviewed were:

- Operations manager, PGSA.
- Manager - Hydrocarbons recovery R&D programme, CIP.
- Intellectual property manager, CIP.
- Project coordinator, CIP.
- R&D leader, CIP.
- R&D engineer, CIP.

Relevance of the project to the acquiring firm

The purpose of this project was to acquire technology to boost the productivity of gas wells. PGSA was interested in acquiring this technology because of the following reasons:

- The production rate of gas wells was declining due to the presence of gas condensate at the bottom of the wells.
- A significant amount of gas still remained trapped into the reservoirs.

Focus of the collaborative work

The technology was fully developed by CIP but it needed to be tested into a real operative environment in order to get a final product. PGSA provided the facilities to carry out the field trials and technical advice on operational considerations to make useful the final product.

Outcomes

The device was tested in different wells and the results were positive and encouraging. The gas production rate in mature wells increased. Indeed, in some wells, the device produced extraordinary increments on gas production. After several installations, the partners defined the range of conditions under which the device produced the best results. Gas production increased substantially as the partners learned more about the technology. Participation of PGSA's field engineers was key to achieving the development of a reliable downhole tool.

As a result of the collaborative work, CIP developed an integral service to improve gas well productivity. The service includes not only the device and installation, but also an operative procedure to indicate whether a well is candidate to use the device or not. What is more, each device is customised to the particular requirements of the well where it is going to be placed. CIP provides the device to PGSA on the basis of service contracts limited in time and by producing area.

A patent application to protect the tool was filled in 2011 and the decision of going for a PCT application was under consideration at the time of the interviews. In this patent, people from both organisations were recognised as inventors, however CIP is the sole owner of the intellectual property rights of the tool.

6.1.4 Case 11

Participating organisations

Acquiring firm - Petróleo y Gas SA (PGSA).

Main business - Exploration and production of gas and crude oil.

Industry partner- Offshore technology (OT).

Main business - Technology supplier to the Oil and Gas industry.

Case overview

This case describes a project where two large independent companies collaborated to design and build an offshore crude oil dehydration and desalination plant. PGSA predicted that crude oil production from offshore would present important volumes of water and high concentrations of salt within the following years. This situation required PGSA to define a strategy to eliminate water and salt from produced crude. PGSA explored different options and found that the best choice was to treat produced crude oil into a dehydration and desalination plant near to the production site. The plant would be located onto an offshore platform and it would require incorporation of an electrostatic separation technology, which PGSA had never used before. This technology was identified as the most suitable option to remove water and salt due to low space requirements in offshore operations. OT’s separation technology performed better on labs and field trials than other two potential alternatives. However, OT had no expertise on designing and installing dehydration and desalination plants onto offshore platforms. In fact, OT had been only supplier of equipment. Both companies agreed to work together to design and build the plant.

Data sources

The major source of data in this case was face-to-face interviews. Other sources of data included documents such as business presentations, technical reports and technology intelligence reports. The roles of the people interviewed were:

- Strategic project execution manager, PGSA.
- Project engineer, PGSA.
- Project coordinator, PGSA.
- Contract manager, PGSA.
- Project control and execution strategist, PGSA.
- Major Projects Manager, OT.
- Technical manager, OT.

Relevance of the project to the acquiring firm

The purpose of this project was to acquire technology capable of dehydrating and desalinating large volumes of crude oil on a marine platform. The acquiring firm was interested in acquiring this technology because of the following reasons:

- It has been estimated that the amount of saline water combined with crude oil produced from offshore reservoirs will increase substantially over the next years.
- The space required for common technologies to process the volume of crude oil and water is much more larger than the space available on the existing marine platforms.

Focus of the collaborative work

The technology offered by OT can deal with the volume of crude oil and water expected, however the technology has been only used in on-land facilities. Both partners collaborated to elaborate the engineering layouts and adjustments to the technology to operate on an offshore platform.

Outcomes

The basic engineering has been completed and now OT is coordinating the manufacturing and procuring of the equipment. The first equipment deliveries were expected by mid 2012. The equipment would be manufactured at different countries. For example, some equipment is being manufactured in Norway, US, and Mexico. This project meant a challenge to OT, since they never before had been in charge of designing an entire dehydration and desalting plant in an offshore environment. In previous projects, OT had only participated as supplier of equipment.

At the moment of the interviews, PGSA had started the preparation of the offshore platform to install the plant. The plant had been planned to start by mid 2013, so that individual equipment tests were scheduled by early 2013, and a pilot test by the second quarter of 2013.

The major challenge in this project is to start up operations in 2013. This is a strategic project for both companies. On the one hand, commercialization of a significant volume of crude oil in the near future depends on the ability of PGSA to eliminate water and salt from produced crude oil. On the other hand, the successful completion and operation of the offshore plant would give OT international reputation on installing offshore dehydration and desalting plants.

6.2 Key activities

This section analyses the effectiveness of the emerging framework (v2.0) in describing the key activities in technology acquisition projects. The discussion of each case is focused on the main conflicts between the activities found in the project and those comprised by the framework.

6.2.1 Case 8

The upper part of Figure 6.1 shows the sequence of activities observed in Case 8. The activities are divided into two types: acquisition-related activities and partnership-related activities. Acquisition related activities comprise: definition of technology requirements, technology scouting, product formulation, laboratory scale testing, process scale-up and implementation. On the other hand, partnership-related activities include collaboration assessment and agreement formalisation.

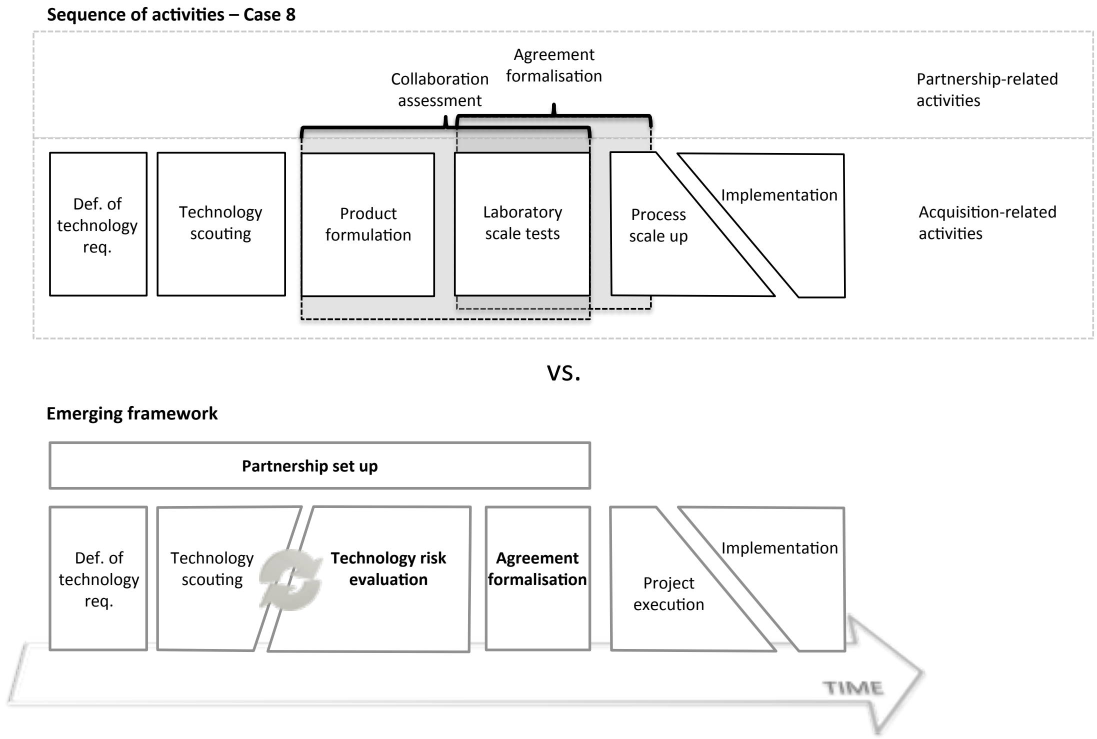


Figure 6-1 Sequence of activities observed in Case 8 vs emerging framework (v2.0)

Figure 6.1 graphically shows the relationship between the activities described in the emerging framework and the activities observed in Case 8. As it can be observed, there is a level of correspondence between them. However, there are activities in the emerging framework that do not describe accurately the sequence of activities observed in case 8. These activities are technology risk evaluation, agreement formalisation and partnership set up. The reasons for these differences are explained below.

Technology risk evaluation

The emerging framework suggests that evaluation of technology risks is an activity closely linked to technology scouting. Nevertheless, case 8 showed a different situation. In this case, there are two key activities that are not explicitly described by the emerging framework: product formulation and laboratory scale tests.

The acquiring firm knew the technology and who were the owners of patents that covered biodegradable oil formulations and production process. The big challenge here was to find an alternative formulation and production process that would not infringe extant IPR. Therefore, Power Co. started to investigate new formulations. Power Co.'s research team got some possible formulations, but these were either not clearly different from existing ones or very difficult to produce. This activity can be referred to as *product formulation* since this effort aimed at exploring possible ways to make technically and commercially viable the oil formulation and its production process.

When the technical staff of Vegetal Oil joined the project, they provided pilot test facilities and expertise in processing vegetable oils. These two pieces were key to finding a solution. Both teams worked to test the options developed by Power Co. At the end, the partners came up with a formulation and production process that were demonstrated to work at laboratory scale, and which did not infringe third party intellectual property rights. This activity can be referred to as *laboratory scale tests*. The outcomes confirmed that a new formulation was possible, so that developing the full-scale process was the next step.

To sum up, this case suggests instead of *technology risk evaluation* there are two activities between technology scouting and the project execution: *product formulation* and *laboratory scale tests*.

Agreement formalisation

The emerging framework suggests that the formalisation of the collaboration agreement starts after a definite evaluation of technical and economic risks, and that it is a condition to move forward in the acquisition process. In practice, this seems to be incorrect. The formalisation of the agreement may start as soon as the partners are convinced that there is value in the project for them, and negotiations may conclude even when the execution of the collaboration work has started.

In this case, the partners began to negotiate the terms and conditions of their relationship before finishing the laboratory-scale tests. Negotiations went over a period of almost two years, and the development teams did not wait to get the contract signed to move on. The companies started to work without a formal agreement. Indeed, the final agreement was signed when the partners were working on the development of the full-scale process. The *formalisation of the agreement* did not stop the collaborative work since this activity did not interfere with the technical process to develop the final product.

In this case, the formalisation of the agreement ran in parallel to laboratory tests and scaling up. The main participants in the formalisation process were managers and lawyers of both firms. *Agreement formalisation*, therefore, is a partnership-related activity that should not be mixed with acquisition-related activities. Indeed, agreement formalisation is an activity that could be considered as part of the activity labelled as *partnership set up* in the emerging framework.

Partnership set up

As noted in the emerging framework, partnership set up includes activities related to the evaluation of the value of the collaboration and development of a common vision among partners (section 5.3.4). In Case 8, although these activities are also observed, they can be divided in two overlapping phases: *collaboration assessment* and *agreement formalisation*. They are called phases since they denote different level of commitment between the partners. These phases run in parallel to acquisition-related activities. *Collaboration assessment* denotes the period of time where the partners evaluate the potential benefits of the joint project. In this case the assessment ran at the same time as product formulation and laboratory scale tests. On the other hand, *formalisation of the agreement*, as mentioned above, indicates the stage of the collaborative work where the partners negotiate the terms and conditions of their business relationship. In this case, the formalisation agreement phase started at the time when the production process was being tested and finished when the scaling-up process was under development.

6.2.2 Case 9

The upper part of Figure 6.2 shows the sequence of activities observed in Case 9. As in case 8, the activities can be divided into two types: acquisition-related activities and partnership-related activities. Acquisition related activities comprise: Definition of technology requirements, feasibility analysis, concept model development, prototype concept testing, equipment development and implementation. On the other hand, partnership-related activities also include assessment of the collaboration and contractual negotiations of the project.

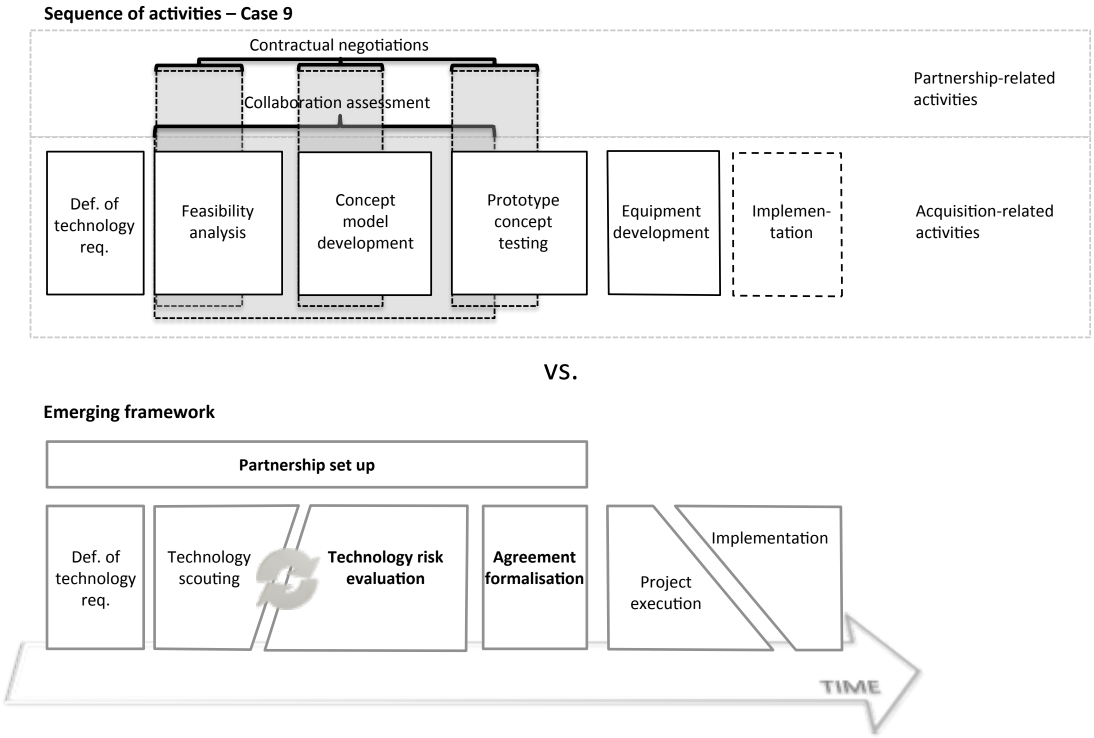


Figure 6-2 Sequence of activities observed in Case 9 vs emerging framework (v2.0)

Figure 6.2 graphically shows the relationship between the activities described in the emerging framework and the activities observed in Case 9. In this project, the key activities roughly correspond to the activities defined in the emerging framework with some variations in names. For example, feasibility analysis and equipment development correspond to technology scouting and project execution. Again, the major differences in the activities are observed between technology scouting and project execution. Like in case 8, technology risk evaluation can be broken down into two key activities: *concept model development* and *prototype concept testing*. In addition, partnership set up is also broken down in two key phases: *collaboration assessment* and *contractual negotiations*. The reasons for these differences are explained below.

Technology risk evaluation

In this case, MyASA decided to develop proprietary equipment so that the evaluation of the technical risks went through two key activities. Firstly, MyASA and its partner designed a conceptual prototype. As a result of this activity, the partners obtained the drawings, designs of every component and manufacturing directions to build a physical model. These outcomes provided confidence to MyASA that it would be possible to build the equipment. This activity is referred to as *concept model development*. Secondly, the prototype concept was tested. Although the conceptual design reduced the uncertainty of the development, the true technical challenges had not been addressed. One key challenge was to demonstrate that the algorithm to communicate the different components would make the prototype concept work as expected. This activity is referred to as *prototype concept testing* in Figure 6.2. Once that the development team demonstrated that it was possible to achieve an effective communication between the different components, the project moved forward, towards building the physical equipment (equipment development).

Thus, this case study suggests that *technology risk evaluation* can be divided into two key activities: *concept model development* and *prototype concept testing*.

Agreement formalisation

This case illustrates the situation where the partnering firms sign a contractual agreement before starting each key activity in the development process. The partners signed three contracts, one to explore the feasibility of the development, a second one to produce a conceptual model of the equipment, and a third one to test the conceptual model and build a physical prototype. The emerging framework fails to cover this situation. As the contractual negotiations do not interfere with acquisition activities, they are better placed into partnership-related activities. Figure 6.2 shows a schematic representation of the correlation in time between the contractual negotiations and the key activities in the acquisition process.

Partnership set up

Similar to case 8, partnership set-up embraces two overlapping phases: negotiation of the contractual agreement and evaluation of the collaboration. The contractual phase has been already mentioned in the previous paragraph. On the other hand, collaboration assessment comprises the points of the project where both partners evaluated the progress of the project and decided on the possibility to go together forward. Figure 6.2 shows the periods in the acquisition project when collaboration assessment and contractual negotiations took place.

6.2.3 Case 10

Figure 6.3 shows the sequence of activities observed in Case 10 and their correlation to the activities comprised by the emerging framework. Like in the previous two cases, the activities can be divided into two types: acquisition-related activities and partnership-related activities. Acquisition related activities comprise: definition of technology requirements, technology scouting, selection of technologies, field trials, product adaptation and implementation. On the other hand, partnership-related activities include collaboration assessment and formalisation of the agreement.

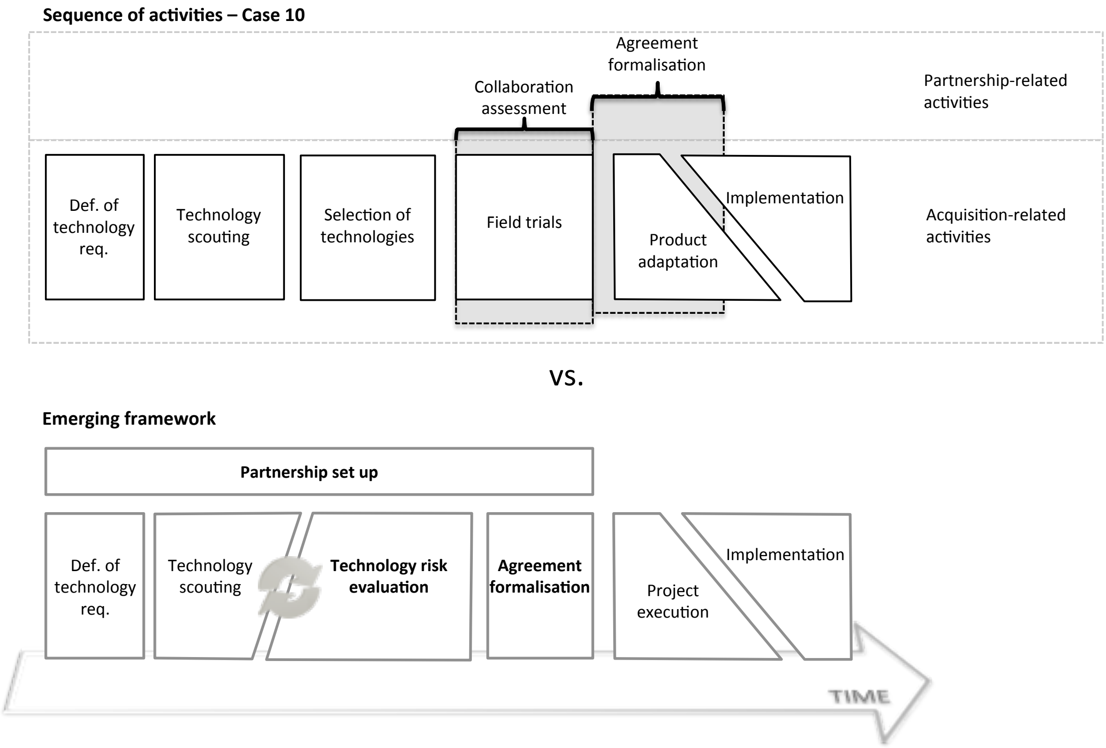


Figure 6-3 Sequence of activities observed in Case 10 vs emerging framework (v2.0)

As it can be noticed in Figure 6.3, there is a certain degree of correlation between the activities observed in Case 10 and those comprised in the emerging framework. The initial and latest activities of the acquisition process are quite similar; the terminology is different although these activities comprise roughly the same tasks. The most evident conflict of activities between case study 10 and the emerging framework is located right at the middle. Again, technology risk evaluation seems to be broad and does not provide a clear indication of the key activities in the acquisition process. In addition, partnership set up and agreement formalisation do not match with the activities observed in case 10.

Technology risk evaluation

In this case, after identifying a range of possible technologies, PGSA selected only the technologies that could boost the production of gas according to the geophysical characteristics of the wells and their operative conditions. Not all the available technologies and commercial products were good candidates because of technical and operative limitations. For example, some of these technologies had been proved to work in crude oil wells, but not in gas wells. This activity is referred in Figure 6.3 to as *selection of technologies*. After selecting the potential technologies, PGSA ran field trials to test their performance in order to define which one would be the most appropriate. PGSA proved a number of technologies offered by different suppliers but the increments in productivity were insufficient. This activity is pointed out in Figure 6.3 as *field trials*. PGSA moved forward in the acquisition process when the technology concept developed by CIP demonstrated to provide a superior performance.

Therefore, this case study suggests *that technology risk evaluation* can be divided into *selection of technologies* and *fields trials*.

Agreement formalisation

In this case, the formalisation of the agreement began just after the technology concept developed by CIP demonstrated such an outstanding performance during the field trials. PGSA become convinced that the technology should be implemented as soon as possible, so that they provide technical support to CIP to make the adaptations needed to get a reliable tool. The technical teams at both companies did not wait to sign the contractual agreement to start interacting. The final contract was approved by the time CIP had started to implement the tool in several gas wells. As noted in the previous two cases, the formalisation of the agreement has been separated from the acquisition-related activities. Figure 6.3 shows the relationship between the activities in the acquisition process and the period of time that the partners spent to formalise the agreement.

Partnership set up

The emerging framework does not show explicitly the activities that partners performed to reach an agreement. Like the previous two cases, this case suggests that the activities are comprised by two key phases in the partnership: *agreement formalisation* and *assessment of the collaboration*. *Agreement formalisation* has been already discussed in the previous paragraph. *Assessment of the collaboration*, on the other hand, took place during field trials. Once that PGSA became confident about the functional performance of the technology, the focus of the collaboration centred into technical issues.

6.2.4 Case 11

A schematic correlation between the sequences of activities observed in Case 11 and the activities comprised by the emerging framework are shown in Figure 6.4. Like in the previous three cases, the activities are divided into two types: acquisition-related activities and partnership-related activities. In this project, acquisition related activities comprised: definition of technology requirements, technology scouting, evaluation of existing technologies, pilot tests, plant engineering and plant construction. On the other hand, partnership-related activities include *assessment of the collaboration* and *formalisation of the agreement*.

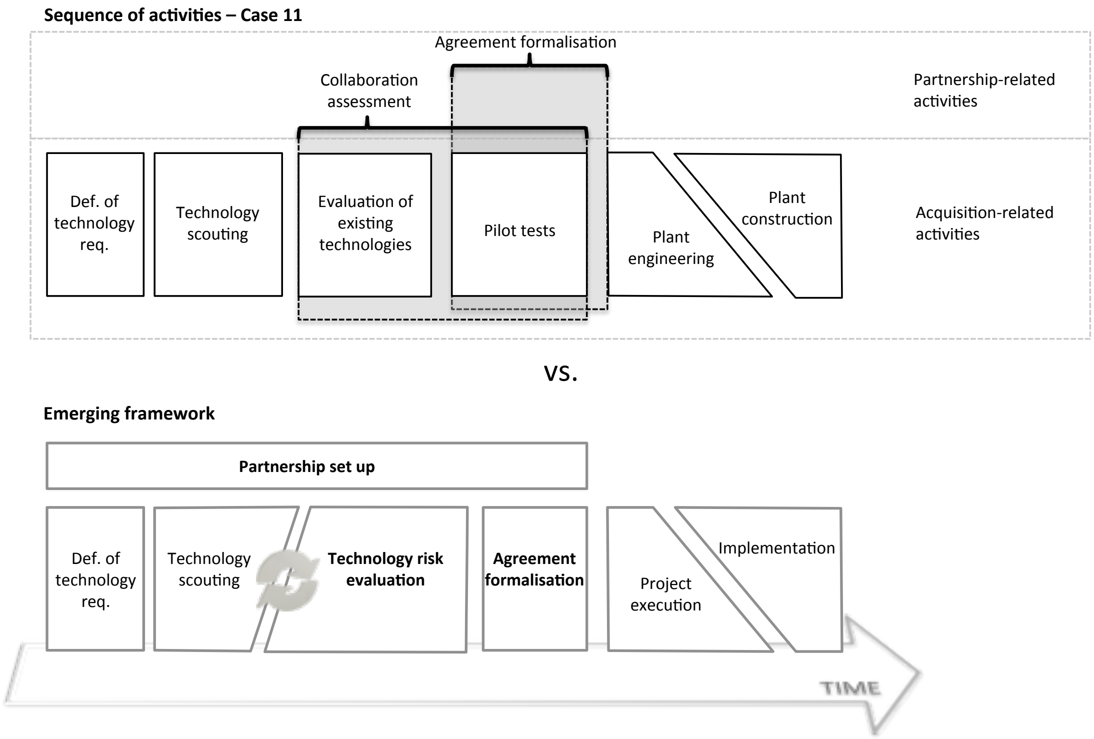


Figure 6-4 Sequence of activities observed in Case 11 vs emerging framework (v2.0)

There is a certain degree of correlation between the acquisition related activities observed in Case 11 and those comprised in the emerging framework. Like in the previous three cases, the main conflict is located in the following activities: technology risk evaluation, agreement formalisation and partnership set up.

Technology risk evaluation

In this case, the evaluation of the technology went through two stages. In the first stage (referred in figure 6.4 to as *evaluation of existing technologies*) PGSA asked potential suppliers of technology to perform laboratory tests to determine whether their technology could meet the operational and functional characteristics required to eliminate the water and salt content of the particular mix of crude oil that is produced in the Gulf of Mexico. The results of these tests provided information to select the technology that would be acquired. Thus, in a second stage (referred in figure 6.4 to as *pilot tests*), before starting formalising the acquisition contract, PGSA performed a second round of pilot test to determine the operative and functional boundaries of the technology. Once that PGSA verified the performance of the technology, the acquisition project moved forward to designing the plant.

To sum up, this case suggested also that technology risk evaluation could be broken down into two activities: *evaluation of existing technologies* and *pilot tests*.

Formalisation agreement

In this case, the process to formalise the agreement ran in parallel to pilot tests, however, the next activity (*plant engineering*) did not start until the contract was signed. So, in that sense, this activity seems to match with the position of this activity in the emerging framework. Nevertheless, like in the previous cases, this activity has been separated from the acquisition-related activities, and has been relocated as a partnership-related activity.

Partnership set up

This activity seems to comprise two key phases: *collaboration assessment* and *agreement formalisation*. The evaluation of the collaboration in this case ran from the evaluation of the technology to pilot tests. Over that period both partners were in close communication to assess the suitability of the technology to be applied in an offshore plant. The other phase, *agreement formalisation* has been already addressed in the previous paragraph.

6.3 Evaluation - key activities

A comparison between the four projects leads to the identification of two sorts of acquisition projects, which depend on whether or not the acquiring partner participates in the development of the technology concept. This distinction is relevant since it affects one key step in the acquisition process.

