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INNOVATION, ENTREPRENEURSHIP AND OUTSOURCING: ESSAYS ON THE USE OF KNOWLEDGE IN BUSINESS ENVIRONMENTS

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I would like to highlight that all works included in the present dissertation contain results that have been presented in international conferences and/or submitted to international, peer-reviewed journals, as follows:

- Organizational Innovation – The challenge of measuring non-technical innovation on large scale surveys, in co-authorship with the German colleagues and submitted to *Research Policy*
- Teamwork in Production – Implementation and its determinants. Estimates for German Manufacturing, individual work accepted in the 14th International Annual European Operations Management Association (EUROMA) Conference
- Spin-offs as a University Technology Transfer Strategy: Lessons from European Best Practices, in co-authorship with the former head of the Technological Trampoline and my supervisor Jaume Valls, presented at the 35th Entrepreneurship, Innovation and Small Business (EISB) Conference in Barcelona and submitted to *Technovation*
- Research commercialization via spin-off: the case of a non-elite university, in co-authorship with colleagues from the UAB, presented in Brussels at the XX Research in Entrepreneurship and Small Business (RENT) Conference and submitted to the *International Journal of Technology Transfer and Commercialization*
- Building bridges between academia and industry: Exploring barriers in Catalonia, in co-authorship with department colleagues and my supervisor, Jaume Valls
- The accumulation of knowledge in small and medium-sized firms: The role of type of knowledge and absorptive capacity, in co-authorship with my supervisor Anna Arbussà and Sanjay Joel, presented in St. Andrews in the framework of the 4th European Academy of Management (EURAM) Conference and submitted to the *International Journal of Small Business*

I dedicate this thesis to those lovely people who most influenced my life, my grandparents. Their last years of life were the first years of my PhD.

- Nagyszüleimnek-

Contents

0 Abbreviations

CDTI	Centre for the Development of Industrial Technology
CEI	Centre for Enterprise and Innovation
CEO	Chief Executive Officer
CIDEM	Centre for Innovation and Business Development
CIE	Centre for Innovation and Entrepreneurship
CIS	Community Innovation Survey
COI	Changements Organisationnels et l'Informatisation
CORDIS	Community Research and Development Information Service
CTO	Chief Technical Officer
DE	Germany
DISCO	Danish Innovation System in a Comparative Perspective
DK	Denmark
DRUID	Danish Research Unit For Industrial Dynamics
EC	European Community
EIMS	European Innovation Monitoring System
EMIS	European Manufacturing Innovation Survey
EPOC	Employee Direct Participation in Organizational Change
ES	Spain
EU	European Union
EUROSTAT	Statistical Office of the European Communities
FR	France
GEM	Global Entrepreneurship Monitor
H	Hypothesis
HQ	Headquarter
ICT	Information and Communication Technology
IE	Ireland
ILO	Industrial Liaison Office
INNFORM	Innovative forms of organizing
IP	Intellectual Property
ISI	Fraunhofer Institute for Systems and Innovation Research
ISO	International Organization for Standardization
IT	Italy

IT	Information Technology
L	Low-technology industries
MBA	Master in Business Administration
MCYT	Ministry of Education and Science
MH	Medium-high technology industries
MIT	Massachusetts Institute of Technology
ML	Medium-low technology industries
NACE	Statistical Classification of Economic Activities in the European Community
NFWO	New Forms of Work Organization
NL	The Netherlands
NUTEK	The Swedish Agency for Economic and Regional Growth
OECD	Organisation for Economic Co-operation and Development
PRI	Public Research Institution
PT	Portugal
R&D	Research and Development
RBSO	Research-Based Spin-offs
RBV	Resource-Based View
RQ	Research question
SESSI	Service des Études et des Statistiques Industrielles
SME	Small and Medium-Sized Enterprise
STP	Science and Technology Park
SW	Sweden
TQM	Total Quality Management
TT	Technological Trampoline
TTO	Technology Transfer Office
UdG	University of Girona
UK	United Kingdom
US	United States
USA	United States of America
UVL	Umist Ventures Ltd
VC	Venture Capital
XTT	Catalan Network of Technological Trampolines

1 Introduction

Innovation, *entrepreneurship* and *outsourcing* represent the backbone of the present dissertation. The use of knowledge in business environments symbolizes the overlapping area of these concepts. Nowadays, knowledge economy challenges researchers to conduct investigation on how knowledge is generated, exploited and commercialized in order to achieve competitive advantage in today's dynamic environments. The present work is an example for that.

These three pillars, as well as their interaction, are briefly described in the followings with the purpose of highlighting their importance in general, and their specific contribution to this work, in particular. Firms are one of the most important poles in any innovation system while most often they are the ultimate knowledge transformers into marketable innovations. That is the underlying reason for the fact that business world examples abound, but they are complemented with academia as one of the main scientific knowledge provider in current society whose final objective is wealth creation and socioeconomic welfare.

More concretely, each of the concepts mentioned represent a chapter, further dealing with two concrete topics. Empirical evidences are testimonies for the different degrees of knowledge exploitation in business environments. Often knowledge and technology are uneasy to separate; innovation, up to some point, is part of the transformation process (from knowledge to technology), entrepreneurship is converting it into an opportunity as part of a complex exploitation strategy, while outsourcing deals with firms' additional and complementary sources of both.

The main objective of the present work is contributing to different areas of research. First, innovation management in terms of organizational innovation, contemplating its importance and challenges for its measurement on large scale surveys (Section 2.1). Then, a particular example of organizational concept –teamwork- in production is analyzed and the matter of its determinants is tackled (Section 2.2). Second, the entrepreneurial transformation of a non-elite university is followed up, since its beginnings including the design phase (Section 3.1) up to present contemplating its functionality and efficiency,

compared to other European public research institutions (Section 3.2). Third, the difficulties and barriers in terms of R&D outsourcing, in general, and with universities, in particular are analyzed on a sample of gazelle companies (Section 4.1), as well as their decision to make-or-buy (Section 4.2).

Finally, a summary of the results, conclusions and particular implications end this work. Future research maintains the interest in these topics, but it contemplates the possibility of widening the conceptual area, methods used and geographic area covered.

Organizational innovation

During the last two decades, innovation and innovation management was between the top priorities on the research agenda of academics, practitioners and policy makers. Different trends succeeded in its study, reflected by the richness in definitions collected, for example, by Cumming (1998) in his overview on innovation and future challenges. Focus topics passed from technical, industrial and commercial aspects, through creativity and culture, large firms versus small firm innovation, sources, patterns, standardization, measurement and monitoring, to human aspects and organizational concepts among others.

As the study of innovation's areas of richness would be too ambitious, focusing on a common definition and basic characteristics of the process seems a more appropriate option. Brown and Ulijin (2004) set the bare minimum stating that:

Innovation is creating something new and implementing it successfully at a market.

This definition is as short as complex. First, "creation" or the creative process implies a variety of steps such as idea generation, the successful development of the idea into a usable concept, and finally the successful application of the concept. Second, "something" most often refers to products or processes. The contribution found in the next chapter goes further than products and/or process and highlights the importance of organizational concepts and organizational innovation as part of this "something". Third, successful implementation at a market is a necessary step concerning the innovation process. Market and its regulatory power acts as a barometer and selection criteria in the diffusion of

innovations. Still, this is the ultimate and most important objective of most innovators. Innovation is not an objective *per se*, it is rather a mean to achieve and satisfy uncovered market needs.

Innovation management deals with a wide variety of topics and a series of sub-braches –in terms of focus and topics-. Until recently, product and process innovations dominated the panorama. Early works on organizational change, development and innovation understand it as a process closely related to the introduction of new technologies in order to achieve new products and/or processes.

During the '90s special interest in organizational change intensified. Womack et al.'s (1990) study turned the attention to the different new organizational concepts and how they enhanced companies' competitiveness. Posterior to Womack, different authors focused on a variety of other concepts and their impact on quality, flexibility and productivity.

As most often strategically important themes go together with efforts in designing efficient systems for their monitoring and measurement, systematically conducted innovation surveys' emergence date back to the same decade. Early questionnaire versions ask manufacturing companies information relevant to their innovative practices in terms of products and processes. By that time, organizational concepts/innovations were part of other studies dealing with information technologies, flexible organizations and employee involvement, among others.

As organizational innovation defined here as "the use of new managerial and working concepts and practices" gain attention and the scientific community was bringing empirical evidences on their effects, those designing tools for monitoring them, considered their possible inclusion in existing surveys. The process was similar when including service sector companies into the targeted samples (Drejer, 2004).

The first work of the next section represents a proposal of concepts to be taken into consideration when trying to design an organizational innovation monitoring system. Empirical evidences come from a survey designed and conducted during more than a decade in Germany. Technological and organizational concepts are part of the same

complex questionnaire gathering detailed information –such as year of introduction, potential use, etc. - in order to bring some light in the black box of measuring organizational innovations on large scale surveys. Still, the actual state of organizational innovation studies is far from the degree of homogeneity and standardization of most R&D and innovation surveys. One of the underlying reasons might be the difficulties in operationalizing such immaterial phenomena.

The second work of the next section deals with a single organizational concept, namely teamwork in production. Although teams as old as mammoth hunting (Benders and van Hootegem, 1999) their use in productive plants, first in automotive settings and later in manufacturing settings, are considered new forms of work organization. There are two main topics related to teamwork in production that could be related to a research gap. First, the occurrence of teamwork, citing Benders et al. (2001), "the discussion about the incidence of group work can be aptly summarized as: much speculation, little data". Results from the previously described survey show the incidence rates in Germany as well as some other characteristics (tasks performed, number of members in teams, etc.). Second, although early detected by Osterman (1994) that "systematic studies on the determinants of adoption rates are extremely scarce" after more than a decade the situation has not changed significantly. Therefore, the described model takes work organization as the dependent variable and test hypothesis found in the literature.

Innovations result in products, processes and/or new forms of work organization. The exploitation of such can be subject of new entrepreneurial ventures. Innovation relates to entrepreneurship through creativity and most often technology-based entrepreneurship supposes high degrees of innovativeness (Fayolle, 2002). Therefore, in the followings the discussion turns to entrepreneurship and one of its particular typologies, academic entrepreneurship.

University entrepreneurship

As in the case of innovation, in general, and organizational innovation, in particular, defining entrepreneurship is problematic. In a recent European conference on the topic

and after studying a variety of other definitions Brown and Ulijn (2004) take the idea of a common core and state that:

Entrepreneurship is a process of exploiting opportunities that exist in the environment or that are created through innovation in an attempt to create value. It often includes the creation and management of new business ventures by an individual or a team.

Some of the most important ideas gathered in this definition remain the process characteristic of entrepreneurship, the environment and value creation, which are briefly commented in the followings. Opportunity is not less important, but is balanced in the particular cases analyzed during the third section with necessity, therefore although literature contemplates its importance, the lack of own data on this matter moves the attention to the other ones.

Before entering in detail one specification is necessary. Entrepreneurship might have diverse facets and typologies. Among this variety university or academic entrepreneurship has differentiated characteristics and university spin-offs are a particular case. For capturing that, the definition used in the present work is the one provided by Pirnay et al. (2003):

New firms created to exploit commercially some knowledge, technology or research results developed within a university.

Spin-offs emerged as part of university's third mission or as a mean of research commercialization with the final aim of contributing to regional and/or national value creation. As it happened in the case of Germany (Krücken, 2003), it all began under a strong political pressure. The institutionalization of the process followed a learning-by-doing path and this has a series of implications and effects. This particular process and its evolution is the main topic of Section 3.

In the meantime the importance of university spin-offs should be highlighted. Shane's (2005) work is a reference in the field. Even most of the authors state new venture's contribution to regional development, their studies do not analyze this impact, but rather start with the assumption that the impact is significant (Harmon et al., 1997). Shane in an

early chapter of "Academic spin-offs and wealth creation" asks why do university spin-offs really matter. His arguments for the importance of university spin-offs include: they encourage economic development, generate significant economic value, create jobs, induce investment in university technologies, promote local economic development, enhance the commercialization of university technologies, are an effective commercialization vehicle for uncertain technologies, are an effective vehicle for encouraging inventor involvement, help universities with their mission, support additional research attract and retain faculty members, help to train students, are high performing companies, creating spin-offs is more profitable than licensing to established companies. Still, Shane's most examples are from the MIT (US) although recognizing that "MIT is admittedly an extreme case of an American university".

Spin-off literature in Europe, as in the US, is often abundant in elite university examples (see the cases of Chalmers University of Technology in Jacob et al. (2003), Louis Pasteur University in Carayol and Matt (2004) or K.U. Leuven in Debackere and Veugelers (2005), their research commercialization strategies and commercialization infrastructure evolution. In order to fill in a gap detected for the case of non-elite universities, Section 4 is dedicated entirely to: 1) university research commercialization via spin-offs and the design of a unit to support such activities, and 2) evolution of research commercialization via spin-off infrastructure and its fit with strategies found by Clarysse et al. (2005) in European public institutions.

Historically, spin-offs emerged as a third modality to commercialize scientific knowledge produced in universities, after R&D contracts and patent licensing. Chronologically, in Catalonia and in Spain, it dates back to the end of the '90s when universities had to face new challenges: the definition and modeling of a new marketing approach and strategy in order to efficiently commercialize academic research results.

The first work of Section 3 contains the description of the model adapted by a regional, non-elite university – University of Girona – and the creation of its Technology Transfer Office and its spin-off creation and support unit – the Technological Trampoline-. Interestingly, this process is a result of observing different European cases whose technology transfer actively employs the spin-off mechanism. These universities are located in three dynamic countries in the field of spin-offs, namely the United Kingdom, Sweden

and Ireland. In the meantime, these countries have different models of research commercialization and provide a rich base as models. Still, the most difficult phase is not identifying the features of other university's best practices, but rather adapting them to local circumstances.

In order to see whether the structure meets content, the second work of Section 3 is the description of the evolution of research commercialization infrastructure with special emphasis on the spin-off promotion unit. The case is an in-depth analysis contemplating the role of regional environment in its different degrees of narrowing, the university, the city and the region. Focusing on this single-case non-elite university is not a pure coincidence. Reasons to do so are described in details as well as the strategy, objectives and evolution of the unit. Moreover, the activities and the available resources in each of the strategic phases get reflected in this paper. Finally, a match with strategies identified in other European public research institutions is intended.

As stated early in this section, spin-offs are valuable technology and knowledge sources for both university research groups and institutions and companies in the region. Still, academia-business interaction in Catalonia is below most European averages. Companies' options to make-or-buy and practical barriers faced are the main topic of the following section.

R&D Outsourcing

In general terms, the complexity of knowledge and the accelerated competitive change makes companies to seek complementary resources of knowledge and technological solutions to their concrete needs. Early innovation policy documents identified the importance of collaborative research involving Triple-Helix active participation and strategic role. These facts go together with a continuous effort in monitoring and measuring, reflected by the inclusion of the "cooperation" concept in the systematically conducted innovation survey.

In this panorama, small and medium sized firms clearly differentiate and they vary widely in the way they scan the technological environment (Julien et al., 1999), adopt innovations

outside their boundries (Sikka, 1999) and create and convert knowledge inhouse (Birchall et al., 1996; de Jong and Vermeulen, 2006). Although studies of knowledge accumulation among SMEs in Europe have been conducted, most often they are based on official statistics and more importantly, as stated in Kleinknecht (1987), data coming from official surveys tend to underestimate R&D activities in SMEs.

There are two important matters to take into account when analyzing innovation in SMEs: first, creating knowledge and converting knowledge into new products and services are critical to a firm in general and especially true for SMEs (Subramanian and Venkatamaran, 2001; Leonard-Barton, 1995; Nonaka and Takeuchi, 1995). Acs and Audretsch (1990) work on innovation and small firms as well as other authors in the '90s bring valuable evidence against Schumpeter's (1950) hypothesis contemplating firms size as a determinant of R&D spending and the rate of technological advance. Second, data and studies based on official statistics should be complemented with other sources of information in order to capture the organization of innovation in SMEs compared to big corporations.

The debate on whether formal and/or informal cooperation (Bönte and Keilbach, 2005) is not subject of the present work, although awareness on the practice of the latter exists, while SMEs are characterized by lower degree of specialization and a grater use of informal organization. Still, this might turn into an advantage when conductive to higher flexibility and faster and better response to continuous changes in markets and customer needs.

In the meantime, the importance of studying these type of organizations rely in their frequency and accumulated volumes (turnover, employees, value added, etc.) in the European economy, in general, and Spain or the Mediterranean area, in particular.

Section 4 contemplates the topic of outsourcing on a sample of 60 firms that show sustained performance and growth during a period of time –the so-called gazelle firms- in terms of outsourced amounts of R&D and the decision between make/buy as well as the practical barriers encountered by these firms when willing to collaborate with different typologies of partners.

Studying this particular typology of SME is part of the regional development agency's strategy of generating role models and best practices in order to involve all SMEs in innovation activities.

The first study in Section 4 concerns the topic of building bridges between academia and industry in the framework of low collaboration rates despite the political and institutional support (in forms of European, national and local grants, programs and projects). The concrete question is what is preventing industry from cooperation with academia? Although several topics, such as theoretical approaches, institutional orientation and models, system and network view, motives and benefits enrich and also difficult the analysis of cooperation, the barriers identified in this work are mainly practical ones. In the meantime, a clear division between them is made: barriers perceived by firms when willing to cooperate, in general, and with universities, in particular. These barriers are analyzed in relation to technological intensity as well as cooperation intensity.

Section 4 continues with a study having the particular aim to investigate two strategically important aspects of R&D decisions in small firms: first, how much do SMEs invest in R&D and, second, how do SMEs decide between internal or external sources of R&D. On the one hand side, the hypotheses contemplate the relationships between type of knowledge and the intensity of R&D in SMEs. On the other hand side, the type of knowledge is related to the sourcing decision of technology. Veugelers and Cassiman's (1999) work found previously that small firms are more likely to restrict their innovation strategy to either make or buy, while large firms are more likely to combine both.

One important role for governments concerning small and medium-sized firms is the design of specific policy prescriptions taking into account the idiosyncrasy of such companies. The irony might be, Acs and Autresch (1999), that only "when technological change depends upon a vital small firm sector, public policy seems to be moving from an implicit towards an explicit nurturing of larger enterprises at the expense of smaller firms".

Each chapter of the present dissertation is as self-contained as possible. Thus, a concluding section of each is included at the end of it. Therefore, instead of a separate chapter at the

end, the final chapter includes a summary of the presented works, most important implications and future research.

All works included in this dissertation were conducted during the PhD years 2002-2007. Most of the chapters are result of a collaborative effort with my supervisors and researchers from other universities and/or research institutions. Remaining errors are totally assumed by the author.

2 Organizational innovation

2.1. Organizational Innovation – The challenge of measuring non-technical innovation on large scale surveys

2.1.1. Introduction

In the current scientific debate the term "innovation" is predominantly linked to research and development (R&D) in order to create new products. There are many studies on innovation revealing that increased R&D activities lead to innovative products which enable companies to achieve competitive advantages and to gain market shares (e.g. Freeman and Soete, 1997). As a consequence, an increasing number of economies started to invest in a R&D-based innovation policy. In regard to R&D investment, particularly some fast developing countries have gained on the traditional European countries, the US and Japan, who lost their competitive advantages in some fields of product innovation.

Hence, during the last decades companies, policy-makers and researchers in Europe, the US and Japan have been searching more thoroughly for accompanying measures to flank their R&D-based strategy by innovation activities in additional fields to maintain and respectively regain their lead in innovation. This search has been reviving the Schumpeterian definition of innovation. Following Schumpeter (1934) at least four types of innovation can be identified. He differentiates between product and process innovations and technical and non-technical innovations (see also Anderson and King, 1993; Damanpour and Evan, 1984; Totterdell et al., 2002): (1) technical *product innovations*, (2) technical *process innovations*, (3) non-technical *service innovations*, and (4) non-technical process innovations, understood as *organizational innovations*.

The measurement of technical *product innovations* is based on a commonly agreed definition which is described in the Frascati Manual (OECD, 2002) and has come to a methodological standardization and harmonization when officially surveying and comparing enterprises at European or international level (OECD, 1997; OECD, 2002; European Innovation Scoreboard; Community Innovation Survey; Grupp and Mogee, 2004). Meanwhile, the scientific debate has intensified in two further fields of innovation.

In this context, Battisti and Stoneman (2005) have made valuable contributions to the field of measuring technical *process innovations*. Further, there is an ongoing discussion about first approaches of methodological considerations to monitor non-technical service innovations (Drejer, 2004; Hipp and Grupp, 2005; Miles, 2005).

However, there have been little conceptual and methodological contributions to the monitoring of *organizational innovations* so far. Organizational innovations in this definition comprise changes in structure and processes of an organization by implementing new managerial and working concepts and practices, such as the implementation of team work in production, performance-based wage systems or just-in-time concepts (Damanpour, 1987; Damanpour and Evan, 1984).

The importance of organizational innovation for competitiveness has been proven by several studies analyzing the impact of organizational innovations on business performance (Caroli and van Reenen, 2001; Damanpour et al. 1989; Greenan, 2003; Piva and Vivarelli, 2002). These studies point to two different results. First, organizational innovations act as prerequisites and facilitators of an efficient use of technical product and process innovations as their success depends on the degree to which the organizational structures and processes respond to the use of these new technologies. Second, organizational innovations present an immediate source of competitive advantage since they themselves have an important impact on business performance in regard to productivity, lead times, quality and flexibility (e.g. Womack et al., 1990; Hammer and Champy, 1993; Goldman et al., 1995).

Although these studies have evidenced the importance of organizational innovations for business performance, the defining and measuring of organizational innovation still lags behind. Different interpretations are associated with the term "organizational innovation" and the lack of a generally accepted definition causes difficulties in designing and implementing measures and indicators that sustain validity on wide coverage (Lam, 2005).

2.1.2. Definition of organizational innovation

The existing literature on organizational innovation is diverse and scattered. There is no consensus on a definition of the term "organizational innovation", which remains ambiguous (Lam, 2005). Different areas of research are developing their own approaches to understand the complex phenomenon of organizational innovation.

A first literature strand focuses on the identification of the structural characteristics of an innovative organization and its effects on product and technical process innovations (Burns and Stalker, 1961; Mintzberg, 1979; Teece, 1998).

A second literature strand, theories of organizational change and development, aims to analyze and understand how organizations change. This field of research covers models of different stages of how organizational change may occur (e.g. Greiner, 1967; Hannan and Freeman, 1977; 1984) as well as classifications of different types of organizational changes from evolutionary to revolutionary (e.g. Levy and Merry, 1986). It aims at understanding the resistance to organizational change and how to overcome the inertia of organizations enabling them to adapt to changing environments and technologies (e.g. Lewin, 1958; Lawrence, 1954).

A third strand of literature focuses on how organizational innovations are emerging, developing and enhancing at the micro level, within the organization. Theories of organizational cognition and learning (e.g. Argyris and Schön, 1978; Duncan and Weiss, 1978) as well as of organizational creativity (e.g. Amabile, 1988) are in the focus of this strand.

All these research approaches understand organizational innovation either as a necessary adaptation to the introduction of new technologies or as a precondition for successful product or technical process innovations. They try to understand how and under which circumstances organizations change. Thereto they analyze triggers and the paths companies then take to achieve a structure increasingly capable of continuous problem solving and innovation. However, the resulting status of the so converted organization as well as the concrete new elements of managerial and work practice are not in the focus of these

approaches, making it difficult to compare and measure the results of organizational innovations.

The independent contribution of organizational innovations to a superior performance and competitiveness of an organization is, at least partially, neglected. However, in the late 1980s MIT's study of the automobile industries in Japan, USA and Germany turned the attention of researchers and managers to organizational innovations as a driving factor for companies' competitiveness (Womack et al., 1990). Under the label "lean production", Womack et al. subsumed an integrated variety of new organizational concepts such as team work, job enrichment and enlargement, decentralization of planning, operating and controlling functions, manufacturing cells, quality circles, continuous improvement processes, zero buffer principles (kanban), simultaneous engineering and just in time delivery, which they discovered to be the main cause for the superiority of the Japanese car industry at this time.

In the following, a field of related managerial approaches like "business reengineering" (Hammer and Champy, 1993), "total quality management" (Ishikawa, 1985), the "fractal factory" (Warnecke, 1992), the "modular factory" (Wildemann, 1992), the "intelligent organization" (Pinchot and Pinchot, 1993), the "agile enterprise" (Goldman et al., 1995), "cellular forms" (Miles and Snow, 1997) or the "N-form corporation" (Hedlund, 1994) were introduced or became broadly known, promising to guide the reorganization of companies to achieve significantly better performance indicators regarding productivity, quality and flexibility.