In cases 8 and 9, the acquiring firms decided to develop their own technology. As a consequence, they were involved in the design and development of the technology concept that might provide solution to their business need. Later, this technology concept was tested to verify whether it could meet the expected performance. Once the technology concept demonstrated both good performance and economic advantages, the acquiring firms decided to go forward and develop the product. In case 8 the final product was a production process while in case 9 manufacturing equipment.

On the other hand, in cases 10 and 11 the firms acquired technology concepts that were independently developed by a third party. In these cases, the acquiring firm evaluated and selected one technology concept between different existing alternatives. Later, after selecting a technology concept, the acquiring firm performed a set of field trials to verify whether it may provide the estimated performance under real operative environments.

The case studies also indicate that there are two kinds of activities: acquisition-related activities and partnership-related activities. The first one refers to a group of tasks that are the consequence of the negotiation between the acquiring firm and its industry partner. The second one refers to technical activities that concern the acquisition of the technology.

In short, the case studies provided evidence to refine the sequence of activities in TA by collaboration described in the previous version of the framework. Figure 6.5 shows the sequence of activities observed through the case studies in comparison with the emerging framework. The key modifications to the previous framework fall in three activities:

1. Technology risk evaluation
2. Agreement formalisation
3. Partnership set up

The rest of the activities were modified only on their names since there is not a substantial change in the tasks they cover.

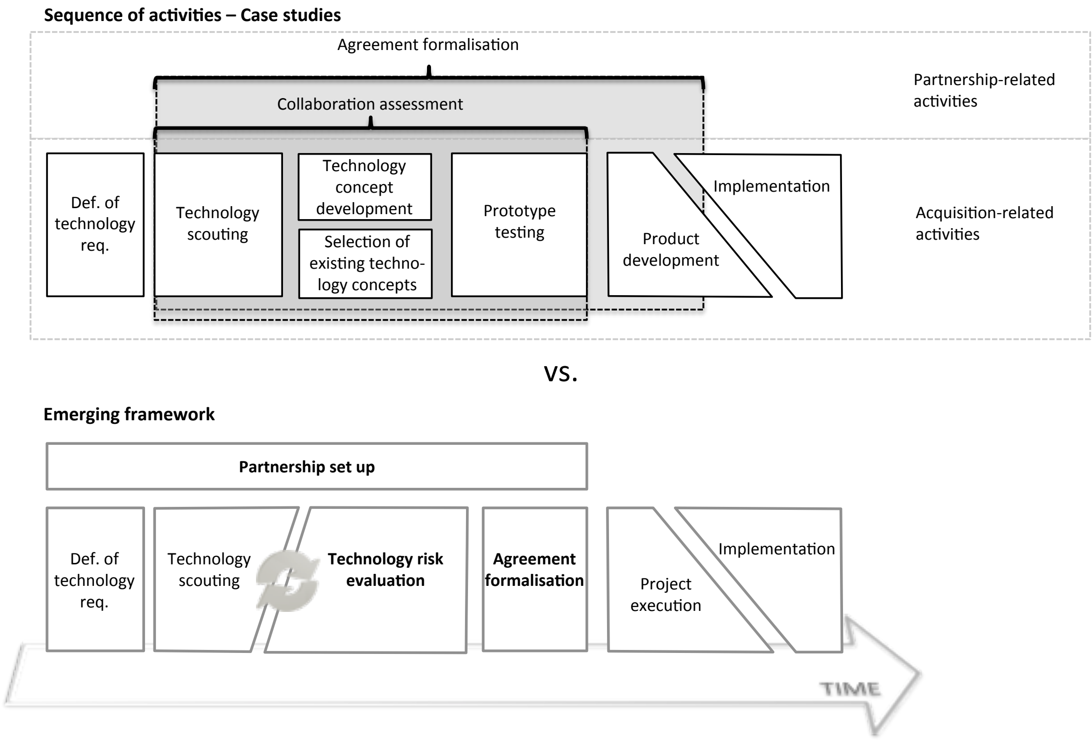


Figure 6-5 Sequence of activities observed in case studies vs emerging framework (v2.0)

6.4 Influential factors

The most relevant factors observed in all cases fall within the factors described in the previous framework (v.20). The analysis of case studies points out that the relevance of those factors is observed through the impact on three broad domains: Partnership stability, co-development execution and transference of the outcome.

Partnership stability. The factor impacts on the motivations of the partnering firms to cooperate in the project and stability of the business relationship.

Co-development execution. The factor impacts on the performance of the collaboration outcome.

Transference. The factor impacts on the transfer of the resulting product to the beneficiary system.

6.4.1 Case 8

The most significant factors observed in Case 8 are comprised within the six categories considered in the emerging framework. Table 6.2 presents a summary of the most relevant aspects of this acquisition project and their domains of impact.

Table 6-2 Case 8 – Relevant aspects

Category ***Factor***	**Key aspects**	**Impact on…**
Strategic alignment		
Business motivations	• There was only one worldwide provider of biodegradable oil with dielectric properties, thus reducing dependence on such a provider was key to cut the unitary cost of environmentally friendly and safer electric transformers. • The project represented a business opportunity for Vegetal Oil Co to get into a new market.	Partnership stability
Management of emerging IPR	• The partners spend over eighteen months to achieve an agreement on who would own the product, royalty fees, commercialisation and production issues and intellectual property rights.	Partnership stability
Project relevance	• Power Co launched in 2006 a new range of environmentally friendly and safer transformers and cutting the cost of biodegradable oil was a key issue to reach higher profitability levels in this market.	Transference
Structural match		
Match of resources and expertise	• Power Co knew the specifications of the final product and had expertise in evaluating the dielectric characteristics of oils, while Vegetal Oil had expertise and infrastructure to scale up the production process. • An external technical advisor supported Vegetal Oil's and Power Co to perform laboratory tests and chemical characterisation.	Co-development execution
Access to the IP exploitation rights	• A wide scope patent covered a wide range of formulations of biodegradable oil for applications in electric transformers. The owner of the patent was a direct competitor of Power Co in the electrical equipment manufacturing industry.	Co-development execution
Development management		
Ease of decision-making	• Finding a date for technical meetings also was a challenge. Coordinating agendas between all the people involved in the development work was not an easy task.	Co-development execution

Table 6-2 Case 8 – Relevant aspects (cont.)

Category *Factor*	**Key aspects**	**Impact on…**
Development management (*cont*) *Ease of communication*	• At the beginning of the collaborative work, a key challenge for the partners was to understand each other's businesses and operations. • The members of the development team of both companies found challenging to coordinate joint activities due to differences in working cultures and business operations.	Co-development execution
Technology uncertainty *Technology performance*	• Laboratory tests demonstrated that the oil formulation met the required specifications of the product and, most important, its characteristics were much better that the existing product. • The technical properties of the resulting oil make it to perform better than the existing commercial products.	Co-development execution
Product novelty	• Vegetal Oil was not familiar with the use of vegetable oils in electric equipment.	Co-development execution
Technology familiarity	• Power Co was not familiar with the manufacturing process to produce vegetable oils.	Co-development execution
Implementation opportunity *Market uncertainty*	• At the beginning of the R&D project, the market growth rate for environmentally friendly products was still very low. • Regulations supporting the use of biodegradable fluids in the electric power generation, transmission and distribution industry in North America, the main market of Power Co, are still insufficient.	Transference
Performance of the project	• The resulting oil does not infringe existing intellectual property rights of third parties.	Transference
Compatibility with existing systems	• Despite the fact that Power Co had already electric transformers using biodegradable oil, it was necessary to carry out tests to prove the performance of the new oil. • The development team at Power Co found that the new oil could be incorporated in the electric transformers without major changes in the current design of its products. • Some changes in current operations and logistics were required to handle and store the new biodegradable oil.	Transference
Contextual factors *Project characteristics*	• External R&D advisors determined that the scope of extant IPR protecting commercial biodegradable oil with dielectric characteristics technically made it impossible to find a distinctive feature that Power Co could use in its formulation without infringing existing intellectual property rights.	Co-development execution
Partners' affinity	• The reasons behind choosing Vegetal Oil as a partner were twofold. Vegetal Oil was located in the same city as Power Co, and Vegetal Oil's owner had a very good business relationship with Power Co's owner.	Partnership stability

6.4.2 Case 9

The most influential factors detected in Case 9 falls across the six categories considered in the emerging framework. Table 6.3 presents a summary of the most relevant aspects of this case study and their domain of impact.

Table 6-3 Case 9 – Relevant aspects

Category *Factor*	**Key aspects**	**Impact on…**
Strategic alignment		
Business motivations	• MyASA has been pushed to adopt a low-volume and flexible manufacturing approach to meet the requirements of their customers. • Initial investment to open new plants near to key customers was very high due to the low number of equipment providers for flexible machines. • CNDT was interested in participating in this project because its financial resources depend largely on supporting industry customers to meet their technology needs.	Partnership stability
Project relevance	• MyASA began an R&D project to explore possible capital investment cuts by developing proprietary machinery. • MyASA's Directors fully supported the development project.	Transference
Vision alignment	• CNDT development team visited MyASA's manufacturing site to understand operations better before giving MyASA a working proposal.	Partnership stability
Contract	• MyASA and CNDT signed three contracts: feasibility analysis and concept development, conceptual model and specifications of the thermal cutting module, and prototype building and testing.	Partnership stability
Structural match		
Match of resources and expertise	• MyASA had skilled people and expertise to develop the mechanical cutting process but not to develop the thermal cutting module.	Co-development execution
Access to funding	• The project was granted with governmental funding to encourage technology collaboration between universities, national research centers and industry.	Co-development execution
Development management		
Project management practices	• MyASA's R&D team had worked only on incremental modifications to equipment. • The development work was divided in three stages: feasibility analysis, concept model development and prototype building. • CNDT proposed to MyASA to follow a structured product development process to deal with technical and economic risks.	Co-development execution
Scope definition	• MyASA's R&D team specified the characteristics of the final product.	Co-development execution

Table 6-3 Case 9 – Relevant aspects (cont)

Category *Factor*	**Key aspects**	**Impact on…**
Technology uncertainty		
Technology familiarity	• At the beginning of the R&D project, MyASA's R&D team did not have enough information to estimate the economic resources required for this development. • No one at CNDT had experience in steel cutting processes when the project started.	Co-development execution
Product novelty	• The concept challenged a paradigm of equipment manufacturers. Commercial piercing equipment did not release the product until all the cutting processes had finished; otherwise the process might loose reference of previous cuttings. • Transferring the steel bars from the mechanical cutting module to the thermal cutting module required a solution to keep cutting references. • Integration of an optical scanner with the cutting process.	Co-development execution
Implementation opportunity		
Performance of the project	• The prototype proved to work as expected. • MyASA not only achieved the development of a proprietary cutting process as expected, but also the acquisition of an optical scanning technology that can be applied to different manufacturing processes.	Transference
Implementation plan	• The thermal cutting module has not been implemented yet in any manufacturing facility.	Transference
Contextual factors		
Partners' affinity	• The team concluded that CNDT could be a good partner to work with for two reasons. Firstly, the team found that CNDT had relevant skills and infrastructure to support them in achieving the development of the piercing process; and secondly, CNDT was about to open an R&D unit in a science park located few miles away from MyASA's main manufacturing site.	Partnership stability

6.4.3 Case 10

The analysis of factors in Case 10 suggests that the six categories considered in the emerging framework cover the most relevant issues. Table 6.4 presents a summary of the key aspects of this acquisition project and their domain of impact.

Table 6-4 Case 10 – Relevant aspects

Category *Factor*	**Key aspects**	**Impact on…**
Strategic alignment		
Business motivations	• In the Burgos basin, the main problem that is leading to production decline in gas fields is the presence of liquids. • Boosting wells production was a key concern in Burgos basin. • One of PGSA's strategic priorities is to raise oil and gas production in fields whose production is declining. • In 2007, CIP started a research project aimed at developing solutions to increase productivity of marginal gas fields.	Partnership stability
Project relevance	• In 2002, a technical group of PGSA was assigned the mission of identifying the root of the decline of gas production and finding the best technologies to boost natural gas production in the Burgos basin.	Transference
Vision alignment	• Back in 2005, one of the CIP's teams was contracted by PGSA to analyse the effect of downhole chokes on crude oil well productivity. This experience was the trigger of a research and development proposal.	Partnership stability
Trust	• Field trials were performed without a formal contractual agreement.	Partnership stability
Structural match		
Access to testing facilities	• Testing the product required stopping operations of producing wells.	Co-development execution
Internal stability of partners	• The administrator that provided the CIP team with access to the well two years ago had been moved to another location.	Co-development execution
Match of resources an expertise	• PGSA provided all the equipment and support to perform field trials while the CIP's R&D team provided the technical expertise.	Co-development execution

Table 6-4 Case 10 – Relevant aspects (cont.)

Category *Factor*	**Key aspects**	**Impact on…**
Development management		
Ease of decision-making	• The OCG and the CIP team worked as an integrated team during the field trials.	Co-development execution
Scope definition	• Both teams agreed that they would work together to refine the device and finding the characteristics of candidate wells to use this technology.	Co-development execution
Ease of communication	• CIP's R&D team and PGSA kept an open communication on the outcomes of fields trials and performance of the technology.	Co-development execution
Development team	• CIP's R&D team was enthusiastic about this project, they wanted to turn the technology prototype into a final product.	Co-development execution
Technology uncertainty		
Technology familiarity	• At the beginning of the acquisition project PGSA were unfamiliar with the phenomenon and very few wells used an artificial system to improve productivity.	Co-development execution
Technology performance	• Before installing the device, the well produced gas at a rate of 0.3 millions cubic feet; after installing the device the well reached a production rate of 3 millions cubic feet, and few hours later production stabilized at a rate above 1 million cubic feet. • Results were corroborated later through trials in fifteen wells. • The device was tested in different wells.	Co-development execution
Product novelty	• None of the commercial devices use a technology similar to the tool developed by the CIP's R&D team. The prototype had been tested in the laboratory. However, to obtain a final product, such a prototype needed to be tested under a real operational environment.	Co-development execution
Implementation opportunity		
Performance of the project	• Based on the success of field trials and massive installation of the device in several wells, managers of other gas producing areas requested the service.	Transference
Familiarity with the final product	• Since the OCG was performing a research initiative at that time using downhole chokes, they understood the operation principle of the prototype.	Transference
Compatibility with existing systems	• Well operators were trained to understand the conditions that were required to operate the technology. The operative conditions were slightly different from traditional operations.	Transference
Contextual factor		
Previous relationship	• Over more than 65 years, the CIP has provided PGSA with technology and technical services.	Partnership stability

6.4.4 Case 11

In Case 11, the most relevant factors fall across the six categories considered in the emerging framework. Table 6.5 presents a summary of the most relevant aspects of this acquisition project and their domains of impact.

Table 6-5 Case 11 – Relevant aspects

Category *Factor*	Key aspects	Impact on…
Strategic alignment		
Business motivations	• The commercial value of crude oil produced from offshore fields, depends on the ability of PGSA to eliminate water and salt content. • The successful completion and operation of the offshore plant would give OT international reputation in installation of offshore dehydration and desalting plants.	Partnership stability
Project relevance	• The major challenge in this project is to start up operations in 2013 otherwise PGSA may lose money because the produced crude oil may not meet commercial specifications.	Transference
Risks and rewards	• PGSA and OT agreed that both companies would develop the conceptual engineering of the plant and OT would take full responsibility for the manufacture and procurement of the equipment.	Partnership stability
Wording of the contract	• PGSA asked OT to include some clauses in the contract to guarantee that the process would perform as expected.	Partnership stability
Structural match		
Internal stability of partners	• At the earliest stages of the acquisition project, PGSA contacted and started laboratory trials with DTECH, a small firm that originally had developed the electrostatic technology. Some time after, OT acquired DTECH and became owner of DTECH's intellectual property and experimental facilities.	Co-development execution
Match of resources and expertise	• During the acquisition project, PGSA hired external technical and engineering advisors to get support on the evaluation of the performance of the technology and identify possible risks.	Co-development execution
Development management		
Scope definition	• PGSA and OT estimated the dimensions and process requirements of all the equipment of the plant.	Co-development execution
Ease of decision-making	• Within the decision-making team there were concerns about the technology risks of using an electrostatic technology; they were cautious, they did not want to take any risks. • The electrostatic technology was found as the best alternative but PGSA had never before used that technology and the level of investment and urgency gave no room for failures.	Co-development execution

Table 6-5 Case 11 – Relevant aspects (cont.)

Category *Factor*	Key aspects	Impact on…
Development management (*cont.*) *Communication*	• In this project PGSA has worked very closely with OT, in particular during the basic engineering. PGSA and OT estimated the dimensions and process requirements of all the equipment of the plant. Both companies spent about a year to accomplish the basic engineering.	Co-development execution
Technology uncertainty *Technology familiarity*	• The most suitable strategy to deal with water and salt required acquisition of a dehydration technology that PGSA had never used before.	Co-development execution
Ease of scaling up	• As a result of pilot tests, an operational issue in the separation technology raised. Oxygen content in the wash water would lead to operative problems in the desalting system; therefore, oxygen must be eliminated from wash water.	Co-development execution
Technology maturity	• The electrostatic separation technology has been used in onshore plants. This project would be the first one to bring this technology to an offshore environment.	Co-development execution
Technology performance	• OT's separation technology showed the best performance. • The decision-making team organized a series of workshops to analyse pros and cons of the technology, as well as to find out how technology risks could be minimized. • PGSA asked to OT to carry out a further set of tests to verify whether the technology would perform as expected.	Co-development execution
Implementation opportunity *Performance of the project*	• The basic engineering has been completed and now OT is coordinating the manufacturing and procuring of all the equipment.	Transference
Implementation plans	• PGSA established three strategies to deal with the presence of water and salt in the short and medium term. Firstly, as immediate action, the wells that were producing crude oil out of commercial specifications would be closed. Secondly, closed wells would be treated to reduce both the volume of water lifted to surface and salt content. Thirdly, in 2013 onwards, damp crude oil would be sent to a D&D plant to eliminate water and salt.	Transference
Contextual factors *Project characteristics*	• The whole project to install an offshore dehydration and desalting plant comprises four sub-projects: conditioning of an existing platform to install the D&D plant, engineering and equipment procurement, plant construction and start up, as well as installation of a power system. PGSA is coordinating the execution of the four projects and different service providers had been hired to accomplish each project.	Co-development execution
Previous relationship	• PGSA had worked in the past with both companies (DTECH and OT). Indeed, some people originally working for DTECH moved to OT.	Partnership stability

6.5 Evaluation – influential factors

The vast majority of the critical factors observed in the four case studies are described by the categories in the emerging framework. There are only three factors in the previous version of the framework that were not found influential in this set of case studies: project manager, participation of the end user, and partner characteristics. However, this does not mean that these factors should be removed from the emerging framework. Indeed, in the four cases there was a project manager, the end user was involved during the development work and the collaboration took place between partners with different characteristics. The reason why these factors were not highlighted is because their impact on the outcomes of the acquisition project was not relevant in comparison to other factors that were either key enablers to overcome the challenges of the project or barriers that increased the level of difficulty of the project. The relevance of the factors was determined by the critical situations described by the interviewees. Table 6.6 presents a summary of the influential factors observed in each case.

In all the cases, there are five recurrent factors: business motivations, project relevance, match of resources and expertise, technology familiarity and performance of the project. Other influential factors that were present in almost all the cases comprise vision alignment, ease of communication, ease of decision-making, scope definition and technology performance.

As it can be also noticed from Table 6.6, every project was characterized by a different set of relevant factors. Although the cases present some characteristics in common, due to the low number of cases it is not possible to draw conclusions about the correlation of a given factor and a particular characteristic of the project. Nevertheless, what can be concluded is that the emerging framework seemed to be robust because it embraced the key factors of the four case studies.

The analysis of case studies, however, suggests a couple of modifications in the categorization of factors. Firstly, project relevance, originally allocated in the strategic alignment category, can be reallocated into the implementation opportunity category. Secondly, market uncertainty can be moved from implementation opportunity to contextual factors. The reasons for these changes are explained below.

Table 6-6 Critical factors observed in case studies

Case no.	8	9	10	11
Business alignment				
Business motivations	✓	✓	✓	✓
Wording of the contract		✓		✓
Management of emerging IPR	✓			
Project relevance	✓	✓	✓	✓
Risks and rewards				✓
Trust			✓	
Vision alignment	✓	✓	✓	
Structural match				
Access to testing facilities	✓		✓	
Access to relevant IP exploitation rights	✓			
Access to funding		✓		
Internal stability of partners			✓	✓
Match of resources and expertise	✓	✓	✓	✓
Development management				
Ease of communication	✓		✓	✓
Ease of decision-making	✓		✓	✓
Enthusiasm of the development team			✓	
Project management practices		✓		
Project manager				
Scope definition		✓	✓	✓
Implementation opportunity				
Implementation plan		✓		✓
Participation of the end user				
Performance of the project	✓	✓	✓	✓
Compatibility with existing systems	✓		✓	
Familiarity with the final product			✓	
Technology uncertainty				
Technology maturity	✓			✓
Ease of scaling up				✓
Product novelty		✓	✓	
Technology performance	✓		✓	✓
Technology familiarity	✓	✓	✓	✓
Contextual factors				
Partners' affinity	✓	✓		
Partners' characteristics				
Previous relationship			✓	✓
Market uncertainty	✓			
Project's characteristics	✓			✓

Project relevance

The reason for moving project relevance from business alignment to implementation opportunity is twofold. Firstly, all the factors were divided into three types according to the domain of impact (see Section 6.4). Project relevance is the only factor in the business alignment category that does not impact on the motivations of the participants to cooperate. Thus, this factor would be better allocated into the implementation opportunity category, which comprises the factors that affect the transfer of the resulting product to the beneficiary system. Secondly, there is a risk of confusing business motivations and project relevance. These two factors are different. The former refers to the drivers that encourage participating firms to begin a collaborative effort. The later denotes the level of importance of the technology to the acquiring firm, and is a factor that may change after a period of time.

Market uncertainty

This factor would be better allocated into the contextual factors category. The reason is because market uncertainty fits the description of the content of this category better. Market uncertainty is an external factor, it is not a factor that either emerges as consequence of the interaction between partners or from technology-related issues.

6.6 Framework v3.0

The set of case studies discussed in this chapter suggests further refinement to the previous version of the framework (v2.0), in particular the dimension representing the sequence of activities over time. The set of case studies discussed in this chapter has provided detailed information about the key activities and factors in technology acquisitions. Figure 6.6 shows a graphical representation of the sequence of key activities and their relationship with the influential factors.

The refined framework combines the key activities in the acquisition process and the influential categories of factors. The activities are divided in two types: partnership-related and acquisition-related activities. Influential factors, on the other hand are divided into six categories: strategic alignment, structural match, development management, technology uncertainty, implementation opportunity and contextual factors. The influence of the categories of factors is distributed in three domains of impact: partnership stability, co-development execution and transference. Figure 6.7 shows a summary of the influential factors in each category and their domain of impact. Table 6.7 provides a description of each element of the refined framework (v3.0).

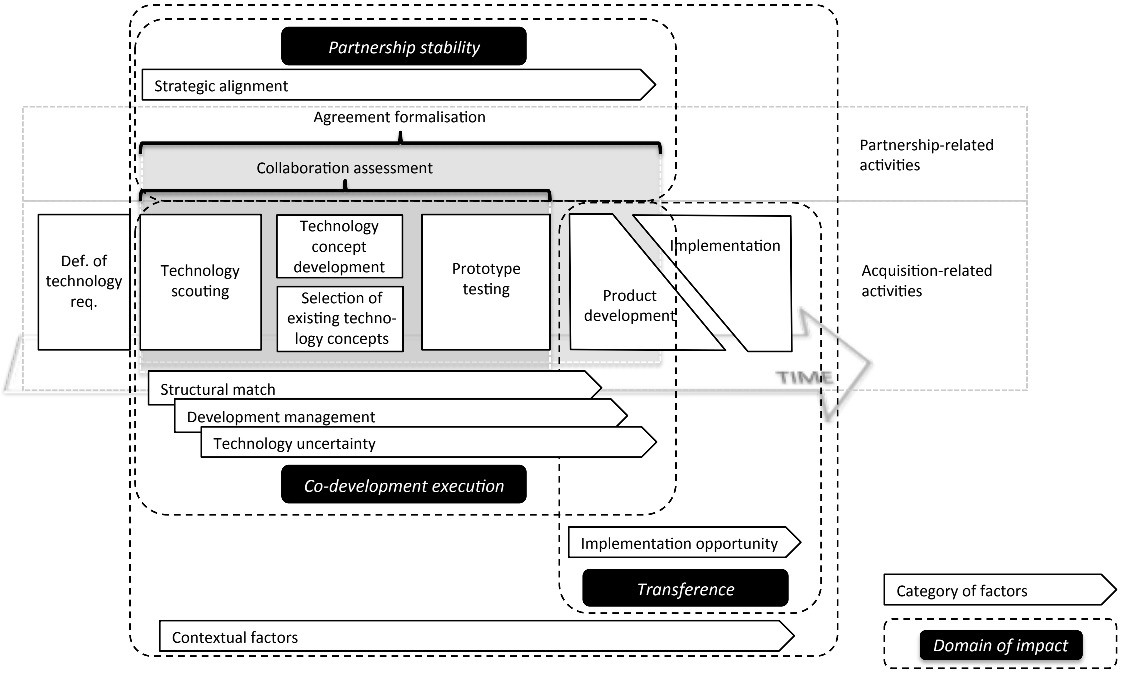


Figure 6-6 Refined framework (v3.0)

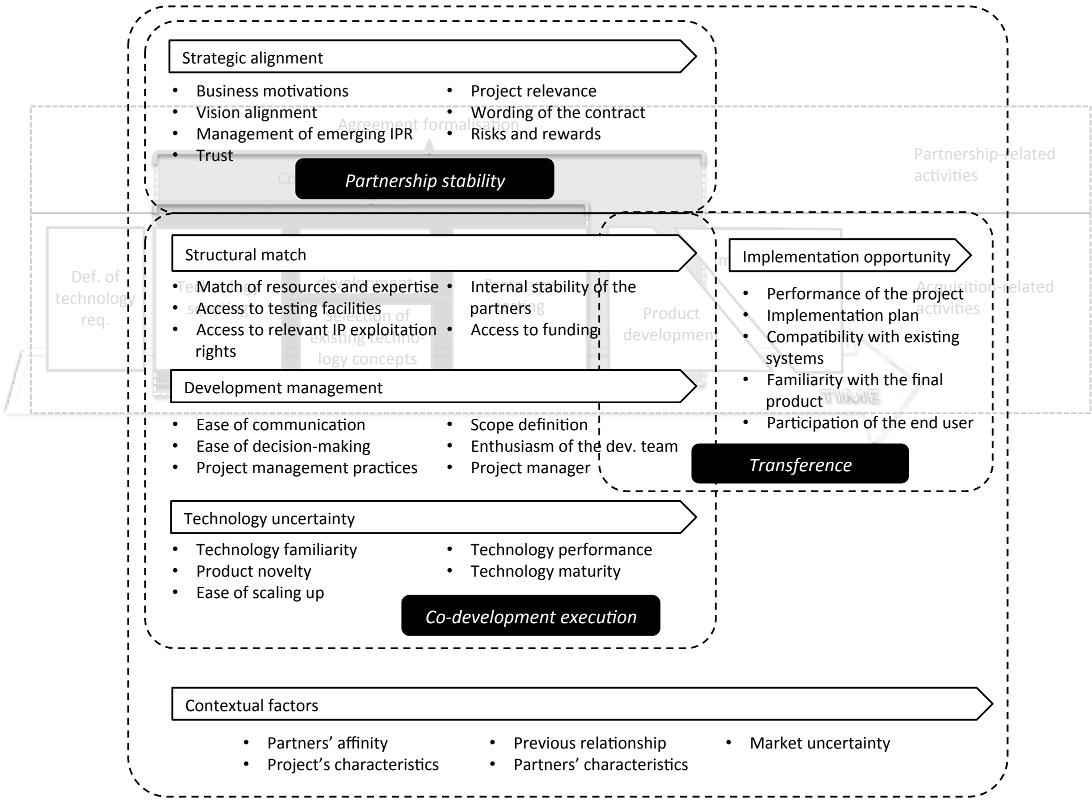


Figure 6-7 Summary of influential factors in the refined framework (v3.0)

Table 6-7 Description of the elements of the refined framework

Element of the framework	Description
Dimension 1 – Key activities	
Partnership-related activities	Activities that drive the partnering organisations to work in collaboration and define the scope of their business relationship.
Acquisition-related activities	Sequence of key activities to achieve an effective acquisition of technology.
Definition of technology requirements	Series of tasks that triggers the decision to acquire a new technology.
Technology scouting	Series of tasks aimed at exploring the state of the art and sources of a particular technology.
Technology concept development	Series of tasks aimed at designing a technology concept that may provide the service required by the acquiring firm.
Selection of existing technology concepts	Series of tasks aimed at evaluating the existing technology concepts and selecting the source.
Prototype testing	Series of tasks aimed at evaluating the performance of the technology concept and suitability to meet the objectives of the acquisition project.
Product development	Series of tasks aimed at embedding the technology concept into a usable product or process.
Implementation	Series of tasks aimed at transferring the resulting product or process to the beneficiary system.
Agreement formalisation	Series of tasks that the partnering organisations perform in order to define the terms and scope of their business relationship.
Collaboration assessment	Series of tasks that the partnering organisations perform in order to estimate how likely it is to reach a collaboration agreement and the value that they generate from the partnership.
Dimension 2 – Influential factors	
Partnership stability	Denotes the domain of impact of the factors that may modify the willingness of the partnering firms to collaborate.
Co-development execution	Denotes the domain of impact of the factors that may affect the ability of the final product to meet the technical and economic specifications of the acquisition project.
Transference	Denotes the domain of impact of the factors that may affect the effective transference of the product developed in collaboration to the recipient system or user.
Strategic alignment	Group of factors that influence the willingness of the partnering organisations to collaborate.
Structural match	Group of factors that influence the quality and availability of resources during the acquisition process.
Development management	Group of factors that influence the ability of the partnering organisations to combine their resources and expertise to develop a product that meets the technical and economic specifications of the acquisition project.
Technology uncertainty	Group of factors that determine the level of the technical challenge of the acquisition project.
Implementation opportunity	Group of factors that affect the chances to transfer the product developed in collaboration to the recipient system or user.
Contextual factors	Group of external factors that define the settings of the acquisition project.