Most of the concrete organizational concepts like manufacturing cells or team work can be found in almost all of these integrated managerial approaches. The labels of the latter were used to highlight the one and most important key factor of business success. Sometimes this led to a misinterpretation of these approaches as simple remedies for deeper and more intractable problems. Consequently, the labels, used to characterize the organizational innovations, became fashion fads with hardly separable contents and ever shorter shelf life (Kieser, 1996). On the other hand, labels, such as "lean production" or "agile enterprise", can be useful to lend new energy to the collective enterprise's attempt to adopt organizational innovations, if not revolutionary then at least evolutionary (Eccles and Nohria, 1992).

Regardless of the interpretation of managerial approaches' labels as fashions or enablers of reorganization, it is widely proven that the adoption of concrete organizational concepts has a paramount impact on the ability of a company to improve its performance (e.g. Caroli and van Reenen, 2001; Damanpour et al. 1989; Greenan, 2003; Piva and Vivarelli, 2002). For the measuring and monitoring of adoption and performance impact of organizational innovations it is therefore necessary to understand them on a conceptual level, as implementation of new and concrete organizational concepts.

Thus, we define organizational innovation as the use of new managerial and working concepts and practices (Damanpour, 1987; Damanpour and Evan, 1984). With this definition it is possible to measure not only whether companies have changed their organization (structure and processes) within a defined time period. Also analysis of adoption ratios of concrete organizational concepts in different companies and company types (sector, firm size, etc.) and the extent of use within the company can be provided. They serve as an indicator for the intrafirm diffusion of different organizational practices.

Yet, some attempts have been made to cluster and classify different types of organizational concepts under certain categories (e.g. Coriat, 2001; Wengel et al., 2000; Whittington et al., 1999). Based on these approaches, organizational innovation can be differentiated into *structural* organizational innovations and *procedural* organizational innovations.

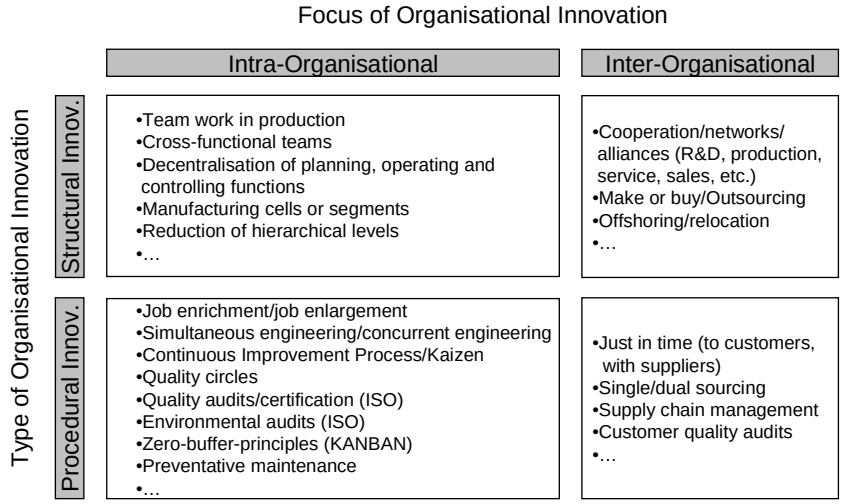
Structural organizational innovations influence, change and improve responsibilities, accountability, command lines and information flows as well as the number of hierarchical levels, the divisional structure of functions (research and development, production, human resources, financing etc.), or the separation between line and support functions. Such structural organizational innovations are for instance the implementation of (cross-functional) teams or the change from an organizational structure of functions (product development, production, human resources etc.) into one of product- or customer-oriented lines, segments, divisions or business units.

On the other hand, *procedural organizational innovations* affect the routines, processes and operations of a company. Thus, these innovations change or implement new procedures and processes within the company, such as simultaneous engineering or zero-buffer-rules.

They may influence the speed and flexibility of production (e.g. just-in-time concepts) or the quality of production (e.g. continuous improvement process, quality circles).

Organizational innovation can be further differentiated into an *intra-organizational* and *inter-organizational* dimension. While intra-organizational innovations occur within an organization or company, *inter-organizational innovations* include new organizational structures or procedures beyond a company's border. This comprises new organizational structures in an organization's environment, such as R&D cooperation with customers or other forms, just-in-time processes with suppliers or customers or supply chain management practices with suppliers.

Figure 2.1.1: An item-oriented typology of organizational innovations



Source: Fraunhofer ISI

Intra-organizational innovations may concern particular departments respectively functions or may effect the overall structure and strategy of the company as a whole. Examples for intra-organizational innovations are the implementation of team work, quality circles, continuous improvement processes or the certification of a company according to ISO 9000.

It is obvious that there is a vast variety of organizational innovations differing in terms of type and focus of these concepts. Based on the examples provided in figure 2.1.1 it becomes clear that the proposed categorization is of analytical nature. In reality, most

innovative organizational concepts address different aspects of business performance at the same time. They may contribute to several business strategies, requiring the use of specific performance indicators to analyze their impacts (see section 2.1.4.1).

2.1.3. Surveying organizational innovations

Hand in hand with the emerging awareness of the importance of organizational innovation for industrial competitiveness, several efforts have been made to include this topic in innovation surveys during the past ten years. In the following chapter some of these attempts will be presented. This overview aims to introduce the objectives and the different methodological approaches which were chosen to cover organizational innovation in large scale inquiries. Against this background some key questions for designing a monitoring and measurement concept of organizational innovations can be derived.

2.1.3.1. NUTEK Survey "Towards Flexible Organizations"

In the framework of the OECD study "Technological and Organizational Change and Labour Demand: Flexible Enterprises – Human Resource Implications" the Swedish National Board for Industrial and Technical Development (NUTEK) decided to analyze the situation in the Swedish economy in the mid 1990s. The aim of this study was to increase awareness towards the importance of modern work organization, so-called flexible work organizations, and to contribute to their diffusion throughout Swedish economy (NUTEK, 1996).

To provide the data for this study a survey was launched covering more than 700 establishments with at least 50 employees in Sweden. They included companies out of the NACE sections Mining and Manufacturing, Construction, Retail, Wholesale, Hotels and Restaurants, Transport and Communication and other business activities including finance and real estate. The survey was conducted in 1995 by sending a written questionnaire to "the executive in charge".

The survey questionnaire was divided into three main sections and collected information as follows. In the first part the questionnaire asked for a *description of the present organization* in

terms of staff and qualification, work organization, technology and product/service development as well as external relations. Within the subsection concerning work organization, the relative importance of continuous improvement, total quality management, ISO 9000, just-in-time and other concepts was to be evaluated as "not", "slightly" or "very important".

The second section had *organizational changes in the 1990's* as its topic, gathering information about important changes in the organization of the work place on a generic level without specifying any typology ("Has there been an important change of the organization of the work place during the 1990's" with possible responses "yes/is being implemented/no", for each of the five years 1990-1994. However, the survey went deeper into the subject when asking about the inspiration to implement the changes, computers as a contributory reason, lack of financial resources, influencing factors, employees affected, training and institutional support).

The last part of the survey aimed to gather data on *financial results for the year 1994* differentiating between revenues and expenditures, employee costs, fixed capital, and other related topics.

2.1.3.2. DRUID Project "DISCO"

Influenced by the NUTEK questionnaire, the **D**anish **R**esearch **U**nit for **I**ndustrial **D**ynamics (DRUID) developed its own survey within the Project **D**anish **I**nnovation **S**ystem in a **CO**mparative Perspective (DISCO), focusing mainly on flexibility understood as the ability of firm to react to a turbulent environment by developing new products and new technological processes on the basis of integrative organizational forms and a culture oriented towards renewal and learning (Lund, 1998). Technological innovations and human resources represent the pillar of this methodology.

The questionnaire, sent out in 1996, addressed Danish private enterprises with 10 and more employees within manufacturing, service and construction. 1 900 firms participated in this survey.

Regarding organizational innovations the survey wanted to know "Has the firm carried through important organizational changes during the period 1993-1995?" with affirmative and negative response possibility. With a further question "Has the firm extended its use of the following organizational traits during the period 1993-1995?" more detailed information was collected about delegation of responsibility, cross occupational working groups, quality circles, integration of functions, wages, job rotation and systems on how to collect proposals from employees (Lundvall and Kristensen, 1997). This design and phrasing of the questions enabled the DISCO survey to specify the share of the industry that changed specific organizational practices (e.g. delegating responsibility, implementing cross occupational working groups, installing quality circles).

2.1.3.3. EPOC Survey

At the same time as the DISCO survey, the EPOC inquiry was initiated as part of a project commissioned by the European Foundation for the Improvement of Living and Working Conditions (European Foundation, 1997). This project aimed to investigate direct **e**mployee **p**articipation in **o**rganizational **c**hange (EPOC). The EPOC survey was meant to provide empirical data on the extent of diffusion of direct employee participation in European economy.

In 1996 the EPOC questionnaire was sent out to enterprises in 10 European countries (DK, DE, FR, UK, IE, IT, NL, PT, ES and SW). 5 786 responding firms sent back a filled in questionnaire.

The survey focused on gathering information on the diffusion of main forms of participation. These main forms of participation are closely interlinked with specific organizational practices: individual consultation “face-to-face”, as a first form of direct participation, has its organizational background in the implementation of regular discussions between employee and manager. Individual consultation "at arm’s length", for example, refers to the organizational form of suggestion schemes. Group consultation with temporary groups signifies the introduction of project groups or task forces. Group consultations with permanent groups can be organizationally realized as quality circles. Group delegation organizationally means the implementation of team work.

The managers were to declare if they had put these forms of direct participation into practice or not. If so, they were to give information on how many years they had been utilizing them, which specific characteristics were involved, which reasons they had for introducing these practices and what consequences these concepts had on qualification and remuneration of employees. Additionally, the respondents were asked if they saw any impact of direct participation on cost reduction, reduction of throughput times, improvement of quality and other impact categories.

By the methodological approach summarized above the EPOC inquiry did not ask for the existence of different forms of work organization by using "labels", but concluded from asking for forms of direct participation to the existence of specific work organization concepts. On the other hand the survey did not ask for changes in the last years, but tried to get information about the existence of direct participation irrespectively to the year of realization.

2.1.3.4. The INNFORM survey

In 1997, as part of the so called "INNFORM project", another international survey dealing with organizational innovation was launched. The INNFORM project was funded by the Economic and Social Research Council in the UK and comprised research activities in Europe, Japan and the US (Whittington et al., 1999). The objective of the INNFORM project was to map the contours of contemporary organizational innovation, to examine the management practices and to test for the performance benefits of these changes. In order to tackle these issues the researchers developed a survey instrument, which was deployed in the UK and western European countries. About 500 firms participated in this survey.

The questionnaire addressed organizational and managerial innovation on three levels: unit, organizational and inter organizational level (Stoneman, 1999). The survey methodology was to serve as a standardized measuring instrument for all regions with no attempt of imposing a generally applicable methodology, even less in the actual landscape of theoretical diversity and empirical incompleteness (Pettigrew et al., 2003).

The survey includes a large number of questions exploring organizational innovations. These are split into several categories. First company structure is explored i.e. the number of senior managers reporting to the chief executive, the number of organizational levels between the manager with the lowest level of profit responsibility and the chief executive and the number of profit centers. Second, sub unit autonomy is addressed, i.e. the degree of discretion given to sub unit managers with regard to operating activities. Third, corporate controls are inquired i.e. the degree to which strategic decisions are in the responsibility of corporate HQ, the use of business performance indicators as targets and linkages between sub units and HQ. Fourth, systems in place are examined, in particular the extent to which the company has a common strategy for IT and its acquisition, user training, common IT systems and in house journals and newsletters. Finally human resource practices are looked at, especially, whether there has been any change in internal labor markets, managerial development events, mission building, team working, inter functional conferences and internal networks.

Against this background, in terms of methodology the survey is interesting for the following reasons: (i) Retrospective the questionnaire looks at the situation in 1992 and 1996 and thus can measure the existing organizational practice as well as organizational change. (ii) Contrary to the EPOC survey, the INNFORM questionnaire again asks for organizational innovations as particular labels and in this respect is similar to the NUTEK and DISCO inquiries.

2.1.3.5. Survey "Changements Organisationnels et l'Informatisation (COI)"

One year after the Europe-wide INNFORM survey a national inquiry was launched in France (Enquête sur les COI, 1998). This survey attempted to describe the changes that had occurred between 1994 and 1997 in work organization (company functional structure, devices to manage task and work time-sharing, relations with other firms) and the use of information technologies (equipment, organization of the computer function, data transfers). The survey was conducted by a consortium of French research units in collaboration with the Service des Statistiques Industrielles (SESSI).

The questionnaire was sent out by mail to a representative sample of industrial firms employing more than 20 people. In total more than 400 firms were questioned.

The questionnaire asked for details about computer use and firm organization in 1997, as well as about relating changes between 1994 and 1997. Organization related matters and topics linked to Information and Communication Technologies (ICT) were also part of the questionnaire. It further included questions like "Which of the following constraints affected your company with regard to organization and computerization between 1994 and 1997?", "Does your company use the following organizational systems" referring to certification, value analysis, profit centers and just-in-time just to mention a few. Another question read: "If the following problems curbed or handicapped the implementation of organizational changes between 1994 and 1997, how important were they?"

The methodological approach of this survey is characterized by an inquiry for ICT innovations in combination with organizational change. Most questions allow for a yes or no response, respectively ticking a box. When examining the use of certain concepts, an assessment of the change (+, =, -) in the share of employees affected since 1994 is required. Some questions give ranges in percentage of employees affected.

2.1.3.6. Community Innovation Survey – CIS

The Community Innovation Survey (CIS) is the main statistical instrument of the European Union that allows the monitoring of Europe's progress in the area of innovation (CORDIS). The methodological basis of CIS is provided by the Oslo Manual. Hence the definition of innovation comprises the development of new or significantly improved products, or the introduction of new or significantly improved processes within an enterprise.

For the first time a question was implemented in the CIS survey of 2001 (CIS III) that asked for innovative management techniques and new organizational structures. This "add-on" was to contribute to a better understanding of the "non-technological" aspects of innovation (EUROSTAT, 2005). The question was as follows: "Did your enterprise during the period 1998-2000 undertake any of the following activities: implementation of

advanced management techniques within your enterprise, implementation of new or significantly changed organizational structures. Possible answers for both aspects were "yes" or "no" (European Community, 2004).

The results collected by this question show great variations at cross country comparison. The share of enterprises which had implemented advanced management techniques during the period 1998-2000 ranged from 7 or 8 % (Denmark and Sweden) up to 31 % (UK and Austria), 36 % (Germany) and even 57 % (Luxemburg). The share of enterprises which had implemented changes in their organizational structures during the same time-frame were at minimum 7 % (France) and at maximum 49 % (Germany) respectively 57 % (Luxemburg) (EU Innovation Scoreboard, 2004).

In the CIS IV questionnaire (2004) the wording of the non-technical aspects of innovation was slightly changed. The question for innovative management concepts was as follows: "Did your enterprise during the three years 2002 – 2004 implement new or significantly improved management systems to better use or exchange information, knowledge and skills within your enterprise?" The organizational question reads as follows: "Did your enterprise during the three years 2002 – 2004 make a major change to the organization of work within your enterprise, such as changes in the management structure or integrating different departments or activities?" Additionally the questionnaire asked: "Did your enterprise during the three years 2002 – 2004 introduce new or significant changes in your relations with other firms, such as alliances, partnerships, outsourcing and sub-contracting?" These modifications intended to specify the questions by explanatory amendments and to give the innovations in inter-firm relations an independent role in the questionnaire. Yet, the results of the newly phrased questions are not available.

Summarizing, the CIS survey was basically designed to cover technical aspects of product and process innovation as defined by the Oslo Manual. Organizational and managerial innovations are an amendment being approached in general terms. This approach provides limited options for response and asks for change, not for the share of establishments that use an innovation.

2.1.3.7. Summary

To conclude: we presented these surveys in order to demonstrate how different the first attempts in monitoring organizational innovations by large scale surveys are. Main differences can be contoured in regard to four aspects:

- *Aggregation level*: organizational innovation is partially treated on a high level of aggregation (e.g. CIS), while other surveys go more in-depth gathering information on different concepts related to organizational innovation (e.g. NUTEK, DISKO, EPOC, INNFORM, COI).
- *Use or Change*: Methodologically, organizational innovation is partially treated as change process and partially as the result of the adoption. This means that surveys asking for the adoption of new organizational concepts allow for a classification of the respondents into adopters and non-adopters of specific concepts (e.g. EPOC, INNFORM, COI). Other surveys (e.g. NUTEK, DISKO, CIS) are asking for changes in a time period and can only distinguish between firms with and without change processes in the field of organizational innovation within the covered time-frame.
- *Use or extent of use*: Surveys asking for the adoption of organizational innovations can differentiate between adopters and non-adopters (e.g. INNFORM, EPOC). In case of adopters at times (COI) the share of affected employees is monitored additionally, which allows for controlling intra-firm diffusion.
- *Labels vs. features*: Inquiries in the field of organizational innovation can be designed by asking for their adoption using labels of new organizational concepts like team work or continuous improvement (e.g. NUTEK, DISKO, INNFORM, COI). In an alternative approach an inquiry can ask for the realization of specific features and then draw a conclusion to the existence of innovative concepts (e.g. EPOC). With this methodological concept the analysis does not depend on the judgment of the respondent and his understanding of a label.

In the following chapter we analyze the implications of measuring organizational innovation using the different concepts introduced above. Here we rely on data derived from a survey conducted in Germany that deals with organizational innovations and applies the methodological alternatives, as mentioned above, in parallel.

2.1.4. Challenges for measuring organizational innovation

Based on these four categories of different ways to measure organizational innovation, which have been outlined in the previous chapter, we now analyze how different indicators and ways of asking for organizational innovation lead to different conclusions concerning a company's organizational innovativeness. We compare the different approaches of measuring organizational innovation as utilized by the formerly described surveys by using the *German Manufacturing Survey 2003* which was conducted by the Fraunhofer Institute for Systems and Innovation Research (ISI). The objective of this questionnaire-based, mailed survey is to gather data on the implementation of innovative technical production concepts, on performance indicators, product innovations, service innovations, inter-firm cooperation, relocation of parts of the company, as well as general data on the company and data on the implementation of innovative organizational concepts, thus organizational innovations. In 2003, we asked 13,259 companies to fill in the questionnaire whereupon 1,450 companies returned a utilizable questionnaire, which makes a response rate of 11 percent. These companies constitute a representative sample of the investment goods industry, chemical industry and rubber and plastic industry. The survey was first launched in 1993 and is conducted every two years (Lay and Maloca, 2004).

2.1.4.1. Aggregation level: Complexity of organizational innovations

As previously illustrated, the term organizational innovation may include many different concepts of how to change traditional organizational structures. Organizational innovations can affect business processes (e.g. continuous improvement processes) as well as organizational structures (e.g. team work). Organizational innovations may occur in an enterprise itself (intra-organizational perspective, e.g. simultaneous engineering), but may also concern relationships to other companies (inter-organizational perspective, e.g. R&D cooperation).

The diversity of organizational innovations implies that they may be an element of many different business strategies:

- Implementing decentralized product- or customer-oriented organizational structures to replace traditional centralized tayloristic-type of organizational structures aims at improving companies' flexibility.
- Implementing quality circles, total quality management or continuous improvement processes contributes to improved quality.
- Implementing simultaneous engineering or cross-functional teams is to shorten the product development processes in the companies.
- Implementing concepts of just-in-time and supply chain management aims at increasing productivity by minimizing storage costs.

The various business strategies are fostered and triggered by different innovative organizational concepts. Therefore, an indicator that merely states whether a company has implemented organizational innovation or not while disregarding the kind of organizational innovation may only have limited explanatory effect. An overall indicator of organizational innovation may merge various business activities in the field of organizational innovation which are targeted towards different objectives like flexibility, productivity, etc. and thus might not be able to explain specific performance differences.

An analysis using such an overall indicator of organizational innovation supports this assumption. In a regression model which aimed to identify variables that had an influence on productivity an overall indicator of organizational innovation was introduced. This indicator was composed of 13 organizational concepts covered in the *German Manufacturing Survey 2003*. This index covered the implementation of team work, simultaneous engineering, continuous improvement processes, decentralization, quality circles, kanban and other innovative organizational practices in a similar way.

Apart from the overall index on organizational innovation, a multiple regression analysis (see Table 2.1.1) tested various other independent variables. The R^2 value indicates that the model explains 38 percent of the variance of the dependent variable "productivity".

Table 2.1.1: Results of a multiple regression analysis using a composite index for organizational innovation

	Productivity	
	Coeff.	t
Outsourcing ratio (1 – [turnover minus inputs per turnover])	-.274	-6.91***
Firm size (number of employees)	.008	0.18
East Germany (establishment located in East Germany, yes = 1 / no = 0)	-.309	-7.12***
Manufacture and assembling staff (staff occupied with manufacture or assembly as a share of all employees)	-.196	-3.86***
Index of IT application	.149	3.10**
Qualification of workforce (share of employees with university or college degrees, masters or technicians on all employees)	.131	2.59**
Rate of export	.097	2.03**
Share of turnover with new products	-.090	-2.14**
Degree of capacity utilization	.097	2,37**
Product quality (share of products re-worked or scrapped)	-.038	-0.95
Supplier to automotive sector (establishment predominantly supplies to automotive industry, yes = 1 / no = 0)	.029	0.66
Index of implementation of innovative organizational concepts	.038	0.83
Constant	1.958	23.42***
8 Sector dummies and production structure	yes	
Observations	417	
corr. R^2	.38	
F-test	13.360***	

*** Significance level <.001 ** Significance level <.05 * Significance level <.10.

The coefficient of the variable "index of implementation of innovative organizational concepts", however, was not statistically significant (coeff. .038). Thus, we can not conclude that there are significant differences in productivity based on the extent of implementation of organizational innovation in general represented in one index.

An in depth analysis with single organizational innovations instead of an overall indicator introduced in the regression model depicted a different picture: some organizational concepts proved to be significantly positively correlated showing a better performance in terms of productivity while others had no significant influence on the dependent variable. Table 2.1.2 gives an overview over the results.

Table 2.1.2: Results of 13 multiple regression analysis each with one organizational innovation (1-13) and control variables outsourcing ratio, firm size, East Germany, manufacturing and assembling staff, index of IT application, qualification of workforce, rate of export, share of turnover with new products, degree of capacity utilization, product quality and supplier to automotive sector (see Table 2.1.1)

	Productivity			
	Coeff.	Sign.	F-test	corr. R^2
1 Customer or product-line-oriented segmentation of central departments	.029	n.s.	14.164***	.054
2 Decentralization of planning, operating and controlling functions	.069	*	14.547***	.361
3 Balanced scorecard	.046	n.s.	14.094***	.363
4 Regular individual consultation	.069	*	14.454***	.358
5 Quality Circle	.048	n.s.	14.127***	.354
6 CIP Continuous Improvement Process	.050	n.s.	14.556***	.361
7 Quality management according to EFQM	.033	n.s.	13.854***	.360
8 Simultaneous Engineering	.018	n.s.	14.052***	.352
9 Cross-departmental temporary development teams	.023	n.s.	13.636***	.345
10 Segmentation of production	- .021	n.s.	14.190***	.352
11 Integration of tasks	- .016	n.s.	14.162***	.353
12 Internal zero-buffer-principle (kanban)	.071	*	14.834***	.365
13 Team work in production	.024	n.s.	14.046***	.350

*** Significance level <.001 ** Significance level <.05 * Significance level <.10.

These first results yet clearly point out the necessity to explore the impact of different organizational innovations on company performance separately. As assumed in the introduction to this chapter some organizational innovations might have an impact on performance in terms of flexibility, while others entail improved quality and others again account for better productivity.

In order to explain and perhaps to predict a superior performance in specific fields like flexibility, quality or productivity it is crucial to not only inquire whether companies implemented organizational concepts at all, but to ask which particular kind of organizational innovation was implemented. It is probable that the effects of overall organizational innovations concerning productivity, flexibility and quality on performance indicators overlap and indicate no significant impact on performance.

2.1.4.2. Use or change: Life-cycle of organizational innovations

As outlined previously, organizational innovations are changes to the structure and processes of enterprises that result from a new understanding of the adequate organization for the current market situation. In former times stable markets and homogenous customer demands required organizational structures that benefited from the advantages of specialization, labor division and centralization ("economies of scale"). However, this has changed. Turbulent and dynamic markets as well as heterogeneous customer demands together with greater market power of the customers require more flexible structures and less hierarchy levels in enterprises in order to promote more decision power in places where the relevant information is directly available.