6.7 Concluding remarks

1. Generally speaking, the core elements of the framework developed in the previous stage remain the same in the refined version of the framework (3.0).
2. The refined version of the framework recognises two types of activities in TA by collaboration: partnership-related activities and acquisition-related activities.
3. Partnership related activities comprise collaboration assessment and agreement formalisation.
4. Acquisition-related activities comprise: definition of technology requirements, technology scouting, technology concept development/selection, prototype testing, product development and implementation.
5. In comparison to the framework presented in chapter 5, the new framework provides a more detailed description of the sequence of activities in TA projects.
6. The refined framework indicates that the impact of the categories of influential factors is divided in three domains: partnership stability, co-development execution and transference.

7 FRAMEWORK VERIFICATION

Contents

This chapter presents the results of a focus group session, whose main purpose was to verify to which extent the framework (v3.0) covered the most relevant activities and factors.

7.1 Focus group overview

A half-day workshop with industry practitioners was performed in order to verify the completeness of the refined framework (ver. 3.0). Specifically, this meeting aimed to achieve four objectives:

1. Identify further concerns about technology collaborations.
2. Identify possible limitations of the framework.
3. Verify the terminology utilized in the framework.
4. Explore additional implications of the research outcomes.

7.1.1 Participant selection

Personal e-mail invitations were sent to 28 potential participants. Potential participants were selected amongst practitioners within the researcher's network who had been involved in industry collaborations and that had expressed their interest in the outcomes of the research project, but had not contributed to the previous stages of the research project. At the end, six people confirmed attendance. The industry expertise of participants included printing, electronics, information technologies, chemicals and industry tooling (Table 7.1).

Two days prior to the workshop, participants received the agenda and a brief description of the main outcomes of the research project. These materials were sent in advance with the purpose of familiarising participants with the content of the workshop.

Table 7-1 Participants to the focus group

Identifier	Industry	Role
Expert_14	Printing	Strategic Product Director
Expert_15	Electronics	Director
Expert_16	Information technologies	Chief executive officer
Expert_17	Chemicals	Project leader
Expert_18	Industry tooling	Research director
Expert_19	Printing	Industry visiting fellow

7.1.2 Focus group description

The focus group comprised a mix of group discussions and practical activities on three key topics:

1. *Challenges and enablers to implement new technologies acquired by collaboration*.

As warming up activity participants were asked to answer the following question: What would be the key challenges and enabling factors to implement technologies acquired by collaboration? During this group discussion, participants raised and discussed different issues. This discussion lasted about 20 minutes.

2. *Influential factors affecting the effective acquisition of technology in projects involving a technology partner*.

The second discussion was conducted around the following question: What are the most influential factors that affect the performance of technology acquisition projects that involve a technology partner? Participants were encouraged to share their thoughts and experiences on the topic. After hearing participants' answers, the facilitator made a presentation of the factors that emerged from case studies. Then, participants were asked to discuss in pairs and raise any relevant factor not considered in the framework and add this to a template placed on the wall. In the following exercise, the researcher asked participants to vote on the most relevant factors within each category. This group activity lasted about 70 minutes.

3. *Key activities in technology acquisition projects involving a technology partner*.

The third discussion was driven by the following question: What are the key activities in technology acquisition projects that involve a technology partner? Like the previous discussion, participants were encouraged to share their thoughts and experiences, before presenting the key activities in technology acquisition by collaboration drawn from case studies. Then, participants were also asked to discuss in pairs and vote on the most relevant tasks within each activity. Participants voted on a template on the wall. Participants were also asked to raise any relevant activity or task not considered in the list before allocating their votes. This activity lasted about 70 minutes.

The focus group finished by summarising the topics discussed and asking participants to fill a feedback form. The main purpose of the feedback form was to get the personal perception of participants about the capability of the framework to capture the key activities and factors of technology acquisition by collaboration, as well as to raise further practical implications.

7.2 Discussion 1 - Challenges and enablers in co-development projects

During the first group discussion, participants mentioned a series of challenges and enablers (Table 7.2). Most of those issues were either similar or very closely related to the factors that had been already identified in the framework, albeit through different terminology. Table 7.2 presents the challenges and enabling factors mentioned by participants and their correspondence with the factors in the refined framework (v3.0).

It is important to stress that the framework does not specify whether the factors are barriers or enablers, since the particular effect of each factor will depend on the specific circumstances of the project. The name of the factors in the framework has been assigned trying to keep a neutral position.

In a broad sense, the issues pointed out by participants correlate with factors across the six categories of factors in the framework. More than half of all the issues are related to business alignment and development management. This may suggest that how to reach a business alignment with the partner and how to manage a co-development project are two key concerns in technology acquisitions by collaboration.

7.2.1 Implications for the framework

The outcomes of this discussion are relevant in two ways. On the one hand, the issues raised by participants are important insights to improve the description of the factors identified. Particularly, those issues that fit in two different factors are important to define the scope of each factor in the final framework. On the other hand, the results of the discussion allowed the researcher to identify further practical implications of the framework.

Table 7-2 Issues in technology acquisitions by collaboration highlighted by participants

Issues raised by participants C - Challenge E - Enabler	Related factor in the refined framework (3.0)	Category of factor
C- Find a balance between partner's benefits	Agreement on risks and rewards	Business alignment
C- Alignment of business models	Vision alignment	Business alignment
C- Enabling a new competitor	Management of emerging IPR	Business alignment
C- Distrust	Trust	Business alignment
E- No competing goals/industries	Business motivations	Business alignment
E- Co-development expectations	Vision alignment	Business alignment
E- Benefits for partners	Agreement on risks and rewards	Business alignment
E- Understanding motivations	Vision alignment	Business alignment
C- Stability of the partner	Internal stability of the partners	Structural match
C- Assessing the quality of the company	Match of resources and expertise	Structural match
C- Participation of key people	Participation of the end user	Development management
C- Time scales / Misalignment of approaches	Ease of communication	Development management
C- Communication	Ease of communication	Development management
C- Recognise the scope and aim of the project	Scope definition	Development management
E- Develop enthusiasm	Enthusiasm of the development team	Development management
E- Phases/roadmap	Project management practices	Development management
C- Disruptive developments are difficult to launch into the company and into the market	Compatibility with existing systems	Implementation opportunity
C- Avoiding being dazzled by technology	Partner's familiarity with the technology	Technology uncertainty
C- Technology is exciting	Partner's familiarity with the technology	Technology uncertainty
E- Perform a pilot project	Technology performance	Technology uncertainty
C- Understand the market need	Market uncertainty	Contextual factors Implementation opportunity
C- Identify/Measure the culture mismatch	Partners' affinity	Contextual factors
C- Different culture / cultural fit	Partners' affinity	Contextual factors
E- Managing cultural gap	Partners' affinity	Contextual factors

7.3 Discussion 2 - Influential factors

The second discussion explored the factors that affect the outcomes of technology acquisitions by collaboration. In a broad sense, the categories and factors made sense to participants. The most relevant result is, however, the appearance of an additional factor.

After the group discussion and presentation of the factors considered in the framework, participants were provided with a list of such factors, including a brief description for each factor and category. Participants were asked to add any missing factor in each category and then to vote on the most important factors[1]. Additionally, participants were provided with an empty template where they could allocate any further factor not covered by the six categories of factors of the framework.

The results of the voting session are presented in Table 7.3. Factors are ordered in decreasing level of relative relevance. Those factors that are in the list but not numbered did not receive votes. This activity ranked the relative importance of the factors covered by the framework. However, it is important to note that voting aimed primarily to identify the relevance of those factors proposed by participants in relation to the factors included in the framework. In other words, voting would allow the researcher to identify the level of agreement between participants about the relevance of factors mentioned during the group discussion in comparison to those covered by the refined framework. This activity was carried out under the premise that the factors raised by participants having a significant number of votes would indicate the existence of additional relevant factors.

As a result of this activity, participants suggested additional factors in each category, but after a detailed revision it was concluded that the vast majority of them were covered by the current factors. In some cases, their meaning was very close to an existing factor. For example, in the category, structural match, one participant suggested *anticipate ownership changes*; nevertheless this issue is already covered in the framework in the factor referred to as *internal stability of the partners*.

[1] Each participant received one set of sticky notes and 24 sticky dots. Participants were asked to write on a sticky note any additional factor and post it on the template provided. Then, participants who added a new factor explained to the rest of the participants the relevance of such a factor. Thereafter, participants were asked to allocate dots on the factors that would be more relevant in each category, including those added during the session.

Table 7-3 Results of the voting session – relative importance of factors

Relative relevance of factors [total votes]	Factors suggested by participants*
Strategic alignment	
1. Business motivations [a, f, h] [5]	[a] "Alignment of long term aspirations between partners"
2. Trust [b] [5]	[b] "Trust – not a given – Builds"
3. Risks and rewards [d, e] [2]	[c] "Similar needs doesn't build trust"
4. Project relevance [1]	[d] "Needs to be a true win-win for supplier & acquirer"
Management of emerging IPR [0]	[e] "What is the value expectation for each side"
Wording of the contract [0]	[f] "Identify competition between partners"
Vision alignment [c] [0]	[g] "Incremental vs disruptive" {type of project}
	[h] "Long term maintenance relationship"
Development management	
1. Ease of decision-making [i, j] [4]	[i] "Dealing with unexpected"
2. Development team [3]	[j] "Process for adaptation of project" {agree on changes over time/methods}
3. Project manager [3]	
4. Ease of communication [1]	[k] "Process fit for purpose (no more than necessary)"
5. Project management practices [k] [1]	
Scope definition [0]	
Structural match	
1. Internal stability of the partners [l, n] [4]	[l] "Care to maintain key people"
2. Match of resources and expertise [m] [2]	[m] "Activities outsourcing"
3. Access to testing facilities [2]	[n] "Anticipate ownership changes"
4. Access to the IP exploitation rights [2]	
5. Access to funding [2]	
Technology uncertainty	
1. Technology maturity [6] [o]	[o] "Discovery phase to find what you don't know"
2. Technology performance [3]	
3. Technology familiarity [2]	
4. Ease of scaling up [1]	
Product novelty [0]	
Implementation opportunity	
1. Performance of the project [5]	[p] "Clarity on need: performance, price, etc."
2. Participation of the end user [q] [5]	[q] "Internal resistance in either company"
3. Implementation plan [2]	
Familiarity with the final product [r] [0]	
Compatibility with existing systems [0]	
Contextual factors	
1. Partners' affinity [r] [6]	[r] "Culture"
2. *Project champion* [s, t] [3]	[s] "Champion is often needed"
3. Project's characteristics [2]	[t] "Identified contact person on each side"
4. Previous relationship [1]	
Partner characteristics [0]	
Market uncertainty [0]	
Factors not covered in the other groups	
No comments	

*Note: The factors suggested by participants are verbatim reported, in some cases an explanatory note has been added in curly brackets. Superscript letters are used as indicators of the link of the factors suggested by participants and the factors in the framework.

Participants mentioned one factor that did not fit within the list of factors. This factor, labelled as *project champion*, received a significant number of votes. Participants pointed out that a “project champion is often needed” in technology acquisition projects. The framework did not cover this factor; therefore it was considered for inclusion.

7.3.1 Implications for the framework

As a result of this group discussion, it can be concluded that this dimension of the framework is stable at both levels: categories and factors. Participants agreed that the six categories cover the most relevant factors that affect the outcomes of technology acquisition by collaboration. At the level of factors, the results of the focus group suggested that it was necessary to carry out some minor changes in order to make clear what it is included within each factor. Therefore some factors were renamed to clarify what they cover. For example, the category *business motivations* was renamed to as *partners’ motivations compatibility* in order to indicate that this factor includes the compatibility of motivations between the partnering firms. Appendix I provides a summary of the modifications to the labels of the refined framework (v3.0).

In addition, as briefly mentioned above, the emergence of *project champion* as a factor not considered in the framework, led to the revision of the case studies analysed in the previous two stages of the research in order to understand why this factor was not identified before. The analysis of possible causes led to the conclusion that the analytical methods followed in the previous two stages failed to identify this factor. After reviewing the case studies, it was perceived that in two projects one person played a fundamental role to implement the product. This factor did not come out earlier because identification of factors was grounded on the analysis of conversations with people that were involved in the project. In those conversations, interviewees did not mention that one particular person was key in the acquisition project. Indeed, some conversations were carried out with the “project champion of the project” (Case 4 and 10). Therefore, as a result of the focus group, *project champion* is considered as a factor in the final version of the framework. However, given the fact that the relevance of the project champion seems to be critical during the implementation of the resulting product into the recipient system (Case 10), this factor has been allocated in the implementation opportunity category.

7.4 Discussion 3 - Key activities

In the third group discussion, participants commented on the relevance of the activities in the framework. After the group discussion and presentation of activities, participants were provided with a list of all the activities and tasks considered in the framework. A brief description for each activity and task was also provided. Participants were asked to add any missing task and then to vote on the most important tasks in each category.

This discussion was divided into two streams: technology acquisition-related activities and partnership-related activities.

In relation to technology-acquisition activities, participants agreed that the framework described the acquisition process. Nevertheless, from one project to another the relevance of tasks within each activity may vary, depending mainly on the type of project. Therefore, tasks were not ranked in this activity.

Regarding partnership-related activities, participants suggested additional tasks and pointed out the most relevant tasks. Table 7.4 shows the results of the voting session. As in the previous voting session, most of the comments of participants were actually linked to the tasks provided by the researcher.

Table 7-4 Results of the voting session – relative importance of partnership related activities

Relative relevance of tasks [total votes]	Tasks suggested by participants*
Collaboration assessment 1. Development of a common vision [a] [4] 2. Understanding partner's culture [b] [3] 3. Evaluation of partner's resources and capabilities [c] [1] Persuading partner to collaborate [d] [0]	[a] "Requirement clarity of purpose" [b] "Respective cultural fit" [c] "Understand each other" [d] "Agree to collaborate" [e] "Do with-not- Do to!" {provider's willingness to collaborate}
Agreement formalisation 1. Definition of scope and partner's participation [2] 2. Evaluation of the scope of the agreement [2] 3. Development milestones set up [2] 4. Agreement on IPR management [1] 5. *Agreement on returns* [f] [1] Resources provided by each partner [0]	[f] "Agreement on returns"

*Note: The factors suggested by participants are verbatim reported, in some cases an explanatory note has been added in curly brackets. Superscript letters are used as indicators of the link of the factors suggested by participants and the factors in the framework.

Within *collaboration assessment*, participants pointed out *development of a common vision* and *understanding each other's culture* as the most relevant tasks. Persuading the partner to collaborate was the task considered as less relevant by participants. In case studies, this task became relevant in the situations where partners belonged to a different industry and the benefits to one of the partners were not evident at first instance.

Concerning activities within *agreement formalisation*, there were three relevant tasks that were equally scored: *definition of scope and partner's participation*, *evaluation of the scope of the agreement* and *development milestones set up*. Participants added one additional task (*agreement on returns*), which initially had been considered in the framework as part of agreement on IPR management; but participants pointed out that there are projects where no IP rights may emerge. Agreement on returns refers to the distribution of economic benefits that the partnering firms can get as result of the product, or process, developed in collaboration. Therefore, this task is considered as a new one in the final framework.

7.4.1 Implications for the framework

The outcomes of the group discussion indicate that the framework comprises the key activities describing technology acquisition by collaboration. Participants' comments during the discussion allowed the researcher to understand the technology acquisition process better and identify the extent to which the framework applies to other industry sectors not represented in the set of case studies analysed. The main insights from this discussion are summarised below.

Technology acquisition-related activities

As a result of this group discussion, it can be concluded that the key activities in the framework are appropriate; however, the relevance of the tasks describing each activity may not be generalised. It is necessary to define the type of project before ranking the relative relevance of the tasks comprised in each activity. For instance it would be necessary to specify whether the outcome is a product, process, service, and the level of involvement of the acquiring firm in the development of the technology concept.

Partnership-related activities

The result of this group discussion indicates that both collaboration assessment and agreement formalisation made sense to participants. In addition, participants suggested that an additional task to the agreement formalisation phase could be considered, namely *agreement on return*s, which certainly fits with the evidences provided by some case studies.

7.5 Framework evaluation

The results of the focus group (also referred through this chapter as workshop) indicate that the framework seems to be substantially appropriate, complete and stable. The framework comprises the key activities and factors that affect the effective acquisition of technology by means of collaboration. The feedback and comments made by participants suggested that some terminology utilised in the framework might be refined to describe some of the factors better.

In addition, the focus group provided some additions to the framework, one activity (agreement on returns) and one influential factor (project champion). However, there were no changes to the elements of the framework. This suggests that the framework seem to be appropriate to describe TA by collaboration.

At the end of the focus group, participants were requested to complete a feedback form to evaluate the comprehensiveness of the elements of the framework and to comment on practical implications of the outcomes of the research. Participants agreed that the categories of factors, acquisition-related activities and partnership-related activities were comprehensive[2]. Table 7.5 shows the result of the participants' evaluation of the framework. The topic with the lowest level of agreement concerns whether the partnership-related activities cover the most relevant tasks.

[2] Appendix I shows the feedback form provided to participants.

Table 7-5 Evaluation of the framework

How much do you agree or disagree with the following statements?*					Mean score
• The six groups of factors in the framework are appropriate.					4.25
□Strongly disagree	□Disagree	□Not sure	□Agree ✓✓✓	□Strongly agree ✓	
• The six groups cover the important factors that influence the outcomes of technology acquisition projects.					4.00
□Strongly disagree	□Disagree	□Not sure	□Agree ✓✓✓✓	□Strongly agree	
• The six acquisition-related activities in the framework are appropriate.					4.00
□Strongly disagree	□Disagree	□Not sure	□Agree ✓✓✓✓	□Strongly agree	
• The six acquisition-related activities cover the critical tasks of technology acquisition projects.					4.00
□Strongly disagree	□Disagree	□Not sure ✓	□Agree ✓✓	□Strongly agree ✓	
• The two partnership-related activities are appropriate.					4.00
□Strongly disagree	□Disagree	□Not sure	□Agree ✓✓✓✓	□Strongly agree	
• The two partnership-related activities include the most relevant tasks.					3.75
□Strongly disagree	□Disagree	□Not sure ✓	□Agree ✓✓✓	□Strongly agree	
• The framework is clear and appropriate.					4.00
□Strongly disagree	□Disagree	□Not sure	□Agree ✓✓✓✓	□Strongly agree	

*Only four participants completed the feedback form. Two participants left the session after the second group discussion due to other business commitments.

7.6 Concluding remarks

1. Practitioners from different industry backgrounds participated in the focus group. The comments and feedback provided by the participants supported the results of the research and also suggested ways to improve the clarity of the framework.
2. Participants agreed that the framework describes the acquisition process by collaboration and that it comprises relevant factors that affect the outcomes.

8 RESULTS DISCUSSION

Contents

This section describes the elements of the final version of the framework (v3.1) and discusses the implications for theory and practice.

8.1 Framework v3.1

Compared to what has been published in extant literature, the framework offers a comprehensive perspective on the relevant activities and factors that affect technology acquisition projects that involve the participation of an industry partner. Figure 8.1 shows a graphical representation of the final framework. The framework comprises three main elements:

- Acquisition-related activities.
- Partnership-related activities.
- Influential factors.

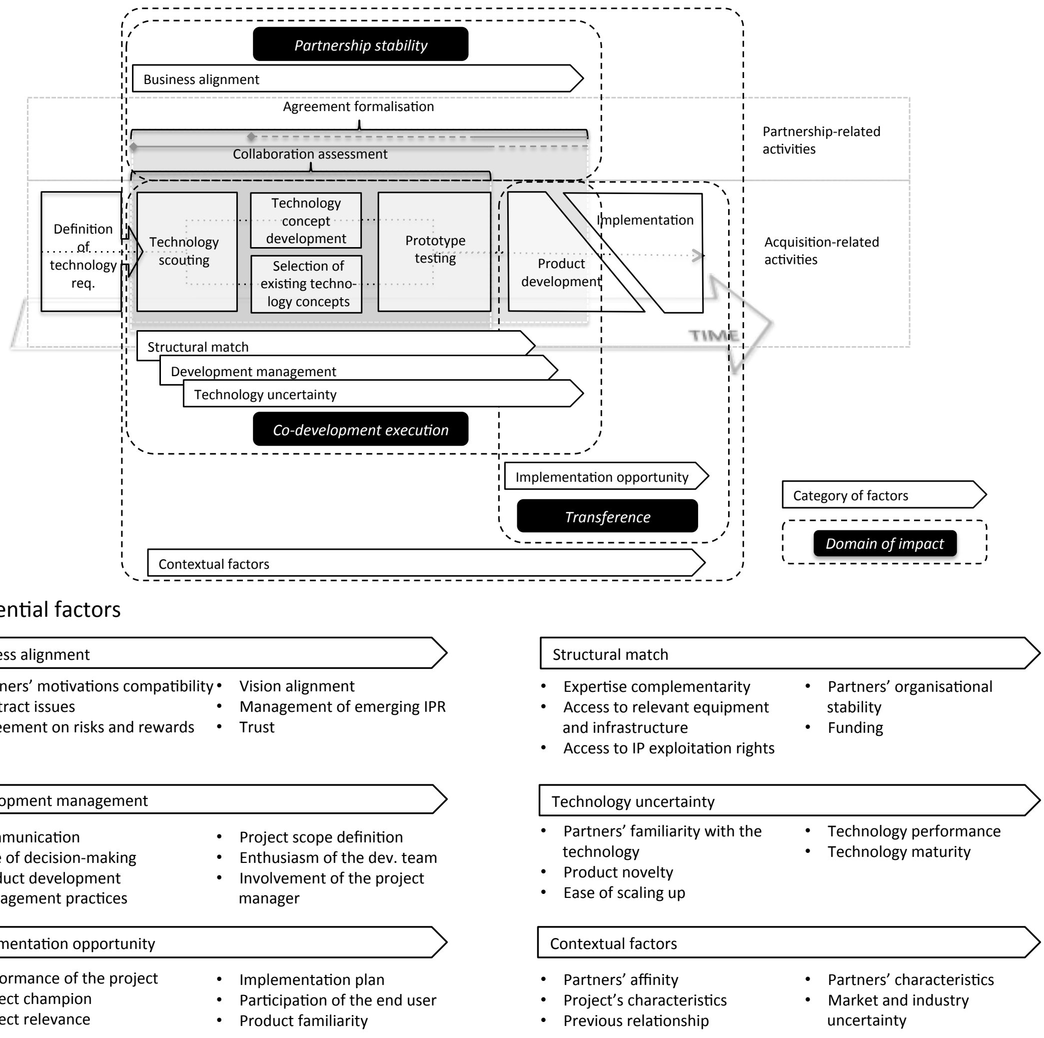


Figure 8-1 Final framework (v3.1)

8.1.1 Acquisition-related activities

The acquisition process is described by a sequence of six key activities depicted in Figure 8.2. Industry partners get involved within the first four activities of the acquisition process. There are two general patterns to acquire technology involving a partner. In the first pattern, the acquiring firm develops the technology concept in collaboration with the partner; in the second one, the partner supplies the technology concept (or prototype), so that the collaboration is focused on adjusting the technology concept to meet the specific requirements of the acquiring firm. The description of each activity and collaboration patterns are described below.

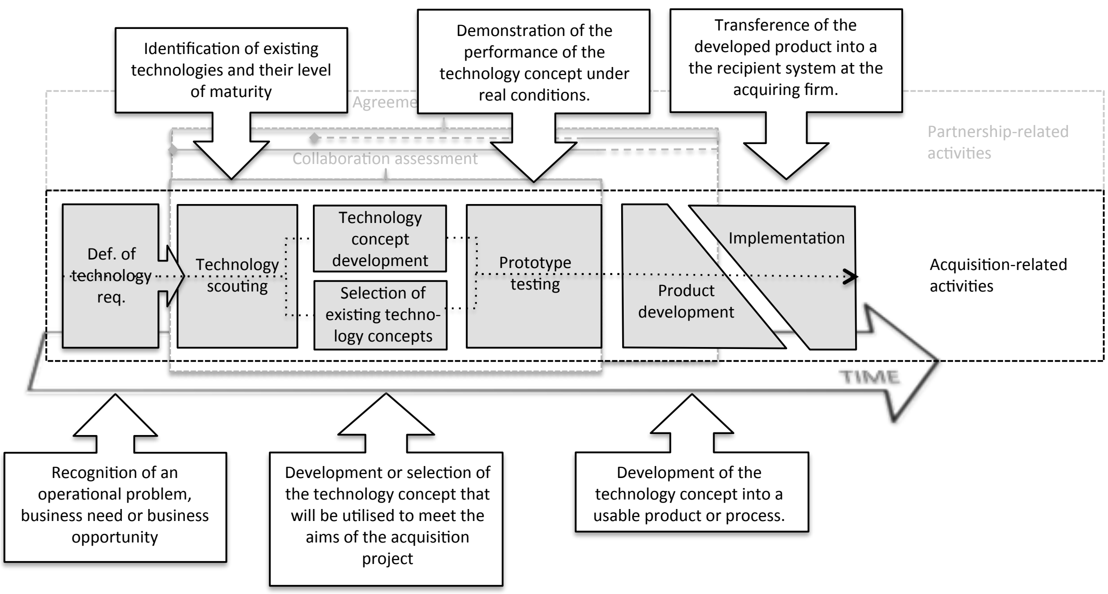


Figure 8-2 Final framework – Acquisition related activities

Definition of technology requirements

Technology acquisition projects usually start with the recognition of an operational problem, business need or business opportunity. The motivation to acquire technology is often triggered by the outcomes of strategy or technology planning exercises. As a result of these exercises, the acquiring firm recognise the value of the project and a broad definition of the application of the technology. Selecting the best way to meet particular business needs or opportunities is one common challenge that acquiring firms usually face. At the beginning of an acquisition project, firms may have a broad idea about the technology that is required and the resources needed to acquire it. Often, the selection of the solution is based on a cost-benefit evaluation, nevertheless it may be difficult to estimate the resources required by the project and the value of the final product. For instance, when the project involves the development of a new-to-the world product, the acquiring firm may find it difficult to obtain an accurate estimation of the benefits.

Technology scouting

After recognising the potential benefits, the following activity aims to identify existing technologies and their level of maturity. At this stage, the technology concepts that other firms have used to address a similar operational problem or business opportunity are explored, as well as potential providers and the protection scope of current intellectual property rights. However, when there is not a proven technology concept that meets the operational problem or business opportunity, firms may look for suitable technologies. At the end of this stage, firms come out with a better understanding of the technology in different dimensions: maturity of existing technologies and commercial products, protection scope of related IPR as well as organisations and individuals carrying out R&D activities.

Technology concept development/selection

A third set of tasks aims to develop the technology concept that will be utilised to meet the business need of the firm. This stage of the acquisition process may involve a different set of tasks depending on the level of maturity of the technology. On the one hand, in those cases where the technology is either at a low level of development or never used before to meet a similar need (or application)[1], the acquiring firm may start a research programme to explore whether the technology could provide the expected service. At this stage, a conceptual prototype is designed and its performance is evaluated by means of simulations or laboratory trials. At the end of this stage, the acquiring firm develops a better estimation of the resources required to incorporate the technology into a product that meets the objectives of the project. On the other hand, technologies that have reached a higher level of maturity[2] are likely to be available in

[1] Equivalent to TRL 1 to 5

[2] Equivalent to TRL 6 to 9

the market. Those technologies can be available as product prototypes or commercial products. In such cases, the tasks performed by the acquiring firm are focused on evaluating the suitability of existing technology concepts from different criteria: functional performance, acquisition cost, operation costs, reliability and compatibility with existing systems. The potential source of the technology is also evaluated. Usually the number of suppliers is small as the technology concept is at a lower level of maturity. At the end of this stage, the acquiring firm makes a decision on the technology concept that is going to be acquired and the possible sources.

Prototype testing

In a fourth stage, lab tests and field trials are carried out in order to demonstrate whether the technology concept would provide the required performance under real conditions. These tests provide important technical and economic data to define the characteristics of the product that will incorporate the technology, as well as the scope, time and resources required to get a final product. At the end of this stage, the acquiring firm may also identify implications to implement the product into the recipient system. All the information generated at this stage is key to decide whether or not the acquiring firm should go into the development stage.

Product development

This stage comprises a series of tasks aimed at turning the technology concept into a usable product or process. The execution of this stage starts by defining the functional characteristics of the final product. This phase comprises tasks such as engineering layouts, pilot tests, field trials and development of additional components. The partners are somehow involved in the development tasks. Experts in manufacturing, engineering, operations and the end user usually participate intensively during the execution of these tasks.

Implementation

The last group of activities looks at transferring the developed product into the recipient system within the acquiring firm. Implementation activities can run in parallel to product development. In particular, this may happen when the product is part of a broader project. At this stage, the exploitation plan starts as well as other tasks such as manufacturing scale up, product customisation and management of production costs.

Development patterns and involvement of technology partners

Technology partners can first involved within the initial four stages in acquisition projects. There are two patterns of involvement of technology partners (Figure 8.3). In the first pattern (path A), partners join the acquisition project at any of the three initial stages of the development project. They provide support to the acquiring firm to make a clear definition of the technology need, choose the most appropriate technology and carry out research activities to explore whether a particular technology concept may provide the performance to meet the objectives of the acquisition project.

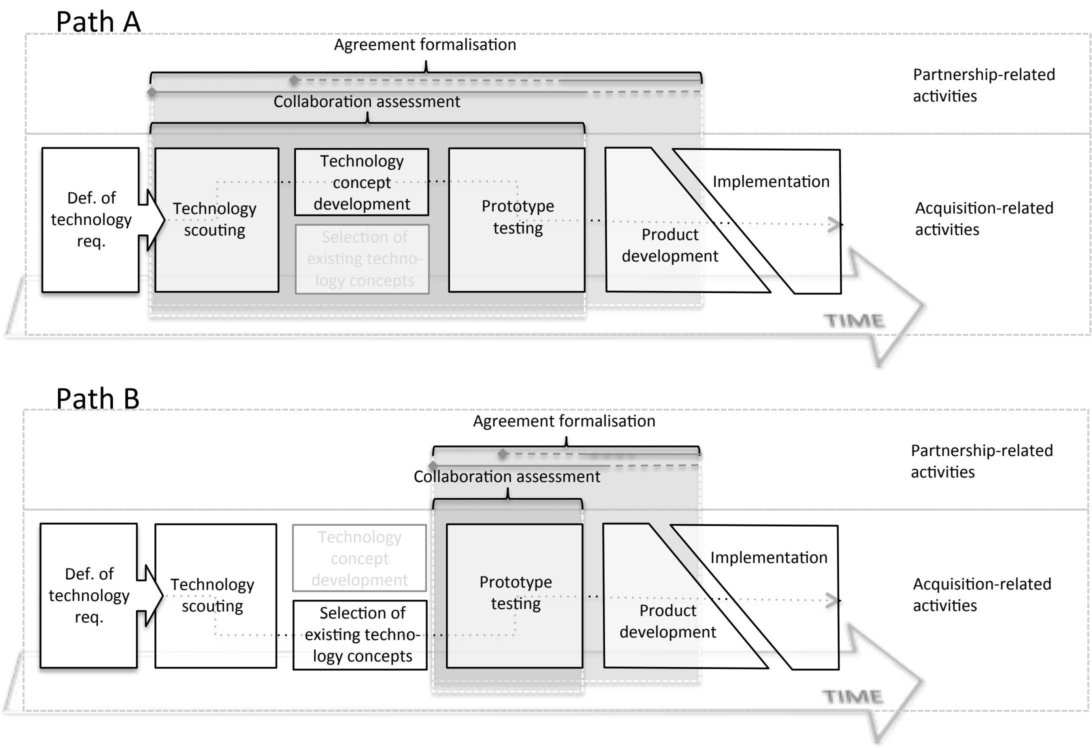


Figure 8-3 Graphical representations of the collaboration patterns.

In the second pattern (path B), partners get involved in the acquisition process at the product concept testing stage. In this pattern, the partner brings to the project a technology concept that someway fits the requirements of the acquiring partner. In this path, the partner independently selects the technology and embeds it into a prototype. Thus, the joint work in this pattern usually starts with laboratory or field trials to evaluate whether the technology concept meets the objectives of the acquisition project and to estimate the resources needed to develop the final product.

8.1.2 Partnership-related activities

Partnership-related activities refer to the activities that drive independent organisations to work in collaboration and define the scope of their business relationship. These activities are carried out in two parallel phases: Collaboration assessment and agreement formalisation (Figure 8.4). The two phases are described below.

Collaboration assessment

This phase comprises the period of time where the acquiring firm and the potential technology partner estimate the benefits that each one can take from the collaboration work and the likelihood to reach an agreement. This phase starts with conversations about the possibility of joining forces to develop a product. These conversations may take place at any moment between the technology scouting or prototype testing in the acquisition process. Usually the conversations are followed by visits to each other's research and development facilities and technical meetings. During this phase partners not only evaluate their capabilities, but also understand each other's culture and business interests. These activities particularly are important when independent organisations collaborate for the first time.

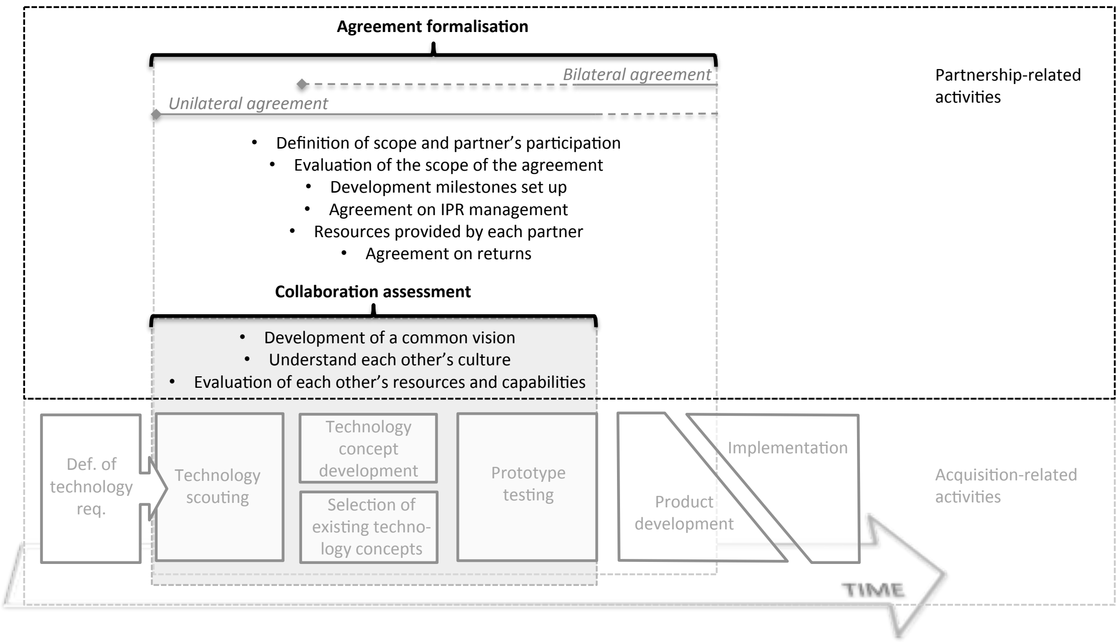


Figure 8-4 Final framework - Partnership related activities

Agreement formalisation

This comprises the period of time when the legal issues and scope of the business relationship are sorted out. This phase starts as soon as the acquiring firm becomes interested in exploring the possibility to work with an external organisation. This phase may comprise two steps. In the first step the initial conversations may be governed by a unilateral contract. For example, the acquiring firm and the technology supplier may sign a research service contract or a non-disclosure agreement. This contract allows the partners to exchange technical information and to execute research activities. In a second step, partners formalise a co-development agreement, which can take the form of a joint development agreement, technology venture or joint venture. This step begins when the partners are aware of the benefits they can take from the project. The agreement establishes duties and rewards for each partner; therefore, it is a period of intensive negotiations. Two relevant issues in negotiations are how intellectual property rights will be managed and the returns for each partner. The elaboration of the agreement usually requires participation of different functional areas of each partner such as legal department, R&D, manufacturing and even marketing. The formalisation of the agreement can take a while, but it is not a condition to initiate the development activities. Some companies consider the formalisation of the agreement as a secondary issue, so that sometimes partners may start working in the development of the product without having signed the agreement. This will depend on how important the project is to the partners and the level of trust between them.

8.1.3 Influential factors

The factors that influence the outcomes of technology acquisitions involving a technology partner are divided into 6 categories:

1. Business alignment.
2. Structural match.
3. Development management.
4. Technology uncertainty.
5. Implementation opportunity.
6. Contextual factors.

These groups of factors affect the outcomes of the acquisition project in different areas. Their impact is reflected over three domains: partnership stability, co-development execution and transference of the outcome to the recipient system. Except for contextual factors, the particular influence of each group of factors corresponds to one domain of impact. The factors covered by business alignment directly impact on the partnership stability domain; factors enclosed in structural match, development management, and technology uncertainty are related to the technical success of the co-development project; and, factors comprised in the implementation opportunity category are linked to the success in the transference of the outcomes of the collaboration to the recipient system. In contrast, contextual factors may affect the whole acquisition project, including the three domains of impact. Contextual factors include situations that define how challenging it would be for the acquiring firm and its partner to achieve the desired outcomes of the project. Figure 8.5 shows the relationship between the influential categories of factors in the framework and their domains of impact.

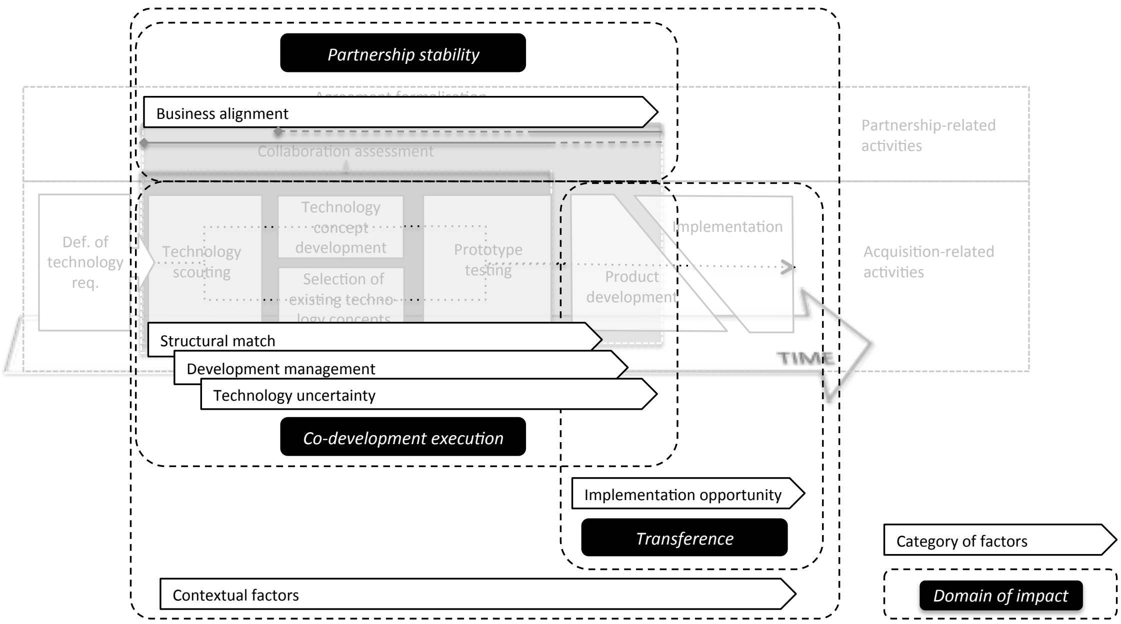


Figure 8-5 Factors affecting technology acquisition by means of collaboration and domains of impact

Business alignment

The business alignment category (or 'strategic alignment' in framework v3.0) comprises a number of factors that influence the willingness of the partnering organisations to collaborate and affect the stability of the business relationship over the duration of the co-development work (Figure 8.6). The factors described below are part of this category.

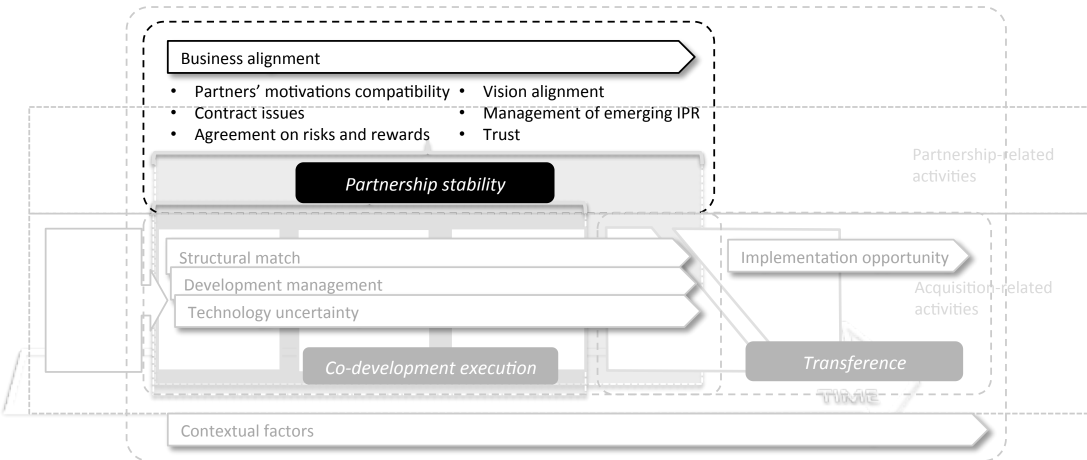


Figure 8-6 Final framework - Business alignment

Partners' motivations compatibility

Partners' motivations to collaborate are based on the recognition of the value of the co-development project for each one. Partners' motivations should be compatible otherwise the partnership may fail. Motivations to collaborate are compatible when partners do not have competing goals, perceive a fair return, and are interested in setting up a long term relationship. Frequently, the acquiring firm is interested in obtaining know-how, access to complementary skills or technology concepts to address a business opportunity or improving its operative efficiency. Conversely, its counterpart is likely to be interested in exploiting its technical capabilities to develop products that solve an industry or market need. Technology supplier firms consider co-development agreements as a means to learn about the specific needs of a particular industry or market, as well as a way to increase their product portfolio.

Vision alignment

Vision alignment is built through mutual understanding of motivations and expectations. Vision alignment refers to a shared understanding of the true reasons that motivate partners to collaborate and the outcomes expected by each one. Understanding motivations and expectations not only refers to the technical specifications of the final product, but also to how such a product adds value to each partner. This implies that partners should also agree on how they will deal with market and industry uncertainties. Vision alignment is built upon mutual understanding of the business of each partner. Partners that work for the first time may not be familiar with their counterpart's core businesses, industry, operations and strategies. The reason for the project and the importance to each partner is rooted in their specific business context and needs. Therefore each partner must understand why the project is important to the other and how the outcomes fit their needs or expectations.

Contract issues

Contract issues comprise the problems that may emerge as a consequence of how the agreement is written. Partners may interpret what is written in the contract differently. Also, it is possible to find that one of the partners may not be willing to do something that is not clearly expressed in the agreement. There are situations that are difficult to foresee and as a consequence partners have to negotiate a solution for every emergent issue not explicitly covered in the agreement. Often, contract issues may lead to delays in the schedule and even to the agreement terminating. It seems that trust is needed to carry on the project while partners find a solution to fill the deficiency in the contract.

Management of emerging intellectual property rights

Co-development projects frequently result in new designs, processes or other types of IPR. Management of emerging IPR seems to be problematic when one of the partners considers IPR as a key element to doing business out of the partnership. Partners usually recognise the new IPR that may emerge before starting the co-development project. According to their previous experiences in collaborative agreements, each organisation may have an internal policy to manage IPR. For example, emerging IPR could be managed in three ways: (1) the acquiring partner holds the exploitation rights for a particular application or industry while the providing partner holds the production, manufacture and exploitation rights for other applications; (2) partners share equally the IP rights and both get equal returns on the economic resources generated by the use or commercialisation of the technology; and (3) all emerging IPR is managed by a special purpose entity which is equally owned by the partners.

Agreement on risks and rewards

Co-development projects involve both technical and market risks. Therefore, partners may expect to obtain benefits proportional to the risks that they would take in the project. If risks exceed the value that one of the partners may take out, then it is likely that this partner will not be interested in the project. This factor is dynamic and it is often the focus of negotiations, particularly before partners formalise the co-development agreement. By signing a co-development agreement, partners agree on who should do what, who should pay for what, and what should be the benefits for each partner, so that they can carry on the project under a clear agreement on risks and rewards. However, as the project progresses technical and market risks may change, therefore any substantial variation on the technical or market premises may lead partners to reconsider their participation in the project.

Trust

Trust is built over the interaction of partners and it seems to be a necessary condition to set up a collaborative project. Hidden agendas may make the partnership fail. Trust is built when partners are clear about their motivations, expectations, and their business goals are different but complementary. Trust is built at two levels: at business and technical level. At business level, trust is built on the interaction of senior managers. Honest discussions during the early stages of the partnership and avoiding overreliance on lawyers to lead contract negotiations seem to encourage trust between partners. On the other hand, at technical level, open discussions and continuous communication between the development team promotes the perception of trust. At this level, trust is important to make the exchange of information within the members of the development team easier.

Structural match

This category covers factors that affect the quality and availability of the resources and skills required to develop the proposed product (Figure 8.7). The factors embraced in this category are described below.

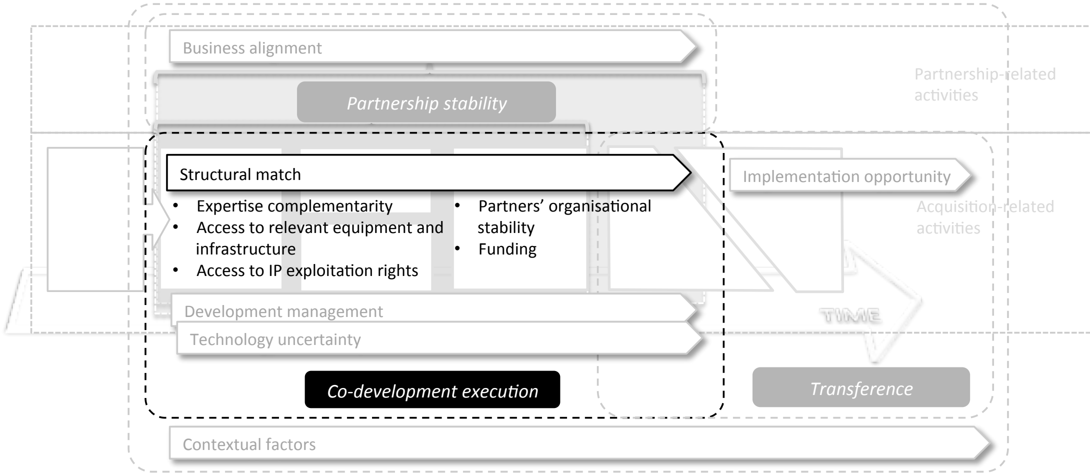


Figure 8-7 Final framework - Structural match

Expertise complementarity

The match between partners' expertise seems to be a condition in co-development projects. Generally partners decide to collaborate because they do not have the expertise required to develop a particular product or solve an operational issue. Usually the acquiring firm provides the specifications of the final product while the technology partner provides the technical or manufacturing expertise. Expertise complementarity is key to initiate a collaborative project.

Partners' organisational stability

Co-development projects may take at least six months to complete, but most of the projects are likely to require more than two years to reach the final product. During this period the partners may have internal organisational changes. For instance, a third party could acquire one of the partners. As a consequence of these organisational changes, key people in the co-development project may leave their company or be moved to a different division. These circumstances have significant impact on the project performance.

Access to relevant equipment and infrastructure

Partners do not need to possess the entire infrastructure required to carry out the project. The project may continue as far as they have access to relevant testing facilities, laboratories and equipment through a third party. Relevant infrastructure and special equipment can be accessible through the partners existing business networks. Acquiring firms often can get access to testing facilities through other business units at their parent companies. Also, specific equipment could be accessed through national laboratories or universities.

Funding

Partners' financial stability is also an issue in co-development projects. Development projects may require significant levels of investments, in particular when the project involves new technologies or new-to-the-world products. Such projects are often evaluated by the functional performance of the product and consequently the time to accomplish those projects and investment may be uncertain. Because of such uncertainty, governmental funding or partners' special internal budgets support a large number of those projects. The performance of the project could be negatively influenced by changes in the funding sources. Schedule delays and changes to the scope of the project are two possible consequences. However, when the co-development project is very important, the acquiring firm may consider providing all the resources needed.

Access to relevant IP exploitation rights

Co-development projects require specific technologies. In most of the cases the technology partners possess the proprietary intellectual property rights of the core technology required to carry out the project. However, when none of the partners holds the exploitation rights of the core technology, some technical issues may emerge. The protection scope of extant IP rights owned by third parties may block partners from using a particular technology. This situation can drive partners to look for alternative solutions and consequently lead the project towards a more complex technology challenge. The protection scope of extant IP rights may increase the technical challenge of the development work.

Development management

The development management category includes factors that have impact on partners' ability to combine their resources and expertise to develop a product that meets the technical and economic specifications of the acquisition project (Figure 8.8). The factors included in this category are described below.

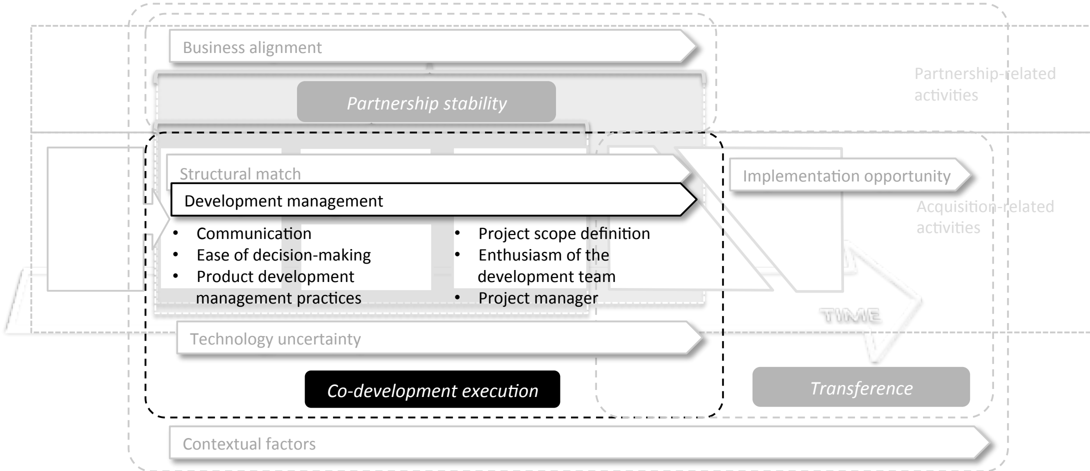


Figure 8-8 Final framework - Development management

Communication

Communication refers to the effectiveness of the mechanisms that partners employ to set up and coordinate the co-development project at both technical and business level. Communication between the members from each partner that are directly involved in development activities is key to achieve opportune solutions to technical issues that may came up during the project. On the other hand, communication at business level is key to review the performance of the project and ensure that the outcomes meet the expectations of all the partners. Nevertheless, communication is not only relevant to make timely decisions, but also to build the environment to cooperate. As mentioned earlier, communication is key to build trust and to improve understanding of motivations between partners. Case studies suggest that regular meetings, participation in validating partial outcomes, face-to-face meetings and having a unique point of contact within each partner make communications more efficient. Communication seems to be improved also through the geographical proximity between the people involved in the development work.