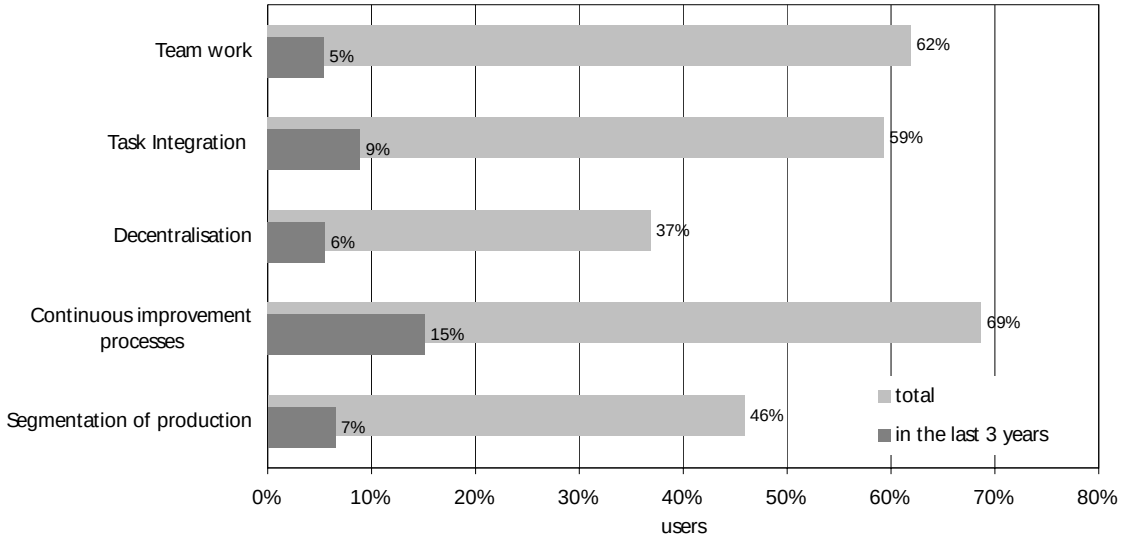
The implemented organizational innovations as a response on the changes in the organizational environment (particularly the market situation) give the companies the ability to increase their performance as long as the market situation does not change. This implies that organizational innovations, as opposed to products, are not subject to an aging process per se. For example, enterprises will gain advantages from concepts like total quality management, supply chain management or just-in-time for more than 3 years after their first implementation. The concept of the "innovative firm" is to be questioned with respect to organizational innovation. At least, other reference periods or "life-cycles" may be considered.

Therefore, in order to empirically measure organizational innovations, it seems necessary to apply a different approach than with measuring product innovations. Product innovations age because of the fast technological progress, therefore the return on these innovations is earned during the first three years after their introduction. In the case of organizational innovations, however, the fact of the innovation being implemented at all rather than the point of time when the innovation is introduced is important.

The following example illustrates this through a comparison between the implementation of organizational innovations in total versus the implementation of organizational innovations within the last three years. The data are taken from the *German Manufacturing Survey 2003* (see Figure 2.1.2). The survey showed that 42% of all firms implemented just-

in-time, 62% team work, 46% a product or customer-oriented organizational structure (segmentation of production) and 59% task integration.

Figure 2.1.2: Implementation of organizational concepts in total vs. within the last three years



Source: German Manufacturing Survey 2003, Fraunhofer ISI

Since the year of introduction of the particular organizational innovation was recorded as well, the results to the possible question "Have you implemented team work, task integration, decentralization, continuous improvement process, or product- or customer-oriented structures in the last three years?" can be reconstructed. This would have led to the following results:

- In the case of team work, 5% of all firms would have stated that they introduced this organizational innovation during the last three years. 57% of all firms that introduced team work would have been considered as not innovative even though they use team work, a concept still regarded as innovative. In a comparison between innovative and non-innovative enterprises, the previously named 5% where team work has been introduced in the last 3 years would have been compared to a group consisting of 57% that have used team work for a long time already and to a group of 38% without any implementation of team work so far.
- Considering task integration, 9% of all companies would have been regarded as innovative, although this innovation has actually been implemented by 59% of all companies.

- 6% of all firms would have introduced decentralization, even though already 39% of all firms have already launched this process
- Instead of 69% in reality, only 15% would have introduced continuous improvement process
- As to the introduction of product and customer-oriented structures (segmentation of production), with the 3-year-rule only 7% of the companies would have been registered in comparison to 39%

The percentages above illustrate that the group of non-innovative firms is not described correctly at all when asking for the innovations of the last three years. A comparison of the performance of firms characterized as innovative and non-innovative (based on the three years question) might expect the following: The group of non-innovative firms might perform better because of the high amount of enterprises that have already used the innovations on a long term (more than three years).

To conclude, when measuring organizational innovations, all firms that use organizational innovations have to be included in the set of innovative firms. This is only guaranteed when all firms that implemented organizational innovations at all are included. A limitation to the companies that introduced innovations in the last three years incorrectly characterizes the latecomers (who are the least innovative of the group of the innovative firms) as innovative.

2.1.4.3. Use or extent of use: Scope of organizational innovations

The extent to which innovation characterizes a company is crucial. When product innovations are offered on the market most of the innovation process and effort is accomplished. Insofar, there is no interim solution between market offering and non-offering. Therefore, to capture the proportion of innovative firms in regard to product innovations, it is appropriate to examine a firm on whether it has launched a product innovation on the market or not. Such a question will identify innovative firms and give hints for policy-makers. Nevertheless it has to be recognized that economic success is only achieved through significant sales.

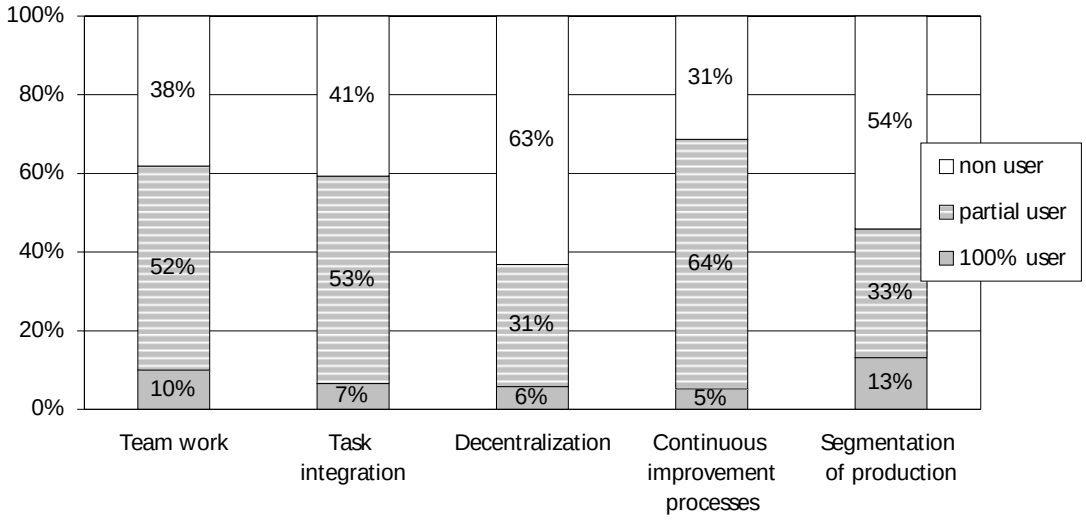
However, this is not valid in the case of organizational innovations. For example, if an organizational innovation is put into practice as a pilot project in a very small area of the enterprise, only a small part of the work is done and there might not be any impact on the performance of the business at all. Yet, if the organizational innovation is realized in highly relevant departments of the business, but an overall implementation is still missing, limited effects might occur. Ultimately, an organizational innovation can be implemented throughout all departments of the firm, so the impact on the performance of the business is maximal and no unutilized potential remains.

This shows that asking for the extent of use in a firm is crucial when investigating and measuring organizational innovation. Only with this knowledge it is possible to estimate the effects of organizational innovation and furthermore to quantify the unutilized potential for non-users and part-users of these organizational innovations.

The analysis of the *German Manufacturing Survey 2003* shows that only a small proportion of the companies that make use of a certain organizational innovation have fully implemented this organizational innovation in all business areas (see Figure 2.1.3):

- More than 60% of all firms claim to have implemented team work; however, only 10% say that they have fully exploited the potential of this organizational innovation.
- Task integration has been realized by more than 60%, but only 7% have implemented this innovation throughout the whole corporation.
- 37% of all enterprises use decentralization, yet only 6% indicate that they have completed the process of decentralization.
- Almost 70% of the companies stated that they use continuous improvement processes, but only 5% indicate that they have completely implemented this organizational concept.
- A total of 46% have begun with the segmentation of production, however just 13% state that the potential of this innovation has been fully exploited.

Figure 2.1.3: Diffusion of organizational innovations between "use" and "non-use"



Source: German Manufacturing Survey 2003, Fraunhofer ISI

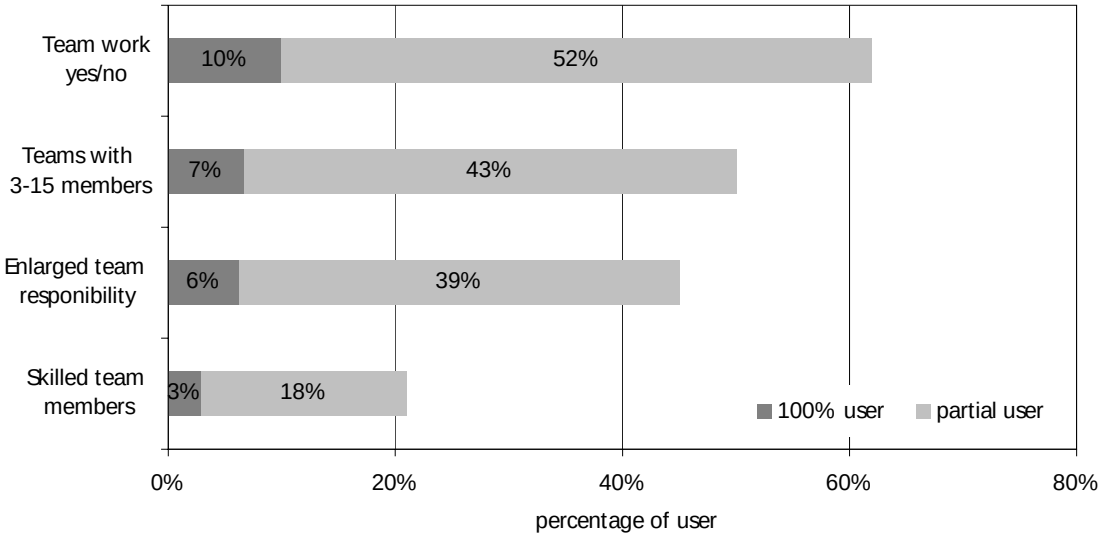
Considering a comparison between innovative and non-innovative firms where the extent of use of an organizational innovation is not regarded, it would be difficult to estimate the impact of this organizational innovation on performance indicators. As for instance, if the group of innovative firms contains a high percentage of businesses that have only partially implemented various organizational innovations without having increased their performance so far, this group of organizationally innovative firms will not stand out with a superior performance.

2.1.4.4. Labels or features: Quality of organizational innovation

Most organizational innovations are not linked to clearly defined measures for changing organizational structures and processes. They are rather basic concepts and their actual implementation depends on the company's management. Except for ISO 9000 (quality assurance) and ISO 14000 (environment protection), there are no standards for these organizational innovations.

Particularly when organizational innovations are very new and are yet not to be assessed as established concepts, companies tend to label their small realization efforts as a successful implementation of the organizational innovation. An example on team work which is integrated in the *German Manufacturing Survey 2003* (see Figure 2.1.4) proves this thesis.

Figure 2.1.4: Diffusion of 'team work'



Source: German Manufacturing Survey 2003, Fraunhofer ISI

62% of the firms answered with "yes" when asked if they had realized team work (10% are users with fully exploited potential and 52% partial users). This result suggests that team work is used by a relevant part of the economy. However, when asking if team work was realized with a team size of 3 to 15 members the share decreased to 50% (of which 43% are partial users). This indicates that 12% of the enterprises realize team work with a group size of 1 to 2 or more than 15 members which does not comply with the basic idea of team work and therefore will not lead to the positive effects that are intended.