Project scope definition

The scope of the project includes definition of the resources provided by each partner, schedule, development milestones and specifications of the outcome. Projects whose scope is not well defined may drive the project to deviations in development cost and time. When one of the partners is familiar with the product or outcome of the project, the scope of the project can be better defined. However, estimation of development costs and schedule appear to be difficult in projects that intend to develop a new product. Schedule, investment, product specifications and development milestones, are defined better in those projects where one of the partners (usually the acquiring firm) is familiar with the final product. On the other hand, in projects where a new technology is involved, at the beginning of the project partners may only define development milestones and general specifications of the outcome. In such cases, development schedule and investment remain flexible and are evaluated on the go.

Ease of decision-making

Decision-making in co-development projects is affected by management practices at each partner. Decision-making is key when unexpected situations occur during the project. Partners may have different approaches to make decisions, and how compatible they are greatly influences the joint decision-making process. Decision-making can slow the development process if management practices are not compatible. Decentralised decision-making structures seem to impact positively the ease of decision-making between partners, in particular when large companies participate in the project. Partners may experience a number of unexpected business and technical situations during the project; therefore, the sooner the partners achieve an agreement, the less delays in the project schedule.

Enthusiasm of the development team

The development team plays a fundamental role in development projects. If team members are not willing to work in the project, it is likely that the project may incur delays or scope deviations. A motivated development team seems to encourage the achievement of the project outcomes as expected. Enthusiasm is encouraged by the combination of a clear understanding of the outcome, possession of relevant knowledge and technical skills, as well as by the level of the technical challenge. The enthusiasm of the development team needs to be constant over the project, not only at the beginning. Changes in the development team may negatively affect the performance of the project. If key members are removed, it is possible that their substitutes do not have the same enthusiasm and consequently the project may not produce the expected outcomes.

Product development management practices

Organisations differ on their approach to managing development projects. Different development management practices may become a barrier to an efficient project management and coordination. Some companies may have a systematic procedure to manage this kind of projects while others may not. The fact that some companies may have experience in development projects does not necessarily mean that they follow a systematic and efficient approach to select, estimate risks, evaluate performance and control such kind of projects. Dividing the project in stages or decision gates allows for a better control of resources and risks. Systematic and compatible development management approaches seem to influence the outcomes of the project positively. The co-development project is likely to be led by the partner possessing more experience and a systematic process to manage development projects.

Project manager

Project managers promote communication between teams and coordinate the development work during the project. As contact point in collaboration projects, project managers are responsible for efficient communications between the partners and members of the development team. The project manager is in charge of keeping the development team focused on the outcome, organising regular meetings between all the people involved and keeping track of the progress of the project. In the event of a technical problem, the project manager may assist the development team to make faster decisions. Also, the project manager may deal with other aspects such as regulatory issues, resource allocation and budget administration. The performance of the project manager may be negatively affected if he/she is in charge of more than one project at the same time.

Technology uncertainty

Technology uncertainty comprises a group of factors that influences the level of the technical challenge to achieve the functional performance and reliability of the final product (Figure 8.9). This category comprises the factors described below.

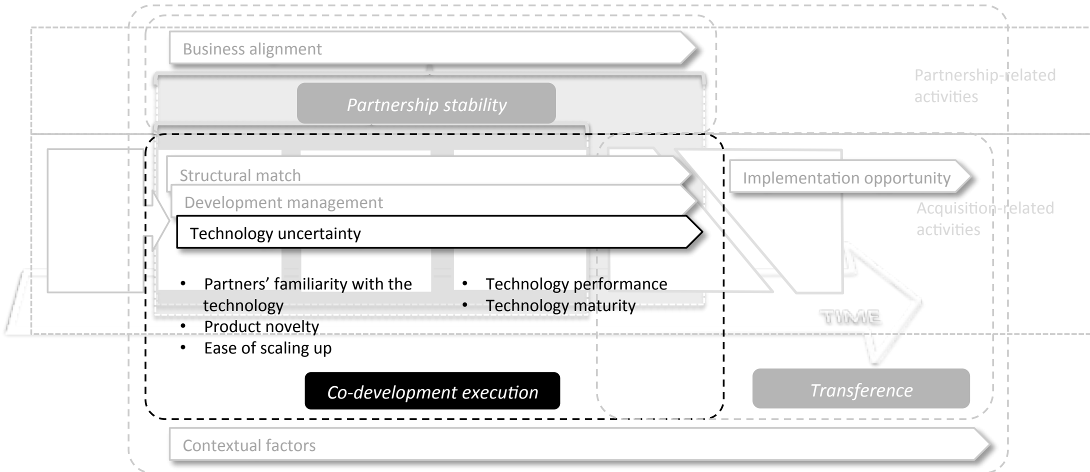


Figure 8-9 Final framework - Technology uncertainty

Partners' familiarity with the technology

Another issue that contributes to technology uncertainty is the level of partners' familiarity with the technology knowledge required in the project. Clearly, when the supplying partner brings the technology concept to the project, such a partner is familiar with the technology. However, familiarity with the technology becomes relevant either when an emerging technology is involved or when none of the partners have implemented the technology into a final product before. In both scenarios, partners may not estimate accurately the time and resources required to develop the product at the beginning of the co-development project. The more familiar the partners are with the technology, the more probable it is that partners understand the resources required to develop the product better.

Technology performance

Technology can exhibit great functional performance under certain environments or applications. However, technology functional performance could be lower under different operational conditions. As a consequence, the product that is being developed may not perform as expected. Product performance is a critical issue in technology acquisition projects. Most of the benefits are estimated on the basis of a certain level of functional performance of the final product. Thus, if the product shows a performance below a certain level, the acquisition project cannot be considered as a success by the sponsoring firm.

Product novelty

Making incremental improvements to existing products implies less uncertainty than developing a new generation or new-to-the-world products. Thus, generally it is much easier to estimate the resources of a project whose aim is upgrading an existing product. The technical and market uncertainties are much larger in projects aimed at developing new-to-the-world products than in those projects aimed at developing new generations of products or incremental improvements. For example, a product of a second generation supposes that a previous version of the product has been already proved under real operational conditions, therefore there is a better understanding of auxiliary systems or components that are required to make the product to perform as expected. Often, new-to-the-world products demand additional efforts to develop auxiliary systems.

Technology maturity

Technology maturity refers to the existence of relevant technology knowledge on a worldwide basis. Technology maturity influences to a large extent the effort required by a new technology to be embedded into a final product. Developing products involving early stage technologies may face several technical challenges because of the lack of relevant technical knowledge. The time and development cost of products that incorporate novel technologies tend to be larger than those products based on well-known technologies.

Ease of scaling up

Product prototypes may perform well at small scale or under controlled environments; however, taking those product concepts to a large-scale production or to real operational environments may not be straightforward. Product prototypes may require further modifications to meet certain specifications. Scaling up may become an issue even when partners are familiar with the technology. Some companies may involve experts in manufacturing or production in the early stages of the acquisition process, so that the selection of the technology considers possible scaling up issues. It seems that taking into account the potential scaling up issues during the selection and development of the product concept, reduces the chances of making greater changes to the original product concept at the product development stage.

Implementation opportunity

This category covers factors that affect the chances to transfer the product developed in collaboration to the recipient system or user (Figure 8.10). Acquisition of technology can only be considered as successful when the final product is implemented into the value chain of the acquiring firm.

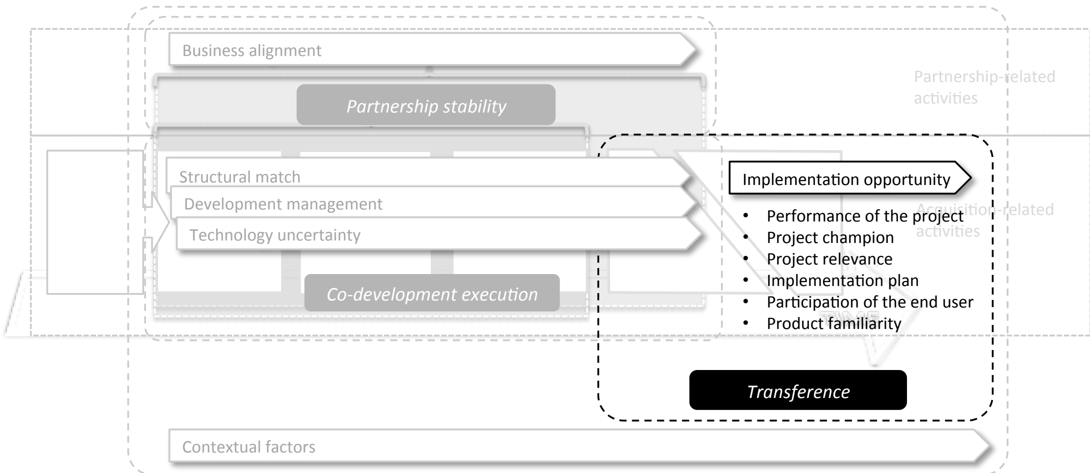


Figure 8-10 Final framework - Implementation opportunity

Performance of the project

The overall performance of the co-development project is one influential factor. Eventually, firms may achieve success in developing a product whose functional performance meets the initial objectives; however, the product may have been completed out of the expected schedule or incurred additional expenses. Generally, the performance of the co-development project is continuously monitored, thus if at some point the outcomes do not meet the expectations, the acquiring partner may decide to stop the project. The criteria to assess performance of the project depend upon the acquiring firm.

Project champion

In technology acquisition projects, there is a key figure in achieving the effective implementation of the technology: the project champion. The project champion is the person that supports the development team to overcome technical and organisational obstacles as well as pulling the co-development work through the final implementation of the product. The lack of this figure in acquisition projects can put at risk the successful achievement of the project. In the event of any unexpected technical or organisational issue, the project champion is the one who plays a key role in finding a solution. Product champions are particularly important in large organisations, where management structures may be complex.

Project relevance

The project is relevant for example when the outcome either fits the current strategic priorities of the acquiring firm or when it opens a new business opportunity. However, the relevance of the project is relative and dynamic. The business environment or strategic intentions of the acquiring firm may change over time. The project must be relevant from the beginning to the end; otherwise the firm may not provide the resources needed and the project may not achieve the expected outcomes.

Implementation plan

Having an implementation plan is another influential factor in the effective acquisition of technology. An implementation plan facilitates the adoption of the technology. Some technologies require specific modifications to existing operational procedures, practices, or the development of a new supply chain. Thus, without a plan, it is likely that the product may take more time to be implemented into the recipient system. For example, the acquiring company may launch a new business unit, which would exploit the new technology and grow through the development of improvements or new products.

Participation of the end user

New technologies are often difficult to implement into large organisations. In particular, new technologies usually require changes to operational procedures or practices, and they are often considered as a potential threat to existing ones. Thus, in a technology acquisition project, organisational resistance within the acquiring firm could be a barrier to achieving success. Involvement of the end user, operative personal and senior managers during the acquisition project facilitate the implementation of the new technology. Their participation increases the chances that the new technology fits with existing procedures and infrastructure. They can provide important advice on the operational issues that may emerge during implementation from the early stages of the acquisition project.

Product familiarity

This factor refers to the level of knowledge of the functional performance, market, price, and other characteristics that the product containing the technology should accomplish. In the case of new generation products, the acquiring partner can be familiar with the application of the product. Therefore, in that situation it would be easier for the acquiring firm to define the specifications of the final product. Nevertheless, when a new-to-the-world product is developed, the acquiring firm and its partner may have difficulties to define the specifications of the final product. Thus, familiarity with the application of the product greatly affects the definition of the co-development project scope and the implementation of the final product. Product familiarity is frequently increased by the previous use of similar products.

Contextual factors

This category includes the factors that define the setting of the acquisition project (Figure 8.11). The five factors included in this category are described below.

Partners' affinity

Partners are likely to be compatible when they have worked in the same industry, country or region. Companies that share these characteristics may have a similar organisational and national culture, thus it is possible that their business practices and procedures could be compatible. Partners' affinity seems to encourage efficient communications and project coordination. Partners' that operate in a different industry, country or region are likely to experience communication and coordination issues during the co-development project.

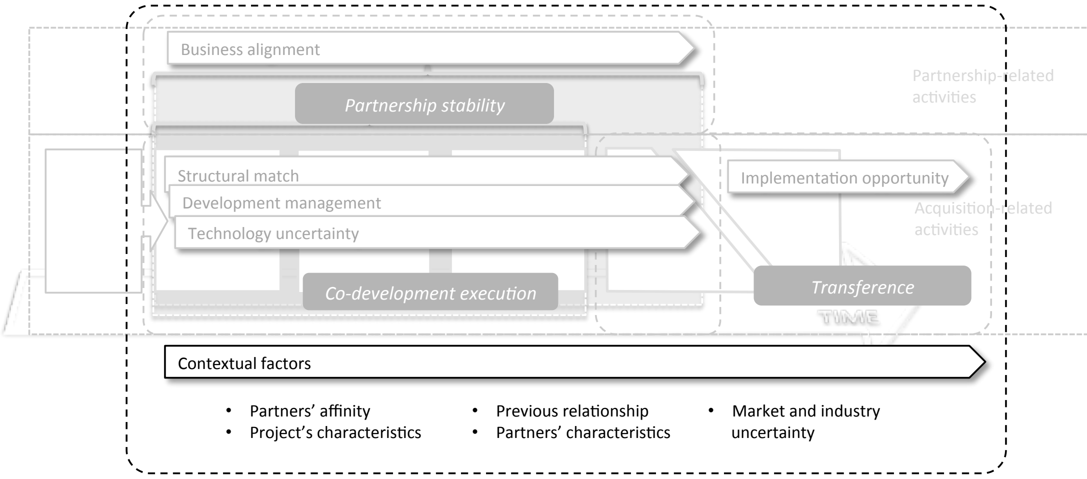


Figure 8-11 Final framework - Contextual factors

Previous relationship

Previous relationship between partners affects the performance of co-development projects. When partners work for first time it is likely that they do not understand each other's business and organisational culture. However, when partners have worked in a previous project, they may have a better understanding of each other's motivations to collaborate, strategies and organisational culture. In addition, communication and decision making becomes easier between firms that have worked together in the past.

Market and industry uncertainty

The changes in the business environment may have influence on the entire project. Market and industry changes may change the relevance of the project to the partners or the scope. For example, it is possible that the spot prices of the product in the market fall under the base price utilised to make the estimation of benefits. In such a case, the acquiring firm may not be interested any more in the project. Variations in the business environment eventually may led partners to reconsider the value of the project and decide whether to carry on or stopping the project.

Project's characteristics

Co-development projects may have different characteristics. For example, projects can be different in terms of scope, level of investment, technologies involved, development stages, or product specific requirements. These characteristics can increase the level of complexity to manage the project. Some projects may require coordination between teams across different locations or disciplines, while others may require a very close interaction between the acquiring firm and the industry partner.

Partners' characteristics

Partners' characteristics, such as size and organisation type are for example two influential characteristics in co-development projects. On the one hand, large companies tend to have complex organisational structures while small companies tend to be much more flexible. In terms of financial resources, small companies may not have as many resources as large firms have, and frequently small companies rely on external funding to carry on development projects. On the other hand, the business scope of organisations such as universities or national laboratories is limited. These types of organisations possess technology expertise and infrastructure, but they may require further advice to develop a commercial or usable product. Supplying firms and customers may have complementary technical and commercial capabilities, but they may become a potential competitor.

8.2 Discussion

This section summarises the key results achieved through the development of the research project and discusses the elements of the final framework in relation to implications for theory and practice.

8.2.1 Implications for theory

The framework provides a holistic perspective of key activities and factors that influence the outcomes of technology acquisition projects carried out by collaboration. In addition, the framework suggests that the performance of TA projects is defined by the impact of factors on three domains: partnership stability, co-development execution, and transference of the technology to the recipient system. The discussion of implications for theory is divided in terms of the activities in the acquisition process, influential factors and domains of impact of the factors.

Key activities

As noted earlier in Chapter 3 (section 3.5), the comparison between practice and literature regarding the activities to acquire technology suggests the existence of knowledge gaps. One of the gaps indicates that extant literature on technology acquisition fails to describe the acquisition process by means of collaboration. The main conflicts seem to be linked to four aspects: sequence of activities, type of activities, partner selection and contractual agreement.

Sequence of activities

Generally speaking, extant literature suggests that the acquisition of external technologies can be described as a linear sequence of activities (e.g. Durrani et al. 1999, Baines 2004, Daim and Kocauglu 2008). The final framework, nevertheless, indicates that some activities can be performed in parallel. For example negotiations can run in parallel to prototype testing, and product development may also run at the same time as implementation.

Type of activities

It seems that extant literature does not make an explicit distinction between technically related activities and business related activities (e.g. Baines 2004). In technology acquisition by collaboration, however, it is relevant to make this distinction. When a technology partner is involved, business-related activities run in parallel to technically related activities; particularly when both partners work together to develop the technology concept. In addition, business related activities (or partnership related activities as indicated in the framework) cover other key activities beyond contractual negotiations such as assessment of the collaboration.

Partner selection

The acquisition processes proposed in extant literature indicate that the selection of the technology supplier takes place after identifying and evaluating the technology alternatives (e.g. Cetindamar et al. 2010). Current literature seems to suggest that the acquiring firm is able to identify the technology that is needed to meet its business objectives. The framework does not make this assumption. The framework covers those situations where the acquiring firm has a low ACAP and therefore requires help to identify and select the best technology alternative. In such cases, the selection of the partner occurs before evaluating the technology, which is contrary to traditional approaches to acquire technology (e.g. Durrani et al. 1999, Baines 2004, Daim and Kocauglu 2008, Cetindamar et al. 2010).

Contractual agreement

Case studies indicate that during an acquisition project, more than one contractual agreement can be signed between the parties involved. For instance, in cases 4 and 9, the partners signed a service contract to evaluate the feasibility of the development and later another contract to develop the product. Indeed, in most of the cases analysed, the co-development agreement was followed by a commercial contract, which established how the economic benefits emerging from the collaboration would be shared. Current literature describing technology acquisition does not give details about this situation (e.g. Chiesa and Manzini, 1998).

Influential factors

The final framework identifies influential factors and groups them into six categories: business alignment, structural match, development management, technology uncertainty, implementation opportunity and contextual issues. There are two key observations emerging from the research.

Firstly, this research provides empirical evidence on the influential factors on technology acquisition through collaboration. Despite the fact that current literature has mentioned a large number of relevant factors (see Table 2.7), only a reduced number of publications have attempted to provide a comprehensive summary of relevant factors affecting technology collaborations (see Table 2.2). However, none of these frameworks seems to be appropriate to describe the specific conditions that affect technology acquisition by collaboration. These frameworks cover factors that either have impact on the stability of the relationship or on the performance of the execution of the co-development project, but not on the transference of the technology to the recipient system.

Secondly, the results indicate the presence of four factors whose influence has been marginally explored in the core literature. These four factors are *wording of the contract*, *enthusiasm of the development team*, *implementation plan*, and *ease of scaling up*. Table 8.1 shows the cases where these factors were relevant. The rest of the influential factors indicated in the final framework are consistent with factors already reported in current literature related to technology acquisition, new product development and management of collaborations and strategic alliances. Except for wording of the contract, participants to the focus group confirmed the relevance of these factors.

Table 8-1 Presence of unexplored factors in case studies

Case no.	1	2	3	4	5	6	7	8	9	10	11
Business alignement											
Wording of the contract			✓						✓		✓
Development management											
Enthusiasm of the development team				✓	✓	✓	✓			✓	
Implementation opportunity											
Implementation plan	✓	✓	✓		✓				✓		✓
Technology uncertainty											
Ease of scaling up	✓	✓				✓					✓

Wording of the contract

The way in which the contract was written was found problematic in three cases (Case 3, 9 and 11). This factor seems to be relevant when the lack of trust between the partnering firms means that one of the partners may use the contract as a primary mechanism to resolve disputes or verify the performance of participants. This factor has been explored superficially in NPD and collaboration management and strategic alliance literature. Extant literature suggests that companies having no prior experience in R&D collaborative agreements may not elaborate a contractual agreement properly (Piachaud 2005). However, empirical evidence suggests that the contract may not be a problem for example when the partnering firms have continuous communication.

Enthusiasm of the development team

NPD related literature has emphasised that the development team is a factor contributing to the performance of collaborative projects (Jassawalla and Sashittal 1998, Petersen et al 2010, Wagner and Hoegl 2006). However, literature citing this factor refers specifically to technical capabilities and structure of the development team. These works seems to disregard the importance of the enthusiasm of the development team. The empirical evidence indicates that the enthusiasm of the development team is an important factor to achieve success, particularly during the development work. This factor was found relevant in five cases (Cases 4, 5, 6, 7 and 10) and also voted in the focus group session amongst the most relevant factors within the development management category. Some scholars have pointed out that the project leader should be enthusiastic about the project (Marxt and Link 2002, Barnes et al. 2006) but not the entire development team.

Implementation plan

Despite the fact that literature on technology management indicates that implementation is a core activity in technology acquisition (see Figure 2.2), having an implementation plan seems out of the factors that contributes to success. Table 2.1 shows a list of factors that have been drawn from published papers in this literature stream, nevertheless none of these factors seems to suggest the importance of having an implementing plan. The empirical evidence obtained in six cases (Case 1, 2, 3, 5, 9 and 11) and in the focus group session indicates the relevance of this factor in technology acquisition projects. Having an implementation plan from the beginning of the collaborative agreement seems to be helpful to define the outcomes of the co-development project and to transfer it to the recipient system effectively.

Ease of scaling up

Four cases involving novel manufacturing technology (Case 1, 2, 6 and 11) indicated that scaling up the process was a key factor in the acquisition project. Participants to the focus group session also identified this factor as relevant. It seems that this factor has not been explored in the strands of literature addressed in chapter 2. Rather, this topic may be deeply addressed by engineering literature such as in biotechnology, chemical engineering and industrial engineering. Ease of scaling up seems to be an important factor to define the time that it is required to bring a new manufacturing technology to industry.

Domains of impact

As discussed in section 6.4, results indicate that the six categories of factors have influence in three areas: stability of the relationship, execution of the co-development project and transference of the technology to the recipient system. Factors in the *business alignment* category impact mainly on the establishment and stability of the relationship. Factors covered by structural match, development management and technology uncertainty have major influence on the quality of the execution of the co-development project. Finally, factors in the implementation opportunity category affect the transference of the product to the recipient system. Contextual issues, on the other hand, have impact on the entire acquisition project across the three areas of impact.

These three domains of impact suggest that effective acquisition of technology by collaboration depends on an effective management of the business relationship, effective co-development execution and effective implementation of the technology. These three conditions represent a step towards better understanding technology acquisition projects carried out in collaboration, and consequently an important input to develop tools to manage such projects.

Each domain of impact seems to be addressed by different literature streams. For example, relevant knowledge about how to achieve stability in the partnership has been published in literature related to RBV (e.g. Das and Teng 2000) and managing collaborations and strategic alliances management (Duysters et al. 1999).

Literature on organisational learning (e.g. Nonaka 1994), organisational culture (e.g. Hofstede 1991) and NPD (e.g. Deck and Strom 2002) stress a number of circumstances that may interfere with the communication and coordination between independent entities. Therefore, this literature are more linked to the conditions that affect the success of collaborative developments. Finally, the focus of literatures on absorptive capacity (e.g. Jiménez-Barrionuevo et al. 2011), knowledge and technology transfer (e.g. Sung and Gibson 2000) and technology acquisition (e.g. Steensma and Corley 2000) concerns conditions that affect the transference of the outcome of the collaborative development to the recipient system.

There are other bodies of literature not addressed in this research that may provide relevant insights at each domain of impact. These literatures include for example, social capital and project management, which may be relevant to explore the stability of business relationships and execution of the co-development projects respectively.

8.2.2 Implications for practice

The discussion about implications for practice of the framework is organised in terms of the challenges and enablers emerged during the focus group. The issues raised by participants about acquiring technology by collaboration in the first group discussion (Table 7.2) can be broadly divided into four topics:

1. Selection of the right project.
2. Partners' business alignment.
3. Partner selection.
4. Management of the project.

The four topics provide important insights into what practitioners think the key challenges are, particularly in technology acquisitions that involve an industry partner. The framework seems to be useful to explain these challenges and suggests some recommendations to sort out such difficulties.

Selecting the right project

This issue has been addressed in R&D and innovation management literature, as it is widely known that the more uncertain the market place requirements are, the more risky is the development project (e.g. Wheelwright and Clark 1992). In particular, portfolio management is a tool that many companies use to balance risks across a number of R&D projects (Cetindamar et al. 2010).

The framework does not provide a straightforward answer to this concern, but it gives some valuable insights. For example, when companies want to develop a new product from scratch and they are not familiar with the required technologies, they may contract potential industry partners to help them to identify the technologies that can be incorporated into the product. On the other, hand, when companies want to bring an externally developed technology concept into a new product, they could evaluate the performance of the technology for the intended application before signing a co-development agreement. In both cases, the performance of the new technology and benefits should be assessed in collaboration with the potential partner before formalising the co-development agreement. Such an evaluation reduces the risk of joining a collaborative venture that would not provide the expected outcomes.

Partners' business alignment

Literature reports a number of situations that promote alignment or fit between partners (e.g. Ireland et al. 2002, Emden et al. 2006). In particular, motivation compatibility and goal correspondence are pointed out as important factors to set up a collaborative agreement and maintain a stable relationship. The framework indicates the period of time where business alignment takes place within a technology acquisition project.

The framework indicates that before formalising a collaboration agreement, the acquiring firm evaluates the performance of the technology. It is during this evaluation period that the acquiring firm, and its potential partner, can estimate how likely is to reach business alignment and work together to achieve a result that can provide benefits to both. Over this period, the acquiring firm can evaluate whether the potential partner is willing to collaborate as well as whether their business interests and culture are compatible. Collaboration assessment is particularly important when firms collaborate for the first time.

Partner selection

Partner selection has been pointed out as a critical and problematic task in collaborative developments. Many authors have proposed a number of ways to deal with this issue. Emden et al. (2006) for example suggest the evaluation of potential partners goes through three phases: technological alignment, strategic alignment and relational alignment. The final framework does not provide a direct guide to select a partner, but it offers some relevant insights.

For instance, the framework indicates that companies looking for technology partners may have different evaluation and selection criteria. On the one hand, if the acquiring company participates in the development of the technology concept, then criteria related to structural match and development management could be more important than those criteria related to business alignment. In this case, for instance, the main criteria to select a partner may be the possession of relevant technical capabilities rather than the value or advantages of a particular technology. On the other hand, if the firm is acquiring an externally developed technology concept, then the issues related to business alignment may be more important than structural match or development management. In this situation, partner selection can be based on two criteria:

willingness of the partner to share the value of the technology and functional performance of the technology concept.

Management of the project

In contrast to the previous three concerns, management of the acquisition project is a topic that still requires attention. So far, relevant literature only addresses issues related to management of the collaborative development, which cover most of the factors that affect the stability of the relationship and outcomes (e.g. Barnes et al. 2006). Nevertheless, this body of literature does not consider the cases where the co-development project is embedded within a technology acquisition project.

The framework offers relevant insights regarding this concern. The framework provides a wider perspective to understand why some companies decide to join a co-development project. Companies get into a collaborative agreement because it is a way to acquire a technology that is relevant to meeting its business needs and this context is not fully recognised in the extant literature.

The framework describes the influential factors and activities from the perspective of the firm that enters into a collaboration agreement to acquire a new technology. In a technology acquisition process, co-development activities take place right at the middle. Figure 8.12 shows the relationship between technology acquisition projects and co-development projects.

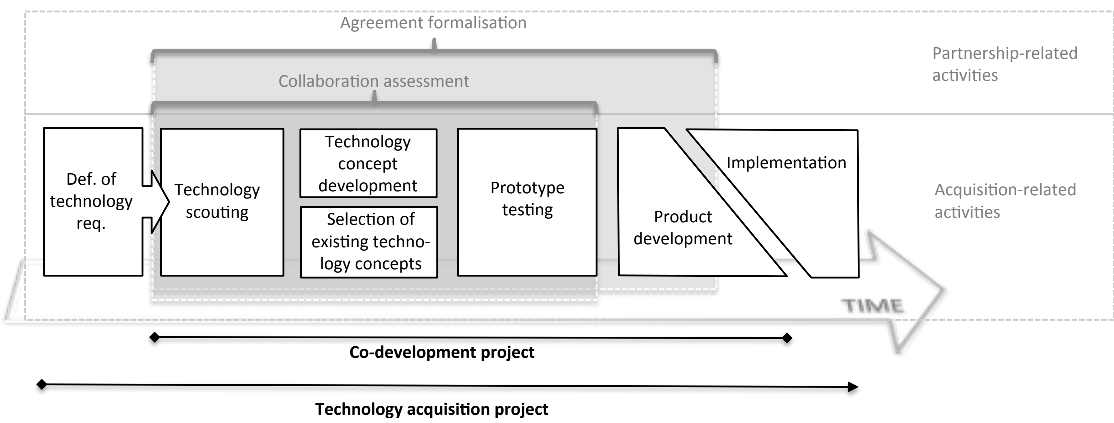


Figure 8-12 Relationship between co-development projects and technology acquisition projects

Co-development projects may start after the acquiring firm defines the technology requirements and finishes once a product or process embedding the technology is mature enough to be incorporated into the recipient system. As it can be noticed, co-development projects are embedded within a technology acquisition project. Therefore, a key element in the framework relates to the factors that affect the likelihood to implement the resulting product into the recipient system, which is not covered by literature related to management of co-development projects.

The results of the research can be applied in practice in different ways. For example, the most straightforward application would be the development of a guideline to help managers to anticipate possible risks or threats to acquisition projects carried out in collaboration. Other applications would include the development of an auditing tool to assess the ability of a firm to acquire technologies through collaboration with a partner or the development of a guide to help companies to manage technology collaborations in a systemic manner. In addition, the framework on its own can be used as didactic material for executive and academic teaching.

8.3 Concluding remarks

1. The final framework (v3.1) comprises 3 key elements: acquisition-related activities, partnership-related activities and influential factors.
2. The framework indicates the specific activities and influential factors that affect technology acquisition projects that involve an industry partner. Particularly there are four factors that seem to be unexplored in the core literature related to technology collaborations that are relevant in TA by collaboration: wording of the contract, enthusiasm of the development team, implementation plan and ease of scaling up.
3. Effective acquisition of technology requires attention in three areas: partnership stability, co-development execution and transference of the product that contains the technology to the recipient system.
4. The results provide implications for practice in different ways, for example the emerging framework would be used to develop managerial guidelines to manage the involvement of industry partners in TA projects systematically.

9 CONCLUSIONS

Contents

9.1 Knowledge gap and research contributions

This research explores technology collaborations from a particular perspective. The research adopts the perspective of a firm that enters into a collaborative project with the aim of getting access to external technical capabilities that are needed to develop a solution for their business needs. As discussed in Section 3.5, literature and practice reviews suggest that there is a need for increasing our understanding of TA by collaboration, particularly in terms of describing the links between key activities and factors that affect the process.

On the one hand, extant literature, particularly on TM, seems to be more interested in exploring particular issues in technology acquisitions (for instance, organisational modes for technology collaborations or management of emerging IPR). Literature acknowledges that inter-firm collaboration is a channel to obtain access to external technology; nevertheless few scholars have attempted to provide a comprehensive framework to describe technology acquisition by collaboration. For instance, Cetindamar et al. (2010) describe the key activities in external technology acquisition and point out some influential factors such as trust and changes in managerial needs. However, their framework does not provide a clear link between the activities and different types of influential factors.

On the other hand, other bodies of literature such as management of strategic and technology alliances, new product development and organisational culture, have explored a large number of factors that ultimately affect communication and coordination between independent organisations. These strands of literature offer relevant information to understand the performance of technology collaborations from a broad perspective; however, only a reduced number of publications have attempted to identify the particular conditions that affect the performance of technology collaborations under a specified context, for example industry-university projects (e.g. Barnes et al. 2006).

This research attempts to provide a better understanding of the conditions that affect TA by means of collaboration, and it was driven by the following question:

> *How can the conditions that affect the effective acquisition of technology by collaboration be described?*

This research contributes to knowledge by providing an integrated framework that suggests there are three key conditions to achieve effective acquisition of technology by collaboration.

1. Effective partnership management. A stable partnership is required to keep alive the commitment of participating firms to reach the final outcomes.
2. Effective execution of the co-development project. The quality and performance of the outcomes greatly depends on the availability of technical resources and an appropriate coordination and communication between the technical teams.
3. Effective transference of the collaboration outcome to the recipient system. If the outcome is not transferred to the value chain of the acquiring firm, the chances to obtain a return on the investment are severely reduced.

If one of these three conditions is not achieved, the partners may not consider the acquisition project to be a success.

In addition, the outcomes of this research contribute to theory in three areas. First, the results provide a comprehensive description of the key activities in TA by collaboration. It is indicated that TA by collaboration is characterised by a series of activities that are divided into two types: partnership related activities and technology acquisition related activities. The former comprises activities that define whether the acquiring firm and the providing firm may achieve a business agreement. The latter comprises the sequence of activities that are key to developing and implementing the outcome in the value chain of the acquiring firm. The distinction between these two types of activities highlights the fact that some activities may run in parallel during the acquisition process. This distinction has not been explicit in previous literature. Extant literature seems to suggest that technology acquisition is a sequential array of tasks where technology acquisition related activities are mixed with business related activities (e.g. Baines 2004).

Second, the results indicate that the acquiring firm may or may not get involved in the development of the technology concept; therefore, it is possible to observe two patterns of involvement of industry partners in the acquisition process. In the first pattern, the acquiring firm is actively involved in the development of the technology concept and the industry partner mainly provides specific skills or technical resources. In the second pattern, the acquiring firm is not directly involved in the development of the technology concept. The industry partner develops the technology concept independently and consequently the relationship is formalised once it is demonstrated that the prototype meets the requirements of the acquisition project. These two patterns have been proposed in previous literature. Existing publications suggest that firms may acquire technology either as know-how or as technology concepts (e.g. Chiesa and Manzini 1998). Nevertheless, these two routes apparently have not been placed together in the context of a technology acquisition process in TM literature.

Third, the results indicate that there are six types of factors that affect the acquisition process: strategic alignment, structural match, development management, technology uncertainty, implementation opportunity and contextual factors. The framework resulting from this research indicates the relationship between these six types of factors and the stages in the acquisition process. Few academic papers have tried to link the relevance of factors with the different stages of an inter-firm relationship (e.g. Marxt and Link 2002), but it seems that none have tried to link relevant factors with the particular activities carried out in a specific technology collaboration context from a process perspective.

In combination, the three distinctive features of the results described above offer a comprehensive description of the technology acquisition process by collaboration, which is a topic that has been marginally addressed in TM literature.

The outcomes of this research also offer relevant contributions to practice. The resulting framework provides managers with a comprehensive description of the key activities and influential factors in technology collaborations from the perspective of the acquiring firm. The framework depicts the key areas that need to be effectively managed in order to achieve success in TA projects involving an industry partner. Thus, the results can be used to develop systematic management processes or tools to anticipate risks and to deal with problematic issues in technology collaboration projects (for instance partner selection or management of the acquisition project).

9.2 Evaluation of the methodological approach

The qualitative research design adopted in this study allowed a deep understanding of the acquisition process involving an industry partner and the factors that affect the outcomes. The research was carried out through four phases and involved 13 interviews with practitioners, 11 case studies and one focus group session. The data collection methods included semi-structured interviews and case studies.

The industries represented in this research include chemicals, oil and gas, tooling manufacturing, biofuels, petrochemicals, construction, paint and coatings, electronics and printing. The research method included three analytical approaches to make sense of data, namely grounded analysis, narrative analysis and cross case analysis.

The exploratory approach undertaken in this inquiry was suitable to meet the purposes of the research. The results increase our understanding of the conditions that affect the acquisition of technologies when a technology partner is involved. The combination of data collection methods and analytical approaches allowed the researcher to develop a framework that includes experiences from a cross section of industries. As suggested by the outcomes of the focus group (Table 7.5), the framework offers an appropriate description of the key activities and factors of technology acquisition projects.

At each phase of the research project, data collection and analytical methods employed offered complementary information on each dimension of the framework. In the first phase, semi-structured interviews allowed the collection of data to build a rich overview of the problematic factors of collaborative developments; in the second phase, the interviews provided valuable data to identify factors and activities that were relevant in the project and understand how these factors affected the outcomes. In the third phase, the researcher explored four co-development projects through in-depth interviews with a range of stakeholders in the participating firms. In this stage, the data collected offered a rich picture of the evolution of each project, as well as how the different factors affected the outcomes. In addition, the data also provided elements to understand how collaborative agreements were formalised. In the last phase, the results of a focus group session indicated that the framework was appropriate and complete. Further, the comments raised by the participants provided relevant inputs to refine the terminology employed in the framework.

9.3 Limitations

Different aspects such as the research approach, selection of cases, theoretical concepts used and criteria to measure success in technology acquisition projects, inherently limit the results of this inquiry. Despite the fact that the researcher performed different actions to mitigate the effects of these limitations on the outcomes of the research, the results still could not be generalizable because of the following reasons.

The results are based on a limited number of case studies. The framework was largely developed from the analysis of 11 case studies. The researcher looked at covering experiences from different industries and technology acquisition projects with different characteristics. However, not all industries are represented in the results. For example, the biotechnology and pharmaceutical industries are not included in this research. Therefore, the results may not apply in all industries.

In terms of case selection, a key criterion to choose candidate cases was to get access to the key people from both parties involved in the collaboration. However, finding and getting access to a set of cases that would share some common characteristics (such as type of technology or completion stage) and in which the researcher could interview people from the partnering firms was difficult, particularly because of the confidential terms agreed between partners. The researcher sent a significant number of requests to have access to case studies, but this strategy produced limited success. Therefore, the researcher opted for exploring and selecting cases that could be accessed through his personal network. This decision led the researcher to follow an ease of access approach to select most of the cases. Consequently this resulted in analysing cases predominantly in process related industries and the researcher having little control over the characteristics of the companies that were included in the cases.

Another aspect having influence on generalisation of the results is the meaning of theoretical concepts used during the inquiry. For example, ‘technology’ is a concept broadly used in different contexts but there is not a universal agreement on its meaning. Arthur (2009), for instance, dedicates an entire book to create a framework for understanding what technology is. He argues that “technology is a collection of phenomena captured and put to use” (Arthur 2009, p.50), which shows how broad this concept can be. Technologies may differ greatly one from one another. Consequently, the outcomes may not be applicable for the acquisition of technologies with attributes different to the technologies involved in the cases analysed in this research.

As discussed in chapter 4, there are different ways to measure success of technology acquisition projects. This research adopts ‘satisfaction with the project’ by the case studies companies as indicator of success. Although it is very subjective, this indicator is the most feasible measurement for this research in relation to other alternatives (see Section 4.5). Therefore, the results of the research may not be applicable when different criteria are utilised as success indicator in technology acquisition projects.

9.4 Further research

Despite the fact that the exploratory nature of this research does not allow for generalisations, the results offer a description of key activities and factors that specifically affect technology acquisitions by collaboration. Further academic research should not only look at exploring whether the main proposition resulting from this thesis can be relevant in other industry sectors, but also to explore additional issues in managing technology acquisition by collaboration.

For example, the researcher observed that formalising a collaborative development agreement when there is no previous relationship between partners and before having a clear account of the technical and economic implications of the project increases the likelihood of failure. Some of the case studies suggested (e.g. Case 4 and 9) that signing a series of contractual agreements with limited scope over the co-development project may allow the partnering firms to manage the risks better and therefore to terminate the relationship when all the parties involved agree without incurring legal battles. Therefore, further research could look at determining the conditions that increase the probability of failure in technology acquisition projects involving an industry partner.

Other areas for further exploration are situations not covered by the scope of this research. For instance, the results may not be appropriate to explain acquisition projects primarily aimed at assimilating new technology knowledge or skills. These projects require the acquiring partner to replicate the knowledge or skills of its partner. The acquisition process and the influential factors may be very different to the process described in this thesis, but further research is needed to define what the differences are.

To sum up, the results achieved meet the original objectives of this research. As noted above, the resulting framework increases our understanding of the conditions that affect the effective acquisition of external technology by means of collaboration. The framework describes how companies acquire technology, presents the key activities and acknowledges influential factors in the process.

REFERENCES

Ang, S.H., 2008. Competitive intensity and collaboration: impact on firm growth across technological environments. *Strategic Management Journal*, 29(February), pp.1057–1075.

Arranz, N. & Fernandez de Arroyabe, J.C., 2008. The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation*, 28(1-2), pp.88–100.

Arthur, W.B., 2009. *The Nature of Technology*, London: Allen Lane.

Baines, T., 2004. An integrated process for forming manufacturing technology acquisition decisions. *International Journal of Operations & Production Management*, 24(5), pp.447–467.

Baloh, P., Jha, S. & Awazu, Y., 2008. Building strategic partnerships for managing innovation outsourcing. *Strategic Outsourcing: An International Journal*, 1(2), pp.100–121.

Barczak, G., Griffin, A. & Kahn, K.B., 2009. PERSPECTIVE: Trends and Drivers of Success in NPD Practices: Results of the 2003 PDMA Best Practices Study. *Journal of Product Innovation Management*, 26, pp.3–23.

Barnes, T.A., Pashby, I.R. & Gibbons, A.M., 2006. Managing collaborative R&D projects development of a practical management tool. *International Journal of Project Management*, 24(5), pp.395–404.

Barney, J., 1991. Firm resources and sustained competitive advantage. *Journal of management*, 17(1), pp.99–120.

Belderbos, R., Carree, M. & Lokshin, B., 2004. Cooperative R&D and firm performance. *Research Policy*, 33(10), pp.1477–1492.

Betz, F., 1998. *Managing technological innovation : competitive advantage from change*, Chichester, New York: Wiley.

Bhaskaran, S.R. & Krishnan, V., 2009. Effort, Revenue, and Cost Sharing Mechanisms for Collaborative New Product Development. *Management Science*, 55(7), pp.1152–1169.

Bronder, C. & Pritzl, R., 1992. Developing Strategic Alliances: A Conceptual Framework for Successful Co-operation. *European Management Journal*, 10(4), pp.412–421.

Bruce, M., Leverick, F. & Littler, D., 1995. Complexities of collaborative product development. *Technovation*, 15(9), pp.535–552.

Bunge, M., 1976. The philosophical richness of technology. In *PSA: Proceedings of the Biennial Meeting of the Philosophy of science association*. pp. 153–172.

Buse, S. & Armonaitis, P., 2010. Outsourcing of R&D: Chances and risks. In *2010 IEEE International Conference on Management of Innovation and Technology (ICMIT)*. Singapore.

Caetano, M. & Amaral, D.C., 2011. Roadmapping for technology push and partnership: A contribution for open innovation environments. *Technovation*, 31(7), pp.320–335.

Cagliano, R., Chiesa, V. & Manzini, R., 2000. Differences and similarities in managing technological collaborations in research, development and manufacturing: a case study. *Journal of Engineering and Technology Management*, 17, pp.193–224.

Campione, T.J., 2003. Making research collaborations succeed. *Research Technology Management*, 46(4), pp.12–15.

Cañez, L. et al., 2007. Linking technology acquisition to a gated NPD process. *Research Technology Management*, (Jul-Aug), pp.49–55.

Cantarello, S. et al., 2011. External technology sourcing: evidence from design-driven innovation. *Management Decision*, 49(6), pp.962–983.

Cetindamar, D., Phaal, R. & Probert, D., 2010. *Technology management: activities and tools*, Hampshire, UK: Palgrave Mcmillan.

Chesbrough, H. & Schwartz, K., 2007. Innovating business models with co-development partnerships. *Research Technology Management*, (January-February), pp.55–59.

Chiesa, V. & Manzini, R., 1998. Organizing for technological collaborations: a managerial perspective. *R&D Management*, 28(3), pp.199–212.

Cohen, W. & Levinthal, D., 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative science quarterly*, (35), pp.128–152.

Colombo, M.G., 2003. Alliance form: a test of the contractual and competence perspectives. *Strategic Management Journal*, 24(12), pp.1209–1229.

Cooper, R.G., 2006. Managing technology development projects. *Research Technology Management*, 1990(Nov-Dec), pp.23–31.

Cooper, R.G., 2001. *Winning at new products* 3rd ed., New York: Basic books.

Cui, Z. et al., 2012. How Provider Selection and Management Contribute to Successful Innovation Outsourcing: An Empirical Study at Siemens. *Production & Operations Management*, 21(1), pp.29–48.

Cui, Z. et al., 2009. Outsourcing innovation. *Research Technology Management*, (Nov-Dec), pp.54–63.

Cummings, J.L. & Teng, B.-S., 2003. Transferring R&D knowledge: the key factors affecting knowledge transfer success. *Journal of Engineering and Technology Management*, 20(1-2), pp.39–68.

Cunha, R.C. & Cooper, C.L., 2002. Does privatization affect corporate culture and employee wellbeing? *Journal of Managerial Psychology*, 17(1), pp.21–49.

Cuthill, I.D.H., Gupta, A.K. & Wilemon, D., 1997. Supplier involvement in new product development. In *PICMET*.

Daim, T.U. & Kocaoglu, D.F., 2008. How Do Engineering Managers Evaluate Technologies for Acquisition? A Review of the Electronics Industry. *Engineering Management Journal*, 20(3), pp.44–52.

Das, T.K. & Teng, B., 2000. A Resource-Based Theory of Strategic Alliances. *Journal of Management*, 26(1), pp.31– 61.

Das, T.K. & Teng, B., 2003. Partner analysis and alliance performance. *Scandinavian Journal of Management*, 19(3), pp.279–308.

Deck, M. & Strom, M., 2002. Model of co-development emerges. *Research Technology Management*, 45(3), pp.47–53.

Denison, D.R. & Mishra, A.K., 1995. Toward a Theory of Organizational Culture and Effectiveness. *Organization Science*, 6(2), pp.204–223.

Durrani, T.S., Forbes, S.M. & Broadfoot, C., 1999. An integrated approach to technology acquisition management. *International Journal of Technology Management*, 17(6), pp.597–618.

Duysters, G., Kok, G. & Vaandrager, M., 1999. Crafting successful strategic technology partnerships. *R&D Management*, 29(4), pp.343–351.

Easterby-Smith, M., Thorpe, R. & Jackson, P.R., 2008. *Management research* 3rd ed., Hampshire, UK: SAGE Publications.

Eisenhardt, K.M., 1989. Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), p.532.

Emden, Z., Calantone, R.J. & Droge, C., 2006. Collaborating for New Product Development: Selecting the Partner with Maximum Potential to Create Value. *Journal of Product Innovation Management*, 23(4), pp.330–341.

Enberg, C., 2012. Enabling knowledge integration in competitive R&D projects — The management of conflicting logics. *International Journal of Project Management*, 30(7), pp.771–780.

Escribano, A., Fosfuri, A. & Tribó, J.A., 2009. Managing external knowledge flows: The moderating role of absorptive capacity. *Research Policy*, 38(1), pp.96–105.

Eskelin, A., 2001. *Technology acquisition: Buying the future for your business*, New Yersey, USA: Addison Wesley.

Ettlie, J.E. & Pavlou, P.A., 2006. Technology-Based New Product Development Partnerships. *Decision Sciences*, 37(2), pp.117–147.

Fabrizio, K.R., 2009. Absorptive capacity and the search for innovation. *Research Policy*, 38, pp.255–267.

De Faria, P., Lima, F. & Santos, R., 2010. Cooperation in innovation activities: The importance of partners. *Research Policy*, 39(8), pp.1082–1092.

Fliess, S. & Becker, U., 2006. Supplier integration—Controlling of co-development processes. *Industrial Marketing Management*, 35(1), pp.28 – 44.

Floyd, C., 1997. *Managing technology for corporate success*, Aldershot: Gower Publishing Ltd.

Ford, S. & Probert, D., 2010. Why do firms acquire external technologies? Understanding the motivations for technology acquisitions. In *Technology Management for Global Economic Growth (PICMET)*. Phuket, pp. 1–9.

Fraser, P., Farrukh, C. & Gregory, M., 2003. Managing product development collaborations—a process maturity approach. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 217(11), pp.1499–1519.

Galbraith, C.S., Ehrlich, S.B. & DeNoble, A.F., 2006. Predicting Technology Success: Identifying Key Predictors and Assessing Expert Evaluation for Advanced Technologies. *Journal of technology transfer*, 31, pp.673–684.

Gales, L. & Mansour-Cole, D., 1995. User involvement in innovation projects: Toward an information processing model. *Journal of Engineering and Technology Management*, 12, pp.77–109.

George, G. et al., 2001. The effects of alliance portfolio characteristics and absorptive capacity on performance A study of biotechnology firms. *The Journal of High Technology Management Research*, 12, pp.205–226.

Gerwin, D., 2004. Coordinating New Product Development in Strategic Alliances. *Academy of Management review*, 29(2), pp.241–257.

Gibson, D. V. & Smilor, R.W., 1991. Key variables in technology transfer: A field-study based empirical analysis. *Journal of Engineering and Technology Management*, 8(3-4), pp.287–312.

Gill, J. & Johnson, P., 2010. *Research Methods for Managers* 4th ed., Cornwall, UK: SAGE Publications.

Goffin, K., Lemke, F. & Koners, U., 2010. *Identifying Hidden Needs: Creating Breakthrough Products*, Hampshire, UK: Palgrave McMillan.

Goffin, K. & Mitchell, R., 2005. *Innovation management: Strategy and implementation using the pentathlon framework*, Hampshire, UK: Palgrave McMillan.

Grant, R.M., 1996. Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17((Winter special issue)), pp.109–122.

Gregory, M., 1995. Technology Management: a Process Approach. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 209, pp.347–356.

Hacklin, F., Marxt, C. & Fahrni, F., 2006. Strategic venture partner selection for collaborative innovation in production systems: A decision support system-based approach. *International journal of production economics*, 104(1), pp.100–112.

Hagedoorn, J., 1995. Strategic technology partnering during the 1980s: trends, networks and corporate patterns in non-core technologies. *Research Policy*, 24, pp.207–231.

Hagedoorn, J., 1996. Trends and Patterns in Strategic Technology Partnering Since the early Seventies. *Review of Industrial Organization*, 11, pp.601–616.

Hagedoorn, J., 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectorial differences. *Strategic Management Journal*, 14(January), pp.371–385.

Hagedoorn, J., Link, A.N. & Vonortas, N.S., 2000. Research partnerships. *Research Policy*, 29, pp.567–586.

Handfield, R.B. et al., 1999. Involving suppliers in New Product Development. *California Management Review*, 42(1), pp.59–82.

Haven, K., 2000. *Super simple storytelling: a can-do guide for every classroom, every day.*, Englewood, Colorado.: Teacher Ideas Press.

Haven, K. & Ducey, M., 2007. *Crash course in storytelling*, London: Libraries Unlimited.

Van Haverbeke, W., Duysters, G. & Noorderhaven, N., 2002. External Technology Sourcing Through Alliances or Acquisitions : An Analysis of the Application- Specific Integrated Circuits Industry. *Technology*, 13(6), pp.714–733.

Hemmert, M., 2004. The influence of institutional factors on the technology acquisition performance of high-tech firms: survey results from Germany and Japan. *Research Policy*, 33(6-7), pp.1019–1039.

Henriksen, A.D.P., 1997. A technology assessment primer for management of technology. *International Journal of Technology Management*, 13(5/6), pp.615–638.

Hipkin, I. & Naudé, P., 2006. Developing Effective Alliance Partnerships. *Long Range Planning*, 39(1), pp.51–69.

Von Hippel, E., 2005. *Democratizing Innovation*, Cambridge, Massachusetts: The MIT press.

Hoffmann, G.F., 1997. Building competitive advantage through technology alliances. In *Innovation in Technology Management. The Key to Global Leadership. PICMET '97*. Ieee, p. 72.

Hofstede, G., 1980. *Culture's consequences: international difference in work-related values*, Beverly Hills: SAGE Publications.

Hofstede, G., 1991. *Cultures and organizations: software of the mind*, Glasgow, UK: HarperCollinsBusiness.

Hofstede, G. et al., 1990. Measuring Organizational Cultures: A Qualitative and Quantitative Study across Twenty Cases. *Administrative science quarterly*, 35, pp.286–316.

Hurmelinna-Laukkanen, P. et al., 2012. Orchestrating R&D networks: Absorptive capacity, network stability, and innovation appropriability. *European Management Journal*.

Inkpen, A.C., 1998. Learning, Knowledge Acquisition, and Strategic Alliances. *European Management Journal*, 16(2), pp.223–229.

Ireland, R.D., Hitt, M.A. & Vaidyanath, D., 2002. Alliance Management as a Source of Competitive Advantage. , 28(3), pp.413–446.

Jassawalla, A.R. & Sashittal, H.C., 1998. An Examination of Collaboration in High-Technology New Product Development Processes. *Journal of Product Innovation Management*, 15, pp.237–254.

Jiménez-Barrionuevo, M.M., García-Morales, V.J. & Molina, L.M., 2011. Validation of an instrument to measure absorptive capacity. *Technovation*, 31(5-6), pp.190–202.

Jones, G., 2001. Determinants and performance impacts of external technology acquisition. *Journal of Business Venturing*, 16(3), pp.255–283.

Jordan, J. & Lowe, J., 2004. Protecting Strategic Knowledge : Insights from Collaborative Agreements in the Aerospace Sector. *Technology Analysis & Strategic Management*, 16(2), pp.241–259.

Karlsson, C., Taylor, M. & Taylor, A., 2010. Integrating new technology in established organizations: A mapping of integration mechanisms. *International Journal of Operations & Production Management*, 30(7), pp.672–699.

Kaufman, A., Wood, C.H. & Theyel, G., 2000. Collaboration and technology linkages: a strategic supplier typology. *Strategic Management Journal*, 21(January), pp.649–663.

Kim, Y. & Lee, K., 2003. Technological collaboration in the Korean electronic parts industry: patterns and key success factors. *R&D Management*, 33(1), pp.59–76.

Knudsen, M.P., 2007. The Relative Importance of Interfirm Relationships and Knowledge Transfer for New Product Development Success. *Journal of Product Innovation Management*, 24(2), pp.117–138.

Lager, T. & Frishammar, J., 2010. Equipment supplier/user collaboration in the process industries: In search of enhanced operating performance. *Journal of Manufacturing Technology Management*, 21(6), pp.698–720.

Lambe, C. & Spekman, R., 1997. Alliances, External Technology Acquisition and Discontinuous Technological Change. *Journal of product innovation …*, 14, pp.102–116.

Lee, S. et al., 2010. Strategic partner selection for collaborative R&D: Literature-based technology intelligence. In *R&D Management Conference*. Manchester, UK: R&D Management.

Lhuillery, S. & Pfister, E., 2009. R & D cooperation and failures in innovation projects : Empirical evidence from French CIS data. *Research Policy*, 38, pp.45–57.