When restricting team work to those models that have teams consisting of 3 to 15 members and that assign an enlarged responsibility to the team, the share drops to 45% (of which 39% are partial users). Moreover, when adding the requirement that all team members are qualified for all up-coming tasks within the team, only 21% of all firms comply with these requirements (of which 18% are partial users).

As depicted above, the measurement of organizational innovations by using no more than a term like "team work" will lead to results that are highly questionable. The quoted example, leads to the assumption that two thirds of all firms are profiting from all possible advantages of team work. In fact, this is only true for less than a quarter of the firms, since only this proportion has yet realized the concept of team work in a proper sense.

Moreover, the percentage of all firms that are utilizing the entire potential of team work in all parts of the business is only 3%.

This accentuates the need for additionally characterizing organizational innovations in such a way that –beyond the term - their characteristic features within companies can be recorded.

2.1.5. Implications, limitations and future research

Although the use of innovative organizational concepts is evidenced to have a positive impact on a company's competitiveness, research lags behind in defining and measuring organizational innovation. This work attempts to more deeply enlighten the definition and measurement of organizational innovations by providing a typology of organizational innovations and contrasting different approaches of measuring organizational innovations.

Comparing approaches of measuring organizational innovations in existing surveys by modeling these organizational innovation indicators in the *German Manufacturing Survey 2003* leads to four main implications for measuring organizational innovation:

- *Complexity of organizational innovation:* It is not sufficient to only ask for "organizational innovation" in general. It is necessary to enquire for different types of organizational innovations separately. This is important because different organizational innovations have different effects on performance indicators. An index based on the summation of various organizational innovations that neglects the different types of organizational innovation might have only limited explanatory power.
- *Life-cycle of organizational innovation*: It is not sufficient to simply ask whether organizational concepts have been changed over the past years. In contrast it is important to determine the proportion of firms that has generally implemented an organizational innovation at all. This is crucial because organizational innovations do not age as fast as product innovations do. Thus, applying the "three years question" incorrectly only classifies latecomers as innovative.
- *Extent of use of organizational innovations:* It is not sufficient to only ask for "use" or "non-use" of organizational innovations. It is, however, necessary to identify the

extent to which organizational innovations have been implemented into business processes. Only this additional information gives indication of the utilized and non-utilized potentials within the company. In order to generate viable estimations on the performance effects of organizational concepts, the extent of use of organizational innovations has to be taken into consideration.

- *Quality of organizational innovation:* It is not sufficient to only ask for labels of organizational innovations like "team work" or "task integration" as in every company organizational concepts are defined and shaped differently and answers of the respondents vary according to their own definition. It is crucial to know how terms like "team work" or "TQM" are used in the respective company. Merely using labels when inquiring about organizational innovations biases the diffusion of organizational innovations across companies.

Our analysis provides evidence that these four points should be taken into consideration when measuring organizational innovation in order to adequately survey companies' and countries' innovativeness as regards the adoption of organizational concepts.

However, there are several limitations to our findings. First, it is obvious that surveying complete definitions of organizational innovations instead of solely labels will increase the complexity of a questionnaire. To include items that monitor the different forms and definitions of organizational innovations within companies may sometimes hardly be realizable, depending on how many elements of organizational innovation are surveyed. Second, adding the extent of use of organizational innovations usually leads to sometimes rough assessments on the part of the respondents instead of gathering facts. But still these estimations allow a better understanding of the "internal adaptation" of an organizational innovation than just asking for "yes" or "no". Finally, the interpretation and presentation of the results that are based on a survey having included the above implications is rather complex and not straightforward. It is not recommended to score companies or countries according to one composite index indicating the most or least innovative in using innovative organizational concepts. On the contrary, with this type of analysis the innovativeness of companies or countries is rather based on a number of single organizational innovations and not on an index. We are aware that these results are more difficult to interpret, but are convinced that they are more useful than simply integrating all organizational innovations into one index. One possibility to display multi-task based

results for organizational innovations are multi-dimensional charts such as the spider graph (Grupp and Mogee, 2004).

This work is not devoted to design universally applicable, "one size fits all" methodologies, but simply to bring some light into the black box of measuring organizational innovation in large scale surveys. More research is needed in the field of theoretical conceptualization of organizational innovations when assuming that a better understanding of the compounding concepts will be helpful in order to develop an adequate monitoring system. For instance, it might be interesting to investigate the importance of organizational innovations across different industry sectors since we only discuss organizational innovations relevant for the manufacturing sector. These organizational innovations might be less relevant for other sectors. Further research is needed to resolve the question for which organizational innovations a common understanding across different companies is yet existent. An interesting task for research might also be to investigate the life-cycle of an organizational innovation. Getting insights into the question after what time of use an organizational innovation is more or less effective in terms of positively influencing performance indicators might help to develop future indicators. Research might tackle this issue by analyzing the influence of different organizational innovations on different performance indicators in longitudinal studies.

There is still plenty of research to do before organizational innovation surveys achieve the degree of homogeneity and standardization most R&D and technical innovation surveys possess. However, the need for constructing an organizational innovation monitoring system is becoming increasingly important as the first attempts of the European Commission to integrate indicators for organizational innovations in the European Innovation Scoreboard demonstrate.

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2.2. Teamwork in production – Implementation and its determinants. Estimates for German Manufacturing

2.2.1. Introduction

The introduction of new products and services, the design and application of new processes, the introduction of new organization and management techniques help companies in facing the challenges of nowadays "turbulent environment" (Lay and Mies, 1997), which due to its high complexity and low predictability is uneasy to characterize. This might be one of the possible reasons why different streams of literature and authors focus mainly on the study of the first mentioned concepts. However, it is not less certain, that techno-organizational innovations are complicated phenomena and their analysis is far from being completed.

Modern manufacturing practices and new production concepts tend to change the "tayloristic" way of working, as a result new forms of work organization and high performance work systems emerge. Following the taxonomy of Bolden et al. (1997) as a multidisciplinary overview of the field of modern manufacturing practices, we focus on the concept of "team-based work" including teamworking, cross functional teams and autonomous work groups, having its primary domain of application in work organization and workplace innovation with special emphasis on employee development.

In the beginning of the 90's, Womack et al. (1990) introduced the concept of lean-production in contrast to craft production and mass production arguing that "… *it is the dynamic work team that emerges as the heart of the lean factory. Building these efficient teams is not simple. First, workers need to be thought a wide variety of skills – in fact, all the jobs in their work group so that tasks can be rotated and workers can fill in for each other. Workers than need to acquire many additional skills: simple machine repair, quality checking, housekeeping and material-ordering. Then they need encouragement to think actively, indeed proactively, so they can devise solutions* …" (p. 99).

Although teamwork is a practice which can be implemented and employed at organization level, the present work focuses on "teamwork in production" defined here as a limited number of various persons, characterized by multi-skill, multi-task and rotation, having

different professional and organizational positions directly participating in making a good and/or service.

A resumed history of team and group working would show that even teams can be as old as mammoth hunting (Benders and van Hootegem, 1999) teamwork, as it is understood here, originates in Japan and had initially been implemented in automobile industry, for later – during the '70s and '80s-, expanding to other countries and sectors, generating patterns and models. They appear in response, modifying or rejecting, partially or completely, features of previous canons. Major differences are to be found in terms of nature of tasks, role of supervisors and main emphasis among traditional Taylorist-Fordist teams, Japanese - lean production teams and Kalmarian teams, the latter including semiautonomous workgroups characteristics to Sweden and Germany starting with the '70s (Durand, 1999).

Firms supporting Tayloristic systems of work are gradually being replaced by companies using an organizational style and structure designed to unlock skills, creativity and commitment of their employees (EC, 2002). Our data collects information about teamwork in production as well as other (23) work organization related practices grouped under the main headings: company structure and staff (6), construction/product development (2), quality/environment (6) and production (9) among manufacturing enterprises having more than 20 employees located in Germany.

The variety of contexts – other than production –, in which team and teamwork appears underlines the concept's versatility. In human resource management, teamwork is related to managerial activity in terms of hiring, training, compensation, evaluation, competences (Stevens and Campion, 1994; Morgeson et al., 2005), while the psychological approach focus mainly on analyzing individual and group personality, traits and characteristics. Proximity and positional angling describes intra enterprise, inter enterprises, inter industry, national and cross national ways of organizing and working in teams (Hoegl and Proserpio, 2004). Further on, the technical component on individual and group level is an important issue to be studied referring to education, skills and on and off-the-job training and experience. Finally, performance, productivity, cooperation, innovation, quality and efficiency are a central theme of the economico-strategic approach of teamwork.

Still, very little attention has been paid to the influential factors in the implementation and use of teamwork in production, going beyond than reporting the results of descriptive analysis or anecdotal evidence. Referring to workplace transformation, Osterman (1994) stated that "systematic studies of the determinants of adoption are extremely sparse. That is, there is little or no research that takes work organization as the dependent variable and tests hypothesis found in the literature". More recently, Benders et al. (2001) pointed out that "the discussion about the incidence of group work can be aptly summarized as: much speculation, little data".

Therefore - while working on an aggregate level wouldn't be appropriate treating work organization as a whole-, the aim is narrowed and focused exclusively to find the determinants of teamwork implementation in production. Although information on various practices is available, the attention is centered to teamwork because of its predominant presence in studies focusing on high performance work organizations, flexible work organizations (Osterman, 2000; Gittleman et al., 1998; NUTEK, 1996), firms using employee involvement programs and/or new, modern, innovative manufacturing practices (Mohrman and Lawler, 1996; Lay et al., 1999).

Consequently, getting a better understanding of what factors might be driving the diffusion of teamwork could be an important step forward in designing promotion and dissemination policies while their benefits and impacts are recognized and most often related to increased quality, productivity and employee satisfaction.

In this context, rather than analyzing teamwork's effects on outputs, it seems more appropriate to take a step back and find answers to three main research questions concerning teamwork in production:

- What are teamwork's adoption and diffusion rates and how these vary among German enterprises? (RQ1)
- What other characteristics of teamwork are detected and how they vary among German enterprises? (RQ2)
- What differentiate firms implementing teamwork in their manufacturing processes of those who don't? (RQ3)

To accomplish this, the formulation of hypothesis is based on two main thematic groups of literature. First, previous studies dealing with adoption and diffusion of new forms of work organization and modern manufacturing practices, including teamwork are mentioned. Second, high variety of research including the study of certain sectors –automotive, electronic, chemical- in different countries like Germany, USA, France and Scandinavia that show evidences of teamwork implementation is referred.

Management and organization literature is abundant in explaining the determinants of innovations, mostly synonymous with technological innovation, well-established and commonly-used models (see Souitari's, 2002 portfolio model of determinants), surveys (for example, the Community Innovation Survey), manuals and guidelines (Oslo and Frascati), measures and variables predominating. For example, R&D -in terms of effort, intensity, department, personnel- or an innovation budget aimed to transform knowledge into industry and market solutions, tax deductions and promotion policies have no direct correspondent when it comes to work organization and implementation of modern manufacturing practices. Those interested in the latter are faced with "high cost of holding surveys … but also with difficulties in operationalizing an immaterial phenomenon such as group work" (Benders et al., 2001).

At survey level, latest tendencies materialize in the inclusion of organizational aspects into initially technologically oriented studies aimed to monitor innovation. While this might not be the optimal path to follow, independent research organizations and institutions conduct their own analysis, some of which are presented in the followings.

2.2.2. Searching for the determinants of "teamwork" in production

For the present study, relevant literature concerning production models as well as writings about new forms of work organization, modern manufacturing practices and/or high performance working systems, including teamwork, in terms of determinants of implementation and diffusion is overviewed. But first, some methodological aspects should be clarified.

The 'team discussion' as labeled by Benders and Van Hootegem (1999) is often based on dichotomies between 'Japanese', 'lean' or 'just-in-time' teams, on the one hand, and 'Swedish', 'German', 'sociotechnical' or 'autonomous' teams, on the other hand. As showed by the authors, even both streams are part of a more general category of work organization, a variety of definitions and characteristics are differentiated. While finding an objective definition might be a 'mission impossible', in words of the same authors, we proceed by using our own definition – presented in the previous section, which is in conformity with the German *gruppenarbeit* or in the line of the sociotechnical approach of teams.