Lin, C. et al., 2012. The alliance innovation performance of R&D alliances—the absorptive capacity perspective. *Technovation*, 32(5), pp.282–292.

Lin, Z., Yang, H. & Arya, B., 2009. Alliance partners and firm performance: resource complementarity and status association. *Strategic Management Journal*, 30, pp.921–940.

Littler, D., Leverick, F. & Bruce, M., 1995. Factors affecting the process of collaborative product development: A study of UK Manufacturers of Information and Communications Technology Products. *Journal of Product Innovation Management*, 12, pp.16–32.

Lunnan, R. & Haugland, S.A., 2008. Predicting and measuring alliance performance: a multidimensional analysis. *Strategic Management Journal*, 29(May 2002), pp.545–556.

MacKinnon, P.K., 1989. Acquiring Technologies Through Strategic Partnerships. *Technology in society*, 11(2), pp.195–202.

Marxt, C. & Link, P., 2002. Success factors for cooperative ventures in innovation and production systems. *International Journal of Production Economics*, 77(3), pp.219–229.

McCutchen Jr, W.W., Swamidass, P.M. & Teng, B.-S., 2008. Strategic alliance termination and performance: The role of task complexity, nationality, and experience. *The Journal of High Technology Management Research*, 18(2), pp.191–202.

McCutcheon, D. & Meredith, J.R., 1993. Conducting case study research in operations management. *Journal of Operations Management*, 11(3), pp.239–256.

McCutcheon, D. & Stuart, F.I., 2000. Issues in the choice of supplier alliance partners. *Journal of Operations Management*, 18(July 1998), pp.279–301.

Mcgee, J.E. & Dowling, M.J., 1994. Using R&D cooperative arrangements to leverage managerial experience: a study of technology-intensive new ventures. *Journal of Business Venturing*, 9, pp.33–48.

Mehlman, S.K. et al., 2010. Better practices for managing intellectual assets in collaborations. *Research Technology Management*, 53(Jan-Feb), pp.55–66.

Meredith, J.R., 1998. Building operations management theory through case and field research. *Journal of Operations Management*, 16(4), pp.441–454.

Minshall, T. et al., 2010. Making asymmetric partnerships work. *Research Technology Management*, 53(May-June), pp.53–63.

Miotti, L. & Sachwald, F., 2003. Co-operative R&D: why and with whom? An integrated framework of analysis. *Research Policy*, 32(8), pp.1481–1499.

Monczka, R.M. et al., 1998. Success Factors in Strategic Supplier Alliances: The Buying Company Perspective. *Decision Sciences*, 29(3), pp.553–577.

Mora-Valentin, E.M., Montoro-Sánchez, Á. & Guerras-Martin, L. a, 2004. Determining factors in the success of R&D cooperative agreements between firms and research organizations. *Research Policy*, 33(1), pp.17–40.

Narula, R. & Hagedoorn, J., 1999. Innovating through strategic alliances: moving towards international partnerships and contractual agreements. *Technovation*, 19, pp.283–294.

Neale, M.R. & Corkindale, D.R., 1998. Co-developing products: Involving customers earlier and more deeply. *Long Range Planning*, 31(3), pp.418–425.

Nonaka, I., 1994. A Dynamic Theory of Organizational Knowledge Creation. *Organization science*, 5(1), pp.14–37.

O'Reilly, C.A., Chatman, J. & Caldwell, D.F., 1991. People and organizational culture: a profile comparison approach to assessing person-organization fit. *Academy of Management Journal*, 34(3), pp.487–516.

Ortiz-Gallardo, V.G., Probert, D. & Phaal, R., 2013. Technology acquisition by collaboration: a conceptual framework. In D. Cetindamar et al., eds. *Strategic Planning Decisions in the High Tech Industry*. London: Springer-Verlag, pp. 143–158.

Paixao-Garcez, M., Sbragia, R. & Kruglianskas, I., 2010. The selection of partners in non-equity bilateral alliances: some qualitative evidences from the Brazilian Petrochemical leader. In *PICMET 2010*. Phuket, Thailand.

Park, B. Il & Ghauri, P.N., 2011. Key factors affecting acquisition of technological capabilities from foreign acquiring firms by small and medium sized local firms. *Journal of World Business*, 46(1), pp.116–125.

Petersen, K.J., Handfield, R.B. & Ragatz, G.L., 2005. Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, 23, pp.371–388.

Piachaud, B., 2005. Outsourcing technology. *Research Technology Management*, 48(3), pp.40–46.

Ragatz, G.L., Handfield, R.B. & Petersen, K.J., 2002. Benefits associated with supplier integration into new product development under conditions of technology uncertainty. *Journal of Business Research*, 55(5), pp.389 – 400.

Ranft, A.L., Lord, M.D. & Carolina, N., 2002. Acquiring New Technologies and Capabilities: A Grounded Model of Acquisition Implementation. *Organization science*, 13(4), pp.420–441.

Rebentisch, E.S. & Ferretti, M., 1995. A knowledge asset-based view of technology transfer in international joint ventures. *Journal of Engineering and Technology Management*, 12(1-2), pp.1–25.

Reuer, J.J. & Zollo, M., 2005. Termination outcomes of research alliances. *Research Policy*, 34, pp.101–115.

Roberts, E.B. & Berry, C.A., 1985. Entering New Businesses : Selecting Strategies for Success. *Sloan Management Review*, 26(3), pp.3–17.

Robertson, T.S. & Gatignon, H., 1998. Technology development mode: a transaction cost conceptualization. *Strategic Management Journal*, 19, pp.515–531.

Robson, C., 2011. *Real world research: a resource for users of social research methods in applied settings* 3rd ed., Padstow, UK: Wiley.

Rothwell, R., 1994. Towards the fifth-generation innovation process. *International marketing review*, 11(1), pp.7–31.

Roussel, P.A. et al., 1991. *Third generation R&D - managing the link to corporate strategy*, Boston, Mass: Harvard Business School Press.

Sen, F. & Rubenstein, A.H., 1990. An exploration of factors affecting the integration of in-house R&D with external technology acquisition strategies of a firm. *IEEE Transactions on Engineering Management*, 37(4), pp.246–258.

Simonin, B.L., 1999a. Ambiguity and the process of knowledge transfer in strategic alliances. *Strategic management journal*, 20(7), pp.595–623.

Simonin, B.L., 2004. An empirical investigation of the process of knowledge transfer in international strategic alliances. *Journal of International Business Studies*, 35(5), pp.407–427.

Simonin, B.L., 1999b. Transfer of marketing know-how in international strategic alliances: an empirical investigation of the role and antecedents of knowledge ambiguity. *Journal of International Business Studies*, 30(3), pp.463–490.

Sivadas, E. & Dwyer, F., 2000. An Examination of Organizational Factors Influencing New Product Success in Internal and Alliance-Based Processes. *The Journal of Marketing*, 64(January), pp.31–49.

Slowinski, G. et al., 2000. Acquiring external technology. *Research Technology Management*, 43(5), pp.29–35.

Spivey, W.A. & Munson, J.M., 2009. Improve tech transfer with this alliance scorecard. *Research Technology Management*, (JAN-FEB), pp.10–18.

Stake, R.E., 2006. Qualitative case studies. In N. K. Denzin & Y. S. Lincon, eds. *Sage Handbook of Qualitative Research*. Thousand Oaks, CA: SAGE Publications, pp. 443–66.

Steele, L.W., 1989. *Managing technology: the strategic view*, USA: McGraw-HIll.

Steensma, H.K., 1996. Acquiring technological competencies through inter-organizational collaboration: An organizational learning perspective. *Journal of Engineering and Technology Management*, 12, pp.267–286.

Steensma, H.K. & Corley, K.G., 2000. On the performance of technology-sourcing partnerships: the interaction between partner interdependence and technology attributes. *Academy of Management Journal*, 43(5), pp.1045–1067.

Stock, G.N. & Tatikonda, M. V, 2004. External technology integration in product and process development. *International Journal of Operations & Production Management*, 24(7), pp.642–665.

Stock, G.N. & Tatikonda, M. V, 2008. The joint influence of technology uncertainty and interorganizational interaction on external technology integration success. *Journal of Operations Management*, 26(1), pp.65–80.

Sung, T.K. & Gibson, D. V., 2000. Knowledge and Technology Transfer: Levels and Key Factors. In *4th International conference on technology policy and innovation*.

Szulanski, G., 1996. Exploring internal stickiness: impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17(Winter special issue), pp.27–43.

Tatikonda, M. V & Rosenthal, S.R., 2000. Technology novelty, project complexity, and product development project execution success: a deeper look at task uncertainty in product innovation. *IEEE Transactions on Engineering Management*, 47(1), pp.74–87.

Tatikonda, M. V & Stock, G.N., 2003. Product Technology Transfer in the Upstream Supply Chain. *Journal of Product Innovation Management*, 20(6), pp.444–467.

Thuriaux-Alemán, B., Eagar, R. & Webster, P., 2010. *The new partnership between research & technology institutes and industry*,

Tidd, J. & Bodley, K., 2002. The influence of project novelty on the new product development process. *R&D Management*, 32(2), pp.127–138.

Tsang, E.W.K., 1998. Motives for strategic alliance: a resource-based perspective. *Scandinavian Journal of Management*, 14(3), pp.207–221.

Twiss, B.C., 1992. *Forecasting for technologists and engineers: a practical guide for better decisions*, Stevenage: Peter Peregrinus on behalf of the Institution of Electrical Engineers.

Un, C.A., Cuervo-Cazurra, A. & Asakawa, K., 2010. R&D Collaborations and Product Innovation. *Journal of Product Innovation Management*, 27, pp.673–689.

Varis, J., Virolainen, V.-M. & Puumalainen, K., 2004. In search for complementarities: partnering of technology-intensive small firms. *International Journal of Production Economics*, 90(1), pp.117–125.

Vilkamo, T. & Keil, T., 2003. Strategic technology partnering in high-velocity environments — lessons from a case study. *Technovation*, 23, pp.193–204.

Van de Vrande, V., VanHaverbeke, W. & Duysters, G., 2011. Additivity and complementarity in external technology sourcing: The added value of corporate venture capital investments. *IEEE Transactions on Engineering Management*, 58(3), pp.483–496.

Van de Vrande, V., Vanhaverbeke, W. & Duysters, G., 2009. External technology sourcing: The effect of uncertainty on governance mode choice. *Journal of Business Venturing*, 24(1), pp.62–80.

Wagner, S.M. & Hoegl, M., 2006. Involving suppliers in product development: Insights from R&D directors and project managers. *Industrial Marketing Management*, 35(8), pp.936–943.

Wahab, S.A., Abdullah, H. & Rose, R.C., 2009. A holistic model of the inter-firm technology transfer based on integrated perspectives of knowledge-based view and organizational learning. *The journal of International Social Research*, 2(9), pp.407–422.

Wheelwright, S.C. & Clark, K.B., 1992. *Revolutionizing product development*, New York: Free Press.

Williams, R.G. & Lilley, M.M., 1993. Partner selection for joint-venture agreements. *International Journal of Project Management*, 11(4), pp.233–237.

Wu, J., 2012. Technological collaboration in product innovation: The role of market competition and sectorial technological intensity. *Research Policy*, 41(2), pp.489–496.

Yasuda, H., 2005. Formation of strategic alliances in high-technology industries: comparative study of the resource-based theory and the transaction-cost theory. *Technovation*, 25, pp.763–770.

Yasuda, H. & Iijima, J., 2005. Linkage between strategic alliances and firm' s business strategy: the case of semiconductor industry. *Technovation*, 25, pp.513–521.

Yin, R.K., 2009. *Case study research: design and methods* 4th ed., Thousand Oaks, CA: SAGE Publications.

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

APPENDICES

Appendix A

Interview protocol (Practice review)

Interviewee name:

Company:

Date:

1) How often does your company participate in co-development projects (or JDA) involving new technologies?

2) General speaking, what is the role of your company in those projects?

A) Technology provider
B) Technology receiver
C) Both (to choose one, preferably as technology receiver)
D) Manufacturing advisor

Case A - Technology provider

3) What areas in your company interact with the acquiring firm in the definition of the scope of the project?

4) What areas in your company participate in the negotiation of the terms of the project?

5) Do you have any structured process to manage the relationship with your client?

a) No

b) Yes, please could you explain me a bit how that process works?

6) What are the main technologies that your company provides in those projects?

a) Information technologies (control systems, telecommunications systems, software)

b) Chemical compounds or materials (alloys, drugs, polymers)

c) Product technology (new designs, instrumentation, tools)

d) Manufacturing technology (assembling, welding, biochemical, chemical processes)

7) What are the most recurrent issues in managing co-development projects?

8) Why do you believe those circumstances are problematic? Could you give me an example?

9) Do your company have any policy on how to negotiate the resulting IP rights?

10) What are the main resources that your company provides to the partnership?

a) Technical knowledge
b) Development capabilities
c) Commercialisation capabilities
d) Relevant operational environment to test the final product
e) Capital
f) Intellectual property
g) Manufacturing expertise and capabilities

11) What are the types of contracts preferred by your company in these projects?

a) Joint ventures
b) Joint development agreements
c) R&D contracts
d) Non-equity alliances
e) Joint R&D
f) Other

12) How often your company is the champion/promoter of the co-development project?

a) Quite frequently
b) Never/ few times

Case 12.a

13) General speaking, what are the main motivations to promote a co-development project?

a) Sharing risks
b) Sharing costs

c) Getting access to particular assets

d) Exploiting under utilised resources

e) Making useful the technology developed within the company

f) Learning

14) When your company is the promoter of the co-development project, is there any problematic issue when the technology is transferred to the user?

15) What are the main criteria to select your partner?

a) Trust

b) Capabilities

c) Commercial reputation

d) Motivations compatibility

e) Geographical location

f) Financial resources

g) Other

16) Do you have any additional comment concerning managing co-development projects that you consider important?

Case B - Technology receiver

3) In general terms, what is the main driver to enter into a collaboration agreement?

a) Developing a new product

b) Improving the performance of current products

c) Improving the performance of current operations

4) What areas in your company participate in the definition of the scope of the project?

5) What areas in your company participate in the negotiation of the terms of the project?

6) What areas in your company participate in the development of the project?

7) In general, who is in charge of evaluating the progress of the project?

8) Do you have any structured process to evaluate the progress of collaborations?

a) No

b) Yes, please could you explain me a bit how that process works?

9) What are the main technologies that your company acquire through this kind of projects?

a) Information technologies (control systems, telecommunications systems, software)

b) Chemical compounds or materials (alloys, drugs, polymers)

c) Product technology (new designs, instrumentation, tools)

d) Manufacturing technology (assembling, welding, biochemical, chemical processes)

10) What are the most recurrent issues in managing collaborations?

11) Why do you believe those circumstances are problematic? Could you give me an example?

12) Generally, who owns the resulting IP rights?

13) What are the main resources that your company provide to the partnership?

a) Technical knowledge

b) Development capabilities

c) Commercialisation capabilities

d) Relevant operational environment to test the final product

e) Capital

f) Intellectual property

g) Skills to define the final specifications of the product

14) What are the types of contracts preferred by your company in these projects?

a) Joint ventures

b) Joint development agreements

c) R&D contracts

d) Non-equity alliances

e) Joint R&D

f) Other

15) What are the main criteria to select your partner?

a) Trust

b) Technical capabilities and skills (e.g. IPR)

c) Commercial reputation

d) Cultural affinity

e) Geographical location

f) Motivations compatibility

g) Reference of a colleague/consultant

16) How often your partner is the promoter of the co-development project?

a) Quite frequently

b) Never/ few times

Case 16.a

17) In that case, general speaking, what are the main motivations to entering into the co-development project?

a) Sharing risks

b) Sharing costs

c) Getting access to particular assets

d) Getting access to the technology and intellectual property

e) Developing a new product/solution

f) Learning

18) When your partner is the promoter of the co-development project, is there any recurrent issue when the technology is transferred?

19) Do you have any additional comment concerning managing co-development projects you consider important?

Appendix B

Interview protocol (Framework development)

Interviewee name:

Company:

Date:

Part I - General approach of the company to acquire new technologies

1) How often does your company acquire new technologies from an external provider?

2) Why does your company acquire new technologies?

3) Typically, how does your company decide on new technologies?

4) How does you company identify and select new technologies?

5) What are the problematic issues related to the identification and selection of new technologies?

6) How does your company decide the technology provider to work with?

7) What are the problematic issues related to the identification of technology providers?

8) When negotiating new technologies, what are the most problematic issues?

9) When a new technology is developed in collaboration, what are the most problematic issues?

10) What are the common issues associated with implementation of new technologies?

Part II - Case study

11) Could you please describe the technology involved and why it was important to your company?

12) How did your company identify the technology?

13) Why did you company decide to acquire the technology?

14) How familiar was your company with the technology?

15) How could you describe the level of maturity of the technology at the time of the acquisition?

16) How many potential providers did your company find for the technology?

17) How and why did your company choose the provider?

18) How familiar was the technology provider with the final application of the technology?

19) How can you describe the relationship with the provider of the technology during the negotiation phase?

20) Regarding the development work, what were the problematic issues?

21) Regarding the interaction with the provider, what were the problematic issues?

22) How was the development work coordinated?

23) In terms of time, cost of development and performance of the technology, did the outcomes meet the initial expectations of the project? why?

24) What were the main challenges that your company face to acquire this technology?

25) What intellectual property rights emerged from the project?

26) How were IPR managed?

27) Do you have any further comment regarding this project that you consider important to mention?

Appendix C

Interview protocol (Framework refinement)

Context of the project

1. Could you please describe me the main business of your company?

2. Could you please describe your main activities in your company?

3. How often your company collaborate with other organisations to develop new technologies/products?

Description of the case

4. Could you please describe the experience of your company in the project?

a) What product/technology was developed?
b) Why this project was important to your company?
c) When and how did this project start?
d) How familiar was your company with the product?
e) Why did you company decide to develop in collaboration this product/technology?
f) How many companies were involved in this project?

Technology scouting

5. How many potential partners did your company find for developing this product/technology?

a) How and why did your company choose its partner for this project?
b) Have your company worked before with the partner in another joint development?
c) How familiar was your company with the technology?
d) How familiar was your partner with the technology?

Value of the technology

6. How did your company estimate the potential value of the technology?

a) Who was involved in the evaluation process?

b) What are the main advantages of the technology selected in relation to other?

Description of the technology

7. Could you describe briefly the technology and what are its key advantages?

a) How could you describe the level of maturity of the technology at the beginning of the joint development?
b) Did your company or your partner have any relevant set of patents?

Project execution

8. How was carried out the project?

a) What type of agreement was employed? (JDA, R&D contract, JV, licensing…)
b) What did each partner bring to the joint development?
c) If you could divide in phases the project, how many phases had the project? What were the key activities in each phase?
d) Regarding the product development work, what were the problematic issues?
e) How was the product development work coordinated?

9. What were your main responsibilities in the project?

Project scope definition

10. Before formalizing the co-development agreement, what activities did your company and its partner carried out?

a) Meetings, lab trials, participation in consortia, business case development…?
b) Who participated in the definition of the scope of the project?
c) What were the main issues in defining the scope of the project?
d) Did your company estimate the success probability of the project?

Agreement formalization

11. How can you describe the relationship with the partner during negotiations?

a) What were the main issues in the negotiation?
b) How were IPR managed? (both existing and emerging IP)
c) What intellectual property rights emerged from the project?

Project outcomes

12. In overall, do you consider this project meet the initial expectations of your company?

a) In terms of time, cost of development and performance of the final product, did the outcomes meet the initial expectations of the project? why?

13. What were the main challenges that your company face to implement the resulting product? (For instance in scaling up the production or in its implementation in current systems)

14. What do you consider were the key factors to achieve the success/failure of this project?

General comments

15. From you personal perspective, what do you believe it was a lesson learned by your company in this project?

16. Do you have any further comment regarding this project that you consider important to mention?

End of the interview

Appendix D

Key activities in technology collaboration

Table C-1 Key activities in technology collaborations – Acquiring firm perspective.

Technology acquisition stage	Rephrasing - Issue	Expert_01	Expert_04	Expert_05	Expert_07	Expert_08	Expert_09	Expert_12	Expert_13
Technology requirements	Foresee industry's future requirements	1						1	1
	Foresee client's future needs	1						1	
	Estimate resources required to accomplish the business objectives							1	
	Identify alternatives to address an operational issue								1
Technology scouting	Identify new technologies and potential applications	1	1	1	1	1			
	Understand the new technology	1							
Technology evaluation	Estimate the cost of the technology						1		
	Decide whether make, buy or collaborate							1	
	Estimate potential economic benefits						1		
	Estimate the feasibility of use of the new technology to a particular application	1	1		1				
Partner selection	Evaluate capabilities of potential partners							1	
	Select a partner to work with						1		
	Keep confidentiality of samples/prototypes/information	1				1			
	Identify potential partners							1	
	Keep confidentiality of development intentions	1							
Negotiation	Manage emerging intellectual property	1			1		1		
	Define the project's scope and outcomes	1						1	
	Build trust between partners						1		
	Make decisions timely					1			
Development	Keep track of the project and evaluation of partial outcomes							1	
	Make decisions about resources allocation						1		
	Scale up the production process	1		1					
	Develop the technology		1						
Exploitation	Implement the technology across the whole company		1						
	Manage manufacturing cost	1							

Appendix E

Relevant activities in technology collaboration

Table D-1 Relevant activities in technology collaborations – Providing firm's perspective

Group	Rephrasing - activity	Expert_02	Expert_03	Expert_05	Expert_06	Expert_09	Expert_10	Expert_11	Expert_12
Technology concept development	Identify technologies that meets clients' future needs			1					1
	Identify technology that meets future industry needs			1					
Building business reputation	Advertise technologies and technical capabilities			1	1		1		
	Build technology/Market reputation			1					
	Publicize the technology concept						1		
Demonstration of technology capabilities	Keep confidentiality of samples/prototypes/information						1		
	Demonstrate the technology						1		
	Estimate the cost of development of the technology				1				
Negotiation	Manage emerging intellectual property			1	1				
	Build trust between partners				1	1	1		
	Share value of the technology					1		1	
	Understand the needs of the partner	1							
Development	Keep the schedule running on time		1						
	Keep track of the project and evaluation of partial outcomes		1			1		1	
	Scale up the production process			1					
	Share decision making		2						
	Estimation of technology risks				1				
Technology transfer	Manage expectations	1							
	Manage manufacturing cost				1				

Appendix F

Examples of the conceptualization stage in the grounded analysis process

"…2 years ago it was decided by one of our operating units, Beta Americas in this case, in consultation with our R&D centre to start a test of that technology in one of their conventional gas wells in [--place--], in which they were interested to see whether we could pick up signals during the hydraulic cycling of those wells, so it was a bit of a mix between the operating unit in the Americas, our conventional gas unit there and the R&D centre. The results from that were very encouraging but also showed that the existing gas technology, which you are probably aware came out of defence and intelligence application, was not yet mature for gas applications so that we started a research collaboration and a product development agreement…"
Informant Company Beta, Case 3.

Activity – field trials

Activity – Value recognition

Factor – Maturity of the technology

Activity – Formalisation of the agreement

"…but it is a very good point you mention here because as I said earlier we acquired this technology, or we developed this technology further, on what has been done in a very small start up company. So small start up companies are certainly not rich in cash so they do not have the means, also not the financial means usually to produce the material or technology on a larger scale, but the investment of our parent country through the venture capital investment round, actually they were in a position to launch their large scale production and this worked quite nicely and actually this company is now going for an IPO later this year…"
Informant Company Epsilon, Case 6.

Factor – Characteristics of the providing partner

"…we identified 6 of 7 potential companies. A couple were ruled out because of geographical reasons, and then we looked at the degree of technical expertise and technology ownership. So, how much are they knowledge/activity do we think these companies have, which is useful. Intellectual property, do they have thought the patent that covered our areas. Those were the two important aspects, but, in fact probably the most important was enthusiasm. How enthusiastic were these companies to work with us? That is the key thing. You can have the best company, the best technology, the best support, but if they are really not interested in working with you then that's not a good start. So, it's always difficult to understand why they are or are not enthusiastic to work with you. There may be reasons for it, they may be working with someone else, or they may not want to get in to your business area because it's not good for them, or whatever. Sometimes it could just be characters. You could just meet someone who is not particularly an enthusiastic person, the wrong contact. So it can be quite subjective but generally speaking you need to have a company that is motivated to do the work with you, to discuss things, to transfer knowledge etc..."
Informant Company Eta, Case 7.

Activity – Partner selection

Factor – Complementary resources

Factor – Enthusiasm of the development team

Appendix G

Extract of the database created to analyse data

Case set	Case ID	Case No	Product target industry	Interviewee perspective	Interviewee company code	Type of technology provider	Type of agreement	Quotation	Factor	Category
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"The final risk is the maintenance of the RFS-2 mandate in the US, that is essentially to maintain. "	Changes in industry and market	Market & industry uncertainty
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"at working level actually the relatinship was excelent, and there is nothing particularly negative in that since we acquire XXXXXX,"	Continuos communication between partners	Communication
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"The main issues were around achieving some technology milestones, an that is still an issue, particularly around a number of things"	Maturity of the technology	Technology performance
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"C5 is pretty standard and works well, C6 has been more challenging. They were out of our technology risks. "	Maturity of the technology	Technology performance
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"We feel XXXXX had the best technology, there were other technologies in the market, so what we did was to enter into a partnership with XXXX in the first instance and, that was in 2008."	Partner's IPR	IP exploitation rights
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"also is another important point for us is safety culture, the ethical culture, to ensure they are aligned with us,"	Business culture compatibility	Partners affinity
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"What it happens substantially is that XXXXXX we now have bought the XXXXXXX biofules" "So they really need somebody to buy them out in order to keep the biofuels otherwise they would not be able to pay their way"	Financial stability	Partners stability
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"But I would say that the technology has not been yet commercially proved. "	Product maturity	Product maturity
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"We would be making a very clear decision on go or not go in one key one next year. That would attempt to be the decision to go the first commercial plant, or whether we say no it is too risky or go ahead"	Project performance	Project performance
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"And the reason that we wanted to invest in cellulosic ethanol is because the very positive mandate I think it was called RFS 2 - Renewable Fuels standard 2 in the US, that provided support for producing the second generation of biofuels"	Business opportunity	Business motivations
1	Bioethanol	1	Biofuels	Acq firm	Alpha	Start-up company	TJV	"They were aligned with us because they thought XXXX brough a financially muscle and ability to take the product to the market and they brought the technology."	Match of resources and expertise	Resources complementarity
1	Bioethanol	1	Biofuels	Prov Firm	Theta	Start-up company	TJV	"So it's just a matter of looking at the overall financial implications of a biological fix versus an engineering fix and then making the best decision based on where we need the cross targets to be. "	Economic implications	Market & industry uncertainty
1	Bioethanol	1	Biofuels	Prov Firm	Theta	Start-up company	TJV	"we had a research committee, so there were members from XXXXXX, and members from XXXXXX that met on a quarterly basis to discuss how things were progressing and how resources were"	Ease of decision making	Decision making
1	Bioethanol	1	Biofuels	Prov Firm	Theta	Start-up company	TJV	"We had XXXXX which was the entity that XXXXX and XXXXXX put in the technology that was going to represent the overall technology licensing package for the production of cellulosic ethanol."	Implementation plans	Implementation plans
1	Bioethanol	1	Biofuels	Prov Firm	Theta	Start-up company	TJV	"the majority of what XXXXXX was putting in was the full time employees into the venture, and so XXXXXXX's contribution was predominantly with respect to actual physical resources as opposed to monetary resources. "	Match of resources and expertise	Resources complementarity
1	Bioethanol	1	Biofuels	Prov Firm	Theta	Start-up company	TJV	"as we had originally set it up as an 18 month programme, throughout that programme we set milestone dates and performance targets for those dates."	Project definition	Scope definition
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"we see it as a growing XXX market so it is a substantial market for transportation fuels" "...we see a growing market that it is something that is part of our core business and effort became something that we wanted to do."	Business opportunity	Business motivations
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"To a degree we were quite familiar " "I think that the main issues that we faced were developing a deeper unstanding of the technology because again, biochemistry is not a natural capability within XXXXXXX " "SO I would say that that was our major challenge."	Familiarity with the technology	Technology familiarity
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	" I don't know for sure that there was one really usual issue around the ownership of I.P. "	Management of emerging IPR	Emerging IPR
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"we are still in the process of proving the technology, so we do not know ultimately whether is going to be successful,"	Maturity of the technology	Technology performance
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"There are some milestones we haven't achieved in terms of the pilot plant."	Maturity of the technology	Technology performance
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"What we want to do is establish the new brand in the market which potentially, as we go forward into the market, we'd market biobutanol under the XXXXX umbrella."	Implementation plans	Implementation plans

Case set	Case ID	Case No	Product target industry	Interviewee perspective	Interviewee company code	Type of technology provider	Type of agreement	Quotation	Factor	Category
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	", it was felt that by combining our marketing expertise and their technology expertise, we can create a kind of joint venture to bring this new molecule to the market. "	Partner's know-how & skills	IP exploitation rights
1	Biobutanol	2	Biofuels	Acq firm	Alpha	Large company	JV	"It has been a strong strategic alignment, and the technology advances that have been there and so, so far so good. "	Vision alingment	Vision alignment
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"And the results from that were very encouraging but also showed that the existing gas technology which you are probably aware came out of defence and intelligence application, was not yet mature for gas applications but that started a research collaboration and a product development agreement. "	Maturity of the technology	Technology performance
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"The times are long gone if they ever existed that we believe that our company can do everything, or can do everything better than others. In fact externalisation, so looking for solutions outside, either we can use or adapt to our needs is one of the central thoughts currently in the R&D organisation."	Product development strategy	Partners characteristics
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"...with a project this size, and this complexity, with all these unknowns, there will always be loose ends. It's impossible to make this process totally watertight and cover every eventuality. "	Project complexity	Project characteristics
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"...this is part of the fibre optics R&D programme which is wider than with XXXXXX"	Relevance of the product	Project relevance
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"the reason we think this is important is that the technology will provide or can provide for us a huge cost advantage in monitoring what is happening in the oil and gas world."	Relevance of the product	Project relevance
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"There is the R&D phase which we do together, with XXXXXX and XXXXX so we provide the oil and gas expertise, and they provide their expertise as I've just explained and also electronics"	Match of resources and expertise	Resources complementarity
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"We can compare with other signals of traditional systems, so that is where we as an operator in the gas field can bring in our expertise, particularly from the geophysics side. "	Match of resources and expertise	Resources complementarity
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"...the commercialisation phase, which is totally with XXXXX. "	Value and risk sharing	Risks and rewards
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"firstly it's a joint R&D effort so both sides through the R&D actually contribute 50/50. "	Value and risk sharing	Risks and rewards
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"we identified [...] 17 application areas. We identified 4 of these as high priority items which is high priority both in terms of fast implication and fast evaluation and also in terms of technical success"	Product specifications	Scope definition
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"For each of the components we have a probability of success, which is of course, a lot of gut feel, but we update this probability of success as we move through the technology maturation stages."	Project definition	Scope definition
1	FOSS	3	Oil & Gas production	Acq firm	Beta	Start-up company	JDA	"Should I'd say building trust between the two sides by clear and upfront communication is very important as well, next to what the lawyers are putting down on paper in their language."	Trust building	Trust
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"Now we have to start thinking about delivering, because once you enter this phase you must understand the loops and commercialisation is. You must understand it thoroughly, which is what this does. There may be questions which need to be faced later on, like who is going to manufacture it, so all that's considered right here. "	Implementation plans	Implementation plans
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"I should say that we place contracts of this type with individuals not companies. We find individuals capable of doing this, and the work is for him, not for the company."	Development team willingness to collaborate	Development team
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"but they didn't actually become part of XXXXXX. They were brought. They didn't actually become part of it in any operational sense and there has been continual change ever since and there must have been several different management structures in XXXXXXX and we have as well. "	Organisational stability	Partners stability
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"if you have a technology which has wide applications, like fibre optics, there are so many applications it's important at the onset to design one application, one application [testing facility] which contains all of the characteristics of the final product. "	Access to testing facilities	Equipment and infrastructure

Case set	Case ID	Case No	Product target industry	Interviewee perspective	Interviewee company code	Type of technology provider	Type of agreement	Quotation	Factor	Category
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"In this case I selected the Alaska gas pipeline, which is still a concept. Which is 5,000 km of 52" pipe, which is a huge project with perm cross and everything, and ground movement and leaks, interference. All that is part of the project, so we use that as our base case. "	Access to testing facilities	Equipment and infrastructure
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"tests were done not as a demonstration of the final product, but as a means to get field data to allow us to complete the design of what the engineer of the product. "	Access to testing facilities	Equipment and infrastructure
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"it's not like a major petro chemical contract where you have a contractor, and the contractor has a hold over everything, you have to have? Because you know what you want out of this, you have a clear objective, know all the people involved, a smallish team, it can be done relatively easy."	Involvement of the project manager	Project manager
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"I then spent the next 18 months trying to persuade XXXXX to do the project and eventually somebody gave me some funding for a project on the control core of the capital value process. XXXXXXX is a structured process ."	Funding availability	External funding
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"I got some funding which allowed me to get together a business team and also to identify the technologies. So I got the funds together, about $30,000 and gave a contract to XXXXXXX to one individual in XXXXXXXX."	Funding availability	External funding
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"when the company sell the product at the end, we would get preference when it comes to supply which makes good sense, but also, we'd get a reduced price from everybody else who is buying the product. Could be 20% depending on the price." "So the advantage is not necessarily gained in selling the product, but in the advantage the product gives us in operations. "	Value and risk sharing	Risks and rewards
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"but as you progress, XXXXXX, slowly moulding to a larger organisation. "	Organisational stability	Partners stability
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"This whole document was written. That was the end product of all of our work. There is a whole batch of reports over here but all of this is written together with me and the contractor. "	Documentation	Product development management
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"You have to drive the contractor. Personal relationships are really important. You argue continuously."	Involvement of the project manager	Project manager
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"They don't believe what you tell them half the time. You have to demonstrate it to them, you have to, and the struggle is, every time you come to see them you're fighting for money."	Involvement of the project manager	Project manager
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"It has to be supported. It has to be part of a larger picture. Your management has to see the ? That the delivery has value"	Value recognition	Business motivations
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"At the early stages, particularly at this stage which usually we may have funded entirely, on a very simple contract that says we own all the intellectual property. We own everything. And that is the difference in the contract."	Value and risk sharing	Risks and rewards
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"As you start out, the larger partner has the initial investment. As you progress, and share, share IP benefits, they also must invest. "	Value and risk sharing	Risks and rewards
1	PCMS	4	Gas transportation and storage	Acq firm	Gamma	Supplier	JDA	"One of the biggest challenges when you do this work is you keep going, you think about it more and you realise there are all these other applications. It's keeping the focus on the one application throughout"	Product specifications	Scope definition
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"but one thing that actually helped there was we had XXXXXX intimately involved in the detail of what we were doing so when we hit a snag they knew all about it."	Continuos communication between partners	Communication
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"...I guess what you need to do is pick up a flavour of the different cultures, different company cultures. XXXXX is very open. We get on very well, I think actually culturally they fit very well with XXXXXX. "	Business culture compatibility	Partners affinity
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"We do work with other oil and gas companies, in fact, most of them are regular customers of ours, but we have closest technical ties at the moment with XXXXXX"	Partners' previous relationship	Previous relationship
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	" [the project] ended with XXXXX in 2008 with the conclusion that yes these technologies work on pipelines, and they were set to be ready for deployment on XXXXX pipelines."	Value recognition	Business motivations

Case set	Case ID	Case No	Product target industry	Interviewee perspective	Interviewee company code	Type of technology provider	Type of agreement	Quotation	Factor	Category
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"We didn't know if we would manage to make that work. In the end everything managed to work out very well actually."	Familiarity with the technology	Technology familiarity
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"We formed a consortium called ROADS for Remote Optically Amplified Distributed Sensors, proposing a 3 year programme 50% funded by UK government. "	Existence of technology knowledge	Application novelty
1	PCMS	4	Gas transportation and storage	Prov Firm	Lambda	Supplier	JDA	"It was a very open relationship. I think that is important. There was a lot of trust there, so I would be quite open and honest with Norman. If there was bad news, he knew all about it, I think that's one thing. Open communication works very well. It was a partnership actually rather than a kind of standard client customer relationship."	Continuos communication between partners	Communication
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"Our position, because we're a licencing company, is we've almost always asked for all if the I.P. rights so that we can keep our whole platform under our I.P. control."	Management of emerging IPR	Emerging IPR
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"Then, of course, on a commercial side, they are our customers, so we have interests in making them happy because they are buying services from us on a regular basis."	Partners' previous relationship	Previous relationship
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"we sold a customer in South America a polyethylene plant; or a licence for a polyethylene plant. "	Partners' previous relationship	Previous relationship
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"So we've developed with them the knowledge of how to make a particular grade of product that they want for their market place and what we have is an additional grade that we can now sell as part of our licencing package. Both parties are happy with the results"	Project performance	Project performance
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"Typically, for this kind of project there might be some local companies, in Brazil for example, that have processes that make that particular grade. SO they can make the grade but they may not be able to make it very efficiently or as cost effectively as we can. But that defines the market that we want to get into."	Business opportunity	Business motivations
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"So it's a particular grade to make, for example to make a certain kind of woven fibre to be used to make plastic. That's a big market in some parts of the world but it's not where we have used our own technology."	Business opportunity	Business motivations
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"we licence a technology to make polyethylene, which means that we would go to a company, say, in South America, who is interested on making polyethylene. They've got access to 400,000 tonnes of ethylene and they want to convert it to polyethylene."	Value recognition	Business motivations
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"It turns out that our customer in South America wants to target certain grades for certain applications which is a big market in South America that we don't, as Western European & North American operators of our technology don't make and haven't made in the past."	Value recognition	Business motivations
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"Yes we succeeded. There is a very clear point. It is to find or come up with the process conditions to make one particular grade. So it's a very clearly defined technical target."	Product specifications	Scope definition
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"It's a very mature process. You're probably looking at it being 20 years in developing the overall process, but the maturity of this particular grade that we define in our process would be obviously brand new."	Existence of technology knowledge	Application novelty
1	Polyethilen	5	Petrochemicals	Prov Firm	Omega	Supplier	Strategic partnership	"The other piece is as with any project. It's important to understand up front who's doing what; who is responsible for what; who's paying for what and establishing a stage gate process whereby either partner can say " 'stop', we're not meeting our targets, we want out." We always make sure that either partner has the ability to stop if the project is not having the required technical success."	Ease of decision making	Decision making
1	Insulation r	6	Construction industry	Acq firm	Epsilon	Start-up company	Minor investment	"we on our side, we implemented a dedicated project manger assigned to this activity full time and who organised everything around the cooperation starting from the regulatory issues and then of course organising work packages and organising regular meetings. "	Involvement of the project manager	Project manager
1	Insulation r	6	Construction industry	Acq firm	Epsilon	Start-up company	Minor investment	"The expectations have been, I would even say over fulfilled, the performance of the final product exceeded, or went beyond the initial specification. The product now appears to be a little bit more costly than what was originally anticipated, but that's ok."	Project performance	Project performance

Appendix H

Case description

Case 9 – Steel cutting process

H.1 Overview

This is a co-development project carried out by a firm and a national research centre. The purpose of this collaboration was to develop a flexible steel cutting machine. This project was important to MyASA because the outcomes would allow MyASA to reduce dependace on external equipment providers. Initially MyASA had considered to carry out the project and to outsource only particular activities. Nevertheless, CNDT proposed to MyASA to work toghether from the beginning of the project to develop firstly the conceptual model.

Developing the conceptual model in collaboration may ensure that the final product would include the most appropriate technology. CNDT was very keen on participating in this project because its financial resources depends largely on supporting industry customers to meet their technology needs. MyASA and CNDT shared their expertise and resources to develop the cutting machine. MyASA provided the specifications of the final product and CNDT provided technology development skills and infraestructure to develop the thermal cutting module.

H.2 Context

Suppliers to the car manufacturing industry are increasingly pushed to produce customized components and to incorporate new materials. On the one hand, manufacturers are assembling a greater mix of products than ever before. "In 1996, 16 percent of plants assembled more than 10 different product types annually. In 2004, 23 percent did so."[1] As an overall consequence, manufacturers are reducing production volumes for each model. This trend is known in the industry as high-mix, low-volume assembly. On the other hand, there is an industry trend to incorporate heat-treated and high-strenght steels. These new materials challenge conventional mechanical cutting

[1] http://www.assemblymag.com/articles/83764-managing-high-mix-low-volume-assembly

processes. Residual stresses induced by these processes reduce the performance of structural components in cars and trucks.

These two drivers are encouraging component suppliers to incorporate flexible manufacturing processes capable of handling new materials. It is estimated that demand for flexible, reconfigurable and precise manufacturing processes is growing at an annual rate of 7.8%.

MyASA, a supplier of structural components to the industry, is experiencing these changes in the industry. Over more than 50 years MyASA has been a supplier to the US automotive industry; but in the last decade, MyASA has been pushed to adopt a low-volume and flexible manufacturing approach to meet the requirements of its customers.

H.3 The challenge

Despite its high quality, extant commercial manufacturing equipment is limited in flexibility and quite frequently is designed to produce large volumes. A single variation in a manufacturing line, often requires the acquisition of additional equipment. Furthermore, new lines or plants may exhibit a large production capacity. In combination, both situations are translated into higher levels of capital expenditure and over-sized production lines or plants.

In 2007 MyASA began a planning journey to explore the value of opening new manufacturing plants in other countries. As a result planning activities, it was found that the initial investments to open new plants near to key customers was very high. The main reason was that some commercial equipment was limited in both capacity and flexibility to address the production requirements of the new plant. The planning team observed that the company could not grow based on the same business model. They knew that they cannot expand their operations to other regions with surplus capacity factories. New plants require equipment with less production capacity and investments according to these production volumes.

On a worldwide basis, there were few manufacturing equipment suppliers offering flexible manufacturing processes. Few multinational firms dominated the market and consequently, flexible manufacturing equipment was expensive. The investment level for new lines and plants was very high as a consequence of the high cost of flexible equipment.

Given this scenario, the planning team concluded that growth in other regions was dependant on developing proprietary equipment for key manufacturing processes. Directors at MyASA agreed the planning team proposal and they instructed the R&D team to explore the possibility of reducing initial investments of forthcoming plants by developing proprietary equipment.

The R&D team accepted the challenge. This was a major challenge to the R&D team given the fact that in the past they had worked only on incremental modifications to equipment. This new challenge would require the R&D team to build equipment from scratch. To deal with the challenge, the R&D team asked Directors for full support of this initiative, since they would need resources and participation of people from other areas.

H.4 An opportunity to develop proprietary equipment

At the end of 2007, the R&D team started to conceptualise the scope of this development project. The project consisted of developing equipment to manufacture heavy truck frames and it was estimated that a first prototype could be developed in 18 months. The scope was from designing proposals for the different subsystems to building a physical prototype.

After analyzing the different stages of the manufacturing process, the development team decided that steel piercing was a stage where they could develop proprietary equipment. This process is critical for the manufacture of crossbars of heavy-duty trucks.

Piercing is the process by which a number of holes are made into a C-steel profile. Usually the steel bars employed are between 10 and 12 meters long. The piercing process is performed into a mechanical cutting machine that can be programmed to make customized products. The diameter and position of the scraps, as well as bar lenght vary from one customer to other.

The first task addressed by the team was to define daily production volumes, quality requirements, scalability, repeatability and operative flexibility of the manufacturing process. The result of this task allowed the R&D team to set up quantitative specifications for the equipment they wanted to develop. Thus, the team set up three objectives for the project:

1. Develop a customizable, precise and speedy piercing process.
2. Produce a process that would require lower capital expenditure.
3. Develop equipment that would require lower plant space than commercial equipment.

The objectives for the project were set up, but the team did not have too much experience in estimating the technical risks. At that time, the company was about to acquire equipment, so that the development team approached the vendor to follow up the design and assembly process. By this means, the development team learned how the equipment was designed, key design criteria, and details of the different components. This learning allowed the team to develop a preliminary estimation for the amount of work and materials needed to build a cutting machine.

H.5 Estimating the value of the project

The team developed a business case to make a better estimation of the economic resources required for this development. They asked people from another subsidiary of the parent company for advice. The main business of this subsidiary was tooling manufacturing, so that they knew fairly well the cost of materials and systems. The conclusion from the business case was that developing a proprietary piercing equipment was plausible.

Based on the business case result, the team gained confidence that they could achieve success. However, they also knew that they did not have all the expertise and infrastructure to carry out the project on their own.

Despite the fact that the economic benefit was clear, the team still did not understand the technology risks of the project. The team doubted whether after two years, when the outcomes of the project were expected to emerge, the resulting technology would be obsolete or could be claimed by anyone else. Therefore, as second step, the team carried out an analysis of the legal protection of the technologies that were available at the time for steel piercing and clamping.

This stage of the development process was performed with support of an external consultant, who helped the team to identify and analyze relevant patents. This analysis revealed technology areas where too much work had been carried out and technology gaps, which represented potential areas to claim proprietary development. Results also helped the team to distinguish technology developers and their areas of expertise. This was an important information input to identify potential technology providers, partners and competitors. Thus, as a result of this stage, the team was not only confident that they could produce an innovative outcome, but they also learned about the different technologies available at the time to cut and handle steel bars.

H.6 In the search for a partner

The team knew that they could develop a piercing process. They had a good understanding of the different components, they knew the specifications of the process, and they had estimated the work required to build a prototype. However that was not enough. They neither had experienced people to do technical drawings nor the entire infrastructure to develop a prototype on their own. Therefore, the team decided that some parts of the development would be outsourced.

Few years before, the R&D team had visited some national research centers in order to identify organizations that could provide them with complementary expertise and infrastructure. As a result they obtained a list of potential partners. From the list, two national research centers were found to have relevant expertise and infrastructure to support MyASA with the development of equipment in this project.

The team visited both institutions (CNDT[2] and CDI[3]) in order to explain to them the purposes of the project. Each Centre was asked to propose the inputs that they could offer to the project. Both institutions expressed the view that they could participate at any point, from identifying and analyzing relevant patents to building a physical prototype.

After these visits, the team had two potential institutions that could provide support in the project, but they decided to pick only one. The team concluded that CNDT could be a good partner to work with for two reasons. Firstly, the team found that CNDT had

[2] Centro Nacional de Desarrollo Tecnológico
[3] Centro de Desarrollo Industrial

relevant skills and infrastructure to support them in achieving the development of the piercing process; and secondly, CNDT was about to open an R&D unit in a science park located few miles away from MyASA's main manufacturing site. The team thought that interaction with the partner would be intense during the project. Therefore, closeness was a decisive criterion to select CNDT as partner. The team considered that having their partner closer might bring also coordination advantages.

H.7 Working together

Initially, the team considered that they would outsource only particular activities of the project; those activities which would require particular expertise or skills that they did not have within MyASA. However, the team later found that CNDT had more to add to the project.

This project represented a challenge to CNDT since none had experience in steel cutting processes. Thus, CNDT's development team visited MyASA's manufacturing facilities before giving a definitive working and economic proposal. In this visit, the CNDT's team took pictures and videos of the manufacturing processes and obtained detailed information of the different components of the cutting process. This visit was important to understand the process and the implications of the development and to define the areas where they could contribute to the project.

In order to deal with technical and economic risks, CNDT suggested dividing the project into three stages: feasibility analysis, concept model development, and prototype building. CNDT usually divides its projects in these stages.

The development team at MyASA had not considered involving CNDT from the very beginning of the project; they thought CNDT could participate at some point later during the development of the concept, but they still did not have a clear idea in which particular activities. Therefore, they accepted the propossal, and the first contract that they signed with CNDT aimed at evaluating the feasibility of achieving success in the development of a proprietary piercing process.

H.8 Finding the best concept

Teams from CNDT and MyASA started to explore in depth every single system, subsystem and component of the cutting process, and thereafter they selected the technology for each part of the process. MyASA shared with CNDT the work they had done so far to identify relevant technologies. Together both development teams analyzed the different options and chose the technologies that may better fit the cutting process to meet the specifications of the final product.

At the end, they came up with a feasible process concept. The concept consisted in a two-module piercing process comprising mechanical cutting and thermal cutting. This concept met MyASA's expectations: a customizable, precise and speedy process; a process that required a low capital expenditure; and, a process that may require a small area to operate.

The concept challenged a paradigm of equipment manufacturers. Commercial piercing equipment did not release the product until all the cutting processes had finished; otherwise the process might loose reference of previous cuttings. This paradigm was found to be the reason for a low production rate. The teams concluded that having the cutting process in two steps could dramatically increase the production rate. Common cuttings would be processed in the first step, and customized cuttings would be processed in a second step.

MyASA had skilled people and expertise to develop the mechanical cutting process but not to develop the thermal cutting module. Therefore, the teams agreed that MyASA would develop the first module and CNDT would be in charge of developing the second module. Thus, once the feasibility stage was completed and MyASA was convinced that CNDT could provide value to the project, a second contract was signed. In this new agreement CNDT would produce a prototype design for the thermal cutting module. The deliverable included drawings, simulations, design of every component and manufacturing directions to build a physical model of the module.

H.9 Developing the prototype

After eight months, CNDT delivered to MyASA the conceptual model and specifications of the thermal cutting module. This outcome lead to a third contract. The aim of this new contract was to build and test the prototype. However, despite the fact that the teams came up with a clear definition of the thermal cutting model, the true challenges were about to come.

The initial design considered a 1:1 scale prototype so it could handle a real size steel bar. Therefore, the teams built a prototype machine of real dimensions. Both partners supplied complementary resources to develop the process. MyASA supplied a robot and some components while CNDT put tools, infrastructure and skills to develop the automation systems.

Both teams knew that there was a key issue to achieve success in the development of the cutting process. Transferring steel bars from the mechanical cutting module to the thermal cutting module required to find a solution to keep cutting references. Without a consistent referencing procedure the process would fail to achieve precision and reliability.

The teams found that some companies and universities were exploring the use of optical scanning technology to identify the location and shape of structures in manufacturing processes. Optical scanning seemed to be a solution to increase flexibility of manufacturing processes. Therefore, the teams decided to employ an optical scanner to identify the position of the holes made during the mechanical cutting, so that they could be used as reference to the thermal cutting. This solution was visualized in the conceptual design, but at this stage of the project the teams had to prove that the thermal cutting process could achieve the expected precision and reliability.

The integration of the optical scanner with the cutting process was a complex task. An algorithm to integrate a commercial optical scanner with all the components of the process was required. This algorithm was essential to allow effective and stable communication between the different components of the process. However, the different operative system of the components made the development of the algorithm difficult.

After some months of intense work, CNDT's development team achieved success in developing an algorithm to connect the components. They requested advice of mathematicians from another national research centre to develop and validate the algorithm. The thermal cutting module prototype was completed once the algorithm was ready, but the module still needed to be tested.

H.10 Assessing the success of the project

MyASA considered that the performance of the prototype was critical to validate whether the optical scanning technology could be a solution to identify the location of holes along a steel bar. If it would be proven that optical scanning technology could be incorporated to the manufacturing processes, then a window of applications might emerge for optical scanning technology in other processes.

After some trials the thermal cutting module proved to work as expected. In particular, it was verified that the different components were able to communicate effectively. Nevertheless, due to inappropriate foundations of the place where tests were performed, the clamping system did not work correctly. The development teams considered this issue as irrelevant, since this problem could be solved by reinforcing the foundations. Beyond this issue, the thermal cutting process worked as expected, the referencing system was able to find the precise location of the holes made in the mechanical cutting process.

As a result of the collaboration, MyASA not only achieved the development of a proprietary cutting process, but also the acquisition of an optical scanning technology that can be applied to many other manufacturing processes.

The thermal cutting module has not been implemented yet in any manufacturing facility. MyASA is planning to introduce this module in a new plant in 2014. The prototype module remains in CNDT's laboratories. The prototype has been converted into experimental equipment where new concepts and possible improvements are tested.

This project was the beginning of a partnership between MyASA and CNDT. They have started a significant number of additional projects thereafter. CNDT is now fully aware of MyASA's business strategies and technology requirements.

Appendix I
Modifications to the refined framework

Table H-1 Summary of modifications to the refined framework

Refined framework (V 3.0)	Final framework (V 3.1)	Notes
Strategic alignment	Business alignment	The name of this category was modified to express a more accurate meaning.
Business motivations	Partners' motivations	The name of this factor was modified to express a more accurate meaning.
Wording of the contract	Contract issues	The name of this factor was modified to express a more accurate meaning.
Risks and rewards	Agreement on risks and rewards	The name of this factor was modified to express a more accurate meaning.
Match of resources and expertise	Expertise complementarity Access to relevant equipment and infrastructure	This factor was divided in two factors to express a more accurate meaning.
Access to testing facilities	Access to relevant equipment and infrastructure	The name of this factor was modified to express a more accurate meaning.
Access to funding	Funding	The name of this factor was modified to express a more accurate meaning.
Internal stability of partners	Partners' organizational stability	The name of this factor was modified to express a more accurate meaning.
Ease of communication	Communication	The name of this factor was modified to express a more accurate meaning.
Project management practices	Product development management practices	The name of this factor was modified to express a more accurate meaning.
Project manager	Involvement of the project manager	The name of this factor was modified to express a more accurate meaning.
Technology familiarity	Partners' familiarity with the technology	The name of this factor was modified to express a more accurate meaning.
-	Project champion	This factor was added to the framework as a result of the focus group.
Compatibility with existing systems	Participation of the end user	This factor was integrated with the existing factor 'Participation of the end user'.
Market uncertainty	Market and industry uncertainty	The name of this factor was modified to express a more accurate meaning.

Appendix J

Focus group – feedback form

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Workshop

Technology partnerships:
Acquiring technologies through co-development projects

Feedback form

Please answer the following questionnaire.

Name:____

How much do you agree or disagree with the following statements?

1. The six groups of factors in the framework are appropriate.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

2. The six groups cover the important factors that influence the outcomes of technology acquisition projects.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

3. The six acquisition-related activities in the framework are appropriate.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

4. The six acquisition-related activities cover the critical tasks of technology acquisition projects.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

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5. The two partnership-related activities are appropriate.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

6. The two partnership-related activities include the most relevant tasks.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

7. The terminology in the framework is clear.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

8. The emerging framework is clear and appropriate.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

9. The emerging framework provides practical implications.
☐ Strongly disagree ☐ Disagree ☐ Not sure ☐ Agree ☐ Strongly Agree
Comments

Do you have any further comment on the emerging framework?

Do you have any suggestions for further research based on the emerging framework?

Do you want to receive a copy of further publications based on the outcomes of this research?
YES NO

Thank you very much for your participation.