Autonomous work groups, teams, appear as means to achieve the objectives of the post-Taylorian enterprise, identified by Peaucelle (2000) as productivity (efficiency), flexibility, deadlines (timeliness), quality and variety (diversity) seen as add-ons to the objectives of the Taylorian enterprise more oriented to productivity, mass production and growth. It is argued that complex and multiform realities coexist and some elements of Fordism/Taylorism continue to exist in today's Toyotism/Post-Taylorism. Some of these post-Taylorian characteristics of the enterprise will serve to show how teamwork implementation varies across organizations.

However, as our concern here is limited to the determinants of teamwork in production, we bring more detailed evidences of previous studies and while they differ in terms of main thematic framework, industrial sector, geographical coverage and other methodological aspects, the preference is no to use any classification criteria generating dichotomies (for example, automotive and non-automotive studies), but to present relevant and thematically close already published writings. Before doing so, a short note is appropriate to be made: some publications are results of research projects conducted in a certain country and writings in original language are more abundant than English version generated articles. This might be a grounded reason of not being among the cited ones.

While in the beginning of the '90s Osterman (1994) stated that little systematic work has been done in the line of the determinants of adoption of innovative work practices, including teams, passing of a decade and increased interest in the issues brought some results in this line. Still, they are far from being systematical. The results of his investigation show that international competition, high skill technology, worker-oriented values, high road strategy and being part of a larger organization are variables positively associated with

the adoption of flexible work practices. In terms of diffusion, a repeated survey (Osterman, 2000) shows that a longitudinal study can bring evidences of diffusion evolution, the author bringing a series of studies done to determine what fraction of American firms had adopted them.

Still in America, Gittleman et al. (1998), using the 1993 Survey of Employer Provided Training, find a positive relationship between establishment characteristics such as introduction of new technology, large size, manufacturing as primary activity, incentive-based compensation, provision of generous benefits and the use of extensive training, on the one hand, and the adoption of alternative work organization practices (including worker teams), on the other hand.

Moving further, J. Benders' and collaborators' contribution to the study of teams and teamwork is relevant in both theoretical and empirical fields. Following a chronological criteria, Benders and van Hootegem (1999) move the team discussion beyond existing dichotomies coming from previous authors and propose an analytical framework including a combination of clusters of variables referred as job and organization design, task environment and national environment. Then, Benders and van Bijsterveld (2000) include and study lean production in Germany as part of recent management fashion. They show how the meaning of team-based work, one of the two dominant reorganization measures, was shaped and reshaped. After having the methodological basis set, Benders et al. (2001) publish findings relative to group work's incidents in 10 European countries using the EPOC – Employee direct Participation in Organizational Change- survey data. A further analysis (EPOC Research Group, 1997) reveals that the main motives of introducing direct participation, of which group consultation being part, are mostly related to both productivity and quality of working life, followed by examples elsewhere in the organization or other organizations, demand from employees and the requirements of legislation or collective agreements (p. 83).

Flexibility focused study, NUTEK (1996), investigates modern work organizations and looks for the effect of certain independent variables on the probability that a major organizational change occurred after 1990. Only some of the tested factors proved important; it is showed that there is a greater probability that change will occur in bigger size work places, participating in R&D activities, being part of a larger organization, while

education, incentives coming from in- or outside the company and location in a larger region act as a bridge in generating flexible (as opposed to traditional) work organizations.

Although the conventional wisdom that teamwork improves productivity, Fuxman's (1999a, 1999b) results rather defend that different typologies of teamwork, Sequential Task Sharing team model characteristic to Japanese team culture and Simultaneous Task Sharing team model typical for Scandinavian team based production systems, both can lead to positive or negative effects on productivity in an asynchronous assembly line. More than a description of the models including origins, characteristics, reasons to implement as well as critics received by each, it is important to highlight that "despite the ongoing disagreements between researchers advocating either model, one of the most significant implications of the movement toward team building in manufacturing is the realization that as technological innovations occur, so must innovation in human resource organization".

This is a grounded reason to consider some of the determinants of technological innovations when looking for the determinants of teamwork in production. One can easily imagine that if complementarities or simultaneity between organizational and technological innovation occur, the determinants of one can have effects on the other. The same author (Fuxman, 1999a) argues that successful implementation of any team based manufacturing system must be supplemented by changes in production philosophy, intense training programs and enhanced labor management relations.

The same link between "manufacturing" production and "human centered" techniques of production is argued by Wallace (2004) in the editorial of a special issue of the International Journal of Operations and Production Management attempting to understand the relationship between the technical organization of assembly production and the development of the Swedish model of work organization and team development. Although using the example of different Volvo plants of the Volvo production system, he argues that similarities with Mercedes, Scania or wider patterns in the automotive industry would be found. This is due to the trend that a core set of common practices is complemented with national, regional or local "culture" add-on practices.

In the same line with the Swedish model, the German team concept or *gruppenarbeit* can be found in works describing, first of all, the automotive and related industries (Springer, 1999; Murakami, 1999, 2001; Mueller, 2001; Wergin, 2003), production environments (Lay et al., 1999), learning environments (Lane, 2001), structures of work (Schumann et al., 1991) or management fashions (Benders and van Bijsterveld, 2000).

2.2.3. Constructs and hypothesis

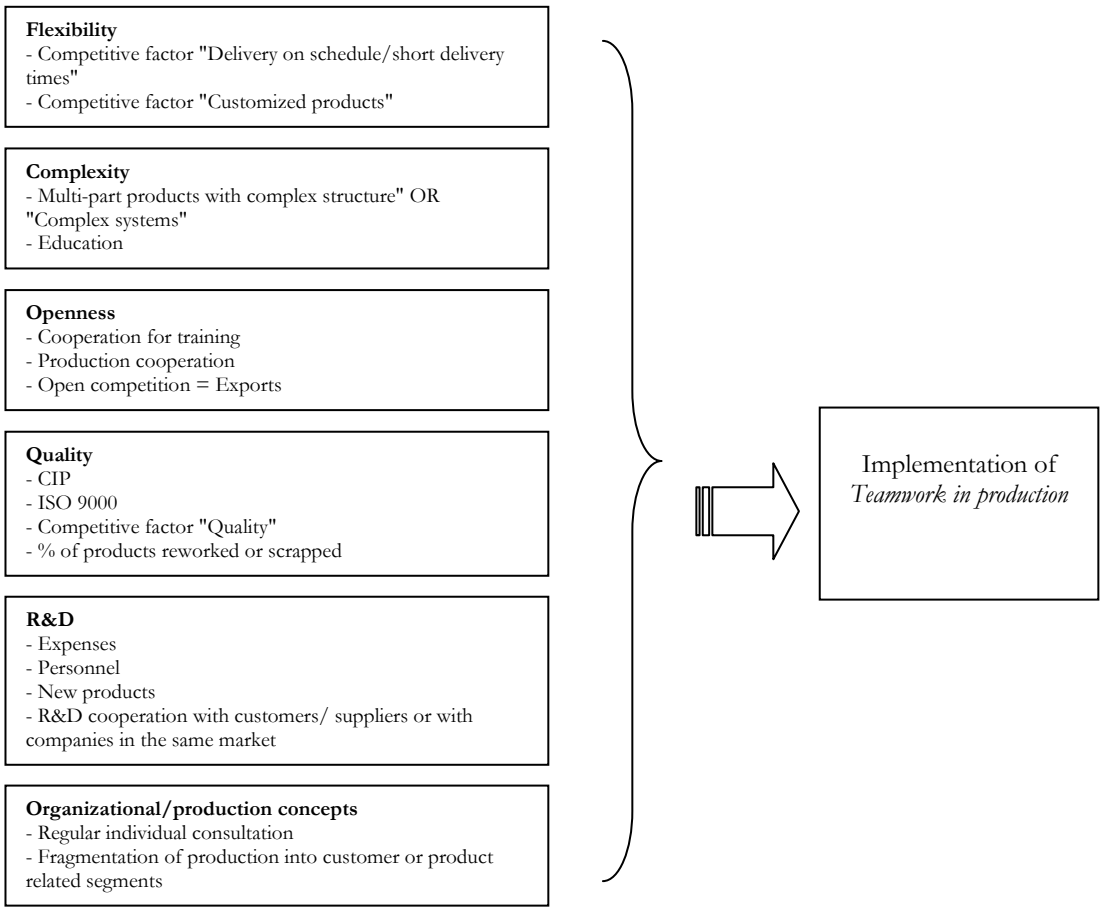
From the previously reviewed literature we build up our model and propose as determinants of teamwork implementation: flexibility, complexity, openness, quality, R&D and company related features which will be further detailed. The relationship between these factors and the implementation of teamwork in production is depicted in Figure 2.2.1.

Teamwork in production

In spite of the little consensus on the topic and definition of teamwork, in this research the concept of *teamwork implementation in production* refers to a limited number of various persons, characterized by multi-skill, multi-task and rotation, having different professional and organizational positions directly participating in making a good and/or service. It strictly refers to implementation, use and/or adoption meaning that it captures whether firms actually introduced it or not. Other elements, like coverage meaning for example the percentage of production employees involved in teams or potential use are not considered when modeling the determinants. The reason underlying this decision is mainly determined by the fact that determinants could be different when tackling the question of adoption degree and implementation.

Authors like Fuxman (1999) state that "successful implementation of any team based manufacturing system must be supplemented by changes in production philosophy, intensive training programs and enhanced labour management systems", apparently and most frequently the topic of teamwork is related first of all to implementation. Still, we agree with Benders et al. (2001) for example who bring valuable examples of different degrees in incidence of group-based workplace.

Figure 2.2.1: A conceptual framework



In the meantime, the search for possible determinants of implementation, identified first the determinants in a framework dominated by technological innovations, because as stated in Fuxman "one of the more significant implications of the movement toward team building in manufacturing is the realization that technological innovations occur, so must innovations in human resource organization". Based on this, one can easily imagine that some determinants of organizational innovations, teamwork in this case, might coincide with determinants of technological innovations. Therefore, in the followings both "organizational determinants" and "technological determinants" are considered.

Flexibility

The term 'flexible organization' is often found in Scandinavian contexts, although is generally understood, accepted and used starting with the end of the 1990s. As discussed in the beginning of the NUTEK (1996) report, flexibility "is a must" in the actual business environment and the rapid response to the continuous change in consumer's demands and

market conditions is one of the great challenges. The following hypothesis captures this idea:

Hypothesis 1: flexibility is positively associated with teamwork implementation/use.

Complexity

Cars, for example, can easily be considered complex systems as they combine a high number of finished goods coming from a variety of manufacturing sectors. As described in Gorgeau and Mathieu (2005) the concept of "autonomous production units" was used firstly by some automobile manufacturers, particularly Volkswagen as early as the 1970s. Fuxman (1999) accordingly to McClelland's Goal Setting Theory sustains that difficult goals are more likely to produce satisfaction than easy ones, employee participation in goal settings and achievement being one of the motivations related to team concepts. The 'variety war' of the 1990s forces planification departments to come up with a variety of new products and short-term plans fit the reality better than long time horizons. Rogers (2005) when describing the independent variables of innovativeness, defines complexity as the degree to which an organization's members possess a relatively high level of knowledge and expertise. Accordingly we formulate the next hypothesis:

Hypothesis 2: Complexity is positively associated with teamwork implementation/use.

Openness

Often cooperation, in terms of number of formalized contracts and typology of partners, is used as a measure of organizations extending their boundaries, seeking in their near up conceptually opposite or complementary fields possible partners in order to obtain benefits or compensate capacity.

Open competition is present in the case of selling product outside the country. As stated by the authors of NUTEK report (1997) competition is assumed to encourage change towards a more flexible organization and workplaces competing in international markets have to adjust and respond quickly to new conditions and market demands. Following this reasoning, we offer the next hypothesis:

Hypothesis 3: Openness is positively related to teamwork implementation/use.

Quality

Contexts in which quality and workplace innovation appear together are frequent. As argued by Fuxman (1999) quality, together with productivity and product variety are important to the team concept in manufacturing. Continuous Improvement Process, quality certification and audits are systems which suppose the implication of high number and degree of employee involvement/participation. That is the reason to expect, that:

Hypothesis 4: Quality related concepts are positively associated with teamwork implementation/use.

R&D

There is little doubt on R&D as a determinant of technological innovations and when it comes to new forms of work organization two opposite considerations arise. Still, the next mentioned are predominant and evidence supported. NUTEK (1996) study found R&D significantly and positively related to flexibility; we would rather be inclined to believe that efficient R&D needing various and quality inputs the use of teams is more probable in research activities. Although the EC (2002) in its study analyzing the obstacles of wider diffusion of new forms of work organization, argues that organizations having competitive strategies strongly oriented to innovation and technology, having high investment rates in R&D might decide that NFWO are not essential or appropriate for their success.

The actual panorama of rapid pace and continuous change in customer needs force sentrepreneurs to fasten development cycles, widen the product range, add value to existing products and services as part of a strategy aimed to improve their innovative capacity (EC, 1999). Anyway, based on previous research we expect that:

Hypothesis 5: R&D has a positive effect on teamwork implementation/use.

Organizational concepts

Often teamwork applies in settings that are characterized by more than one organizational concept. Companies can opt for a variety of organizational concepts depending on their objectives. These can include, for example, the fragmentation of production into customer or product related segments, internal zero buffer principles, just-in-time or regular individual consultation, decentralization of planning, integration of task, among others.

Some of these are more related conceptually and at operative level to teams, therefore we expect that:

Hypothesis 6: Organizational concepts are positively related to teamwork implementation/use.

2.2.4. Research methodology

2.2.4.1. The sample and data collection

The data for this study comes from the European Manufacturing Innovation Survey – EMIS 2003 edition. Conducted on a two-yearly basis by the Fraunhofer Institute for Systems and Innovation Research, the survey collects detailed information on innovations in manufacturing.

Even though the data presented here are part of a more complete dataset –including 8 countries-, the option of reducing the sample to the sub-sample of Germany is based on the repetitiveness, continuity and experience in conducting the survey in this country.

Although by its initial year (1993) the survey was conducted only in Germany, after more than a decade the still ongoing geographical extension is reflected by the participation of ten other European countries, including Austria, Switzerland, Italy, France, Turkey, Slovenia, Croatia, UK, Spain and Greece. Participant enterprises belong to manufacturing sectors and have more than 20 employees.

Thematically, the questionnaire includes eight main areas of interest concerning strategy, modernization of production, production techniques, organization of production, qualification and education, outsourcing and globalization of production, cooperation, indicators and other enterprise related data (Lay and Maloca, 2004).

One could easily argue that similar surveys are available and conducted on international level, while we argue that a holistic approach of innovation, complexity and flexibility are main differentiators.

Firstly, innovation is argued to be more than new products or new processes, questions related to organizational aspects, information and production related technologies being part of the same questionnaire.

Secondly, as a particular advantage of the complex questionnaire used, information is asked not only on a yes/no basis, but more detailed answers are possible. For example, when tackling the issue of information technologies, different technologies are mentioned on a non aggregated level, with possible answers on their implementation or not. Additional data -like year of first use or an estimation of used potential, as well as reasons and motives of non-use -, is collected for both cases.

Finally, flexibility is understood in the present context as a tool in order to fill in a gap on a certain research question or theme important or actual in a limited geographical area. Country-specific additional questions, added to the core questionnaire, permit collecting this kind of information.

A total of 1.450 observations correspond to our German database meaning an 11% response rate. This response rate is in line with other similar surveys having a voluntary character (CIS 2003 response rate is 21% for Germany).

As showed in Table 2.2.1, the sample is stratified in such way as to represent the population of manufacturing firms by size, sector and by state of the federation or *bundesland*. Minor deviations appear in the case of establishments having less than 50 employees, being underrepresented in the sample, and on the contrary bigger size enterprises being lightly overrepresented.

Table 2.2.1: Relative distribution of sample and population firms

	Population of firms		Sample	
	N	%	n	%
Economic activity				
Manufacture of chemicals and chemical products (24)	1771	6,7%	148	10,2 %
Manufacture of rubber and plastic products (25)	3093	11,7%	145	10,0 %
Manufacture of fabricated metal products, except machinery and equipment (28)	7348	27,7%	339	23,4 %
Manufacture of machinery and equipment n.e.c. (29)	6991	26,4%	409	28,2 %
Manufacture of office machinery and computers (30)	199	0,8%	13	0,9 %
Manufacture of electrical machinery and apparatus n.e.c. (31)	2466	9,3%	117	8,1 %
Manufacture of radio, television and communication equipment and apparatus (32)	760	2,9%	52	3,6 %
Manufacture of medical, precision and optical instruments, watches and clocks (33)	2234	8,4%	152	10,5 %
Manufacture of motor vehicles, trailers and semi-trailers (34)	1226	4,6%	54	3,7 %
Manufacture of other transport equipment (35)	424	1,6%	21	1,4 %
Size classes – number of employees				
up to 49	13582	49,1 %	519	35,8%
50-99	6289	22,7 %	301	20,8%
100-199	3780	13,7 %	247	17,0%
200-299	1439	5,2 %	103	7,1%
300-499	1210	4,4 %	120	8,3%
500-999	817	3,0 %	78	5,4%
1000 and more	537	1,9 %	82	5,7%
Region				
Baden-Württemberg	5319	20,1%	327	22,6%
Free State of Bavaria	3854	14,6%	229	15,8%
Berlin	521	2,0%	25	1,7%
Brandenburg	571	2,2%	33	2,3%
Free Hanseatic City of Bremen	130	0,5%	8	0,6%
Free and Hanseatic City of Hamburg	286	1,1%	21	1,4%
Hesse	1809	6,8%	93	6,4%
Mecklenburg-Western Pomerania	298	1,1%	16	1,1%
Lower Saxony	1959	7,4%	104	7,2%
North Rhine-Westphalia	6163	23,3%	300	20,7%
Rhineland-Palatinate	1245	4,7%	52	3,6%
Saarland	290	1,1%	10	0,7%
Free State of Saxony	1530	5,8%	99	6,8%
Saxony-Anhalt	748	2,8%	49	3,4%
Schleswig-Holstein	734	2,8%	25	1,7%
Free State of Thuringia	996	3,8%	58	4,0%

Source: Lay and Maloca (2004)

Although the almost one and a half thousand responses, we base our analysis and show results for the product-based core industries, process oriented sector like manufacture of chemicals and chemical products (24) are left out for comparability reasons. Core industries, in general, are those that make significant contributions to the economy[1]. In our specific case, we consider core manufacturing sectors those that sum up more than 50% of all manufacturing establishments.

This results in 1298 usable questionnaires corresponding to producers of rubber and plastic products (NACE 25), metal products (NACE 28), machinery and equipment (NACE 29), electrical and optical equipment (NACE 30 to 33), producers of motor vehicles, trailers and semi-trailers (NACE 34) and other transport equipment (NACE 35). 30 establishments out of these did not provide information relative to teamwork in production. Consequently our final sample consists in 1268 valid responses.

2.2.4.2. Variables and measurement

Dependent variable

We base our analysis on "teamwork" as the dependent variable in order to find hints of what might be some of the influencing factors or conditions when implementing or not such organizational technique. Dichotomous in nature, it takes value 1 when teamwork is implemented/used and 0 otherwise.

Although we dispose of additional information on the use of teamwork in production, as the main purpose of the present work is strictly related to implementation, we do not focus our attention and do not work with other measures or typologies of variables as it could be ratio of staff working in teams or the number of employees forming typically a team. These examples could describe or help us understanding the depth of teamwork implementation or other qualitative aspects, complementary to the one we study.

[1] Core industries may be defined as having:

- a large share of manufacturing value added
- the potential to increase exports or displace imports of manufactured products
- strong linkages with intermediate goods producers, for example, larger anchor firms that use manufactured outputs from smaller suppliers

(source: The Georgia Tech Policy Project on Industrial Modernization by Jan Youtie, Philip Shapira and J. David Roessner http://www.cherry.gatech.edu/mod/pubs/aspen/app2.html)

Independent variables

Flexibility (H1) is measured by variables that capture the ranking of 6 competitive factors for companies. These factors include price, quality, innovation/technology, delivery on schedule/short delivery times, customized products and services. When delivery on schedule/short delivery times, **deliv**, is the first best ranked competitive factor, complexity takes the value of 1 and 0 otherwise. An enterprise getting competitive advantage from its customized products is supposed to have an increased flexibility in order to be able to respond to customers' needs. Therefore, when customized products is the best ranked factor among the six items, the variable **custom** turns 1 and 0 otherwise.

Complexity (H2). There are two proxies for the concept of complexity. On the one hand side, a variable for product complexity is used. It can take the values of one-piece products, multi-part products with simple structure, multi-part products with complex structure and complex systems. Out of these **pcomplex** takes the value of 1 when in the case of multi-part products with complex structure or complex systems. Still, complexity is not just a matter of products or processes. On the other hand side, complexity can be a characteristic of circumstances or situations; therefore, the variable **edu** captures the sum of all employees having any type of education or training (university graduates, graduates of technical collages, technicians/masters, employees with commercial or technical/industrial training, commercial or industrial trainees) as compared to semiskilled and unskilled workers.

Openness (H3) is a characteristic of firms in terms of international markets they target or their willingness to cooperate. Two types of cooperation are distinguished: cooperation for (vocational) training **coopedu** and production cooperation (for capacity compensation) **coopprod**. They take the value 1 if firms engaged in such activities and 0 otherwise. International openness is captures by the share of sales to Europe and abroad exceeding sales targeting the region or the country of the firm (1 for true, 0 otherwise).

Quality (H4). The rich dataset permits different approaches and proxies for the quality concept. Therefore, 4 variables are computed. The variable **cip** turns 1 when the firm implemented the technique of continuous improvement process, the same happening for **iso** when the company has the certification ISO 9000:2000. Back to competitive factors,

when companies ranking quality as their competitive advantage the variable quality turns 1, otherwise 0. Finally, **scrap** captures the share of product or semi-finished goods that due to quality control have to be reworked ore are scrapped.

R&D (H5). Conventional measures for R&D are used on modeling the determinants of teamwork implementation in production. Share of R&D expenditure in turnover (**rdexp**), percentage distribution of the company staff exclusively dedicated to R&D/design (**rdpers**). These are "classics" for capturing R&D inputs. For the possible case of R&D outputs, **nprod**, represents the case if companies integrated new products or products with significant technical improvements into the production, for example application of new materials or changes in product functions (1 if this was the case, 0 otherwise). Internal R&D activities can be most often complemented with external R&D, therefore R&D cooperation –**rdcoop**- with customers/suppliers or with companies in the same market is the proxy for capturing such activities (1 if true, 0 otherwise).

Organizational/production concepts (H6) are part of conceptual delimitation concerning different areas of interest such as organizational concepts related to company structure/staff, construction/product development, quality/environment and production related organizational concepts. Out of these we believe that regular individual consultation (**indiv**) and the fragmentation of production into customer or product oriented segments (**frag**) can act as determinants of teamwork. Each takes the value of 1 when companies implemented them and 0 otherwise.

Size and sector. Based on previous studies dedicating efforts in searching for the characteristics influencing the adoption of alternative workplace practices (Gittleman et al., 1998; Osterman, 1994) like TQM, quality circles, worker teams among others, it's stated that there is no clear direction of the relationship between these practices and size. Arguments for higher adoption rates exist in the case of both large firms and smaller establishment. In the meantime, some industries are more likely to influence the implementation of teamwork. In this matter factors relative to the good produced are likely to determine differences in adoption.

Model specification

Implementing teamwork in production was measured by a binary variable. It takes the value of 1 when respondent firms implemented teamwork in production and 0 otherwise. To identify the determinants explaining the likelihood of implementing teamwork in production, the basic model is:

$$\text{Log}\,(P_i/1\text{-}P_i) = ß_0 + ß_1\text{deliv} + ß_2\text{custom} + ß_3\text{pcomplex} + ß_4\text{edu} + ß_5\text{coopedu} + ß_6\text{coopprod} + ß_7\text{cip} + ß_8\text{iso} + ß_9\text{scrap} + ß_{10}\text{rdexp} + ß_{11}\text{rdpers} + ß_{12}\text{nprod} + ß_{13}\text{rdcoop} + ß_{14}\text{indiv} + ß_{15}\text{frag}$$

where,

$ß_i$ ($i = 0 \ldots 15$) are the coefficients

$\text{Log}\,(P_i/1\text{-}P_i)$ is the logarithm of the ratio of the probability that firm i has implemented teamwork in production to the probability that the same firm has not.

2.2.5. Findings and discussion

2.2.5.1. Descriptive statistics

This section has the aim of responding to the questions relative to teamwork adoption and implementation giving answers to our first research question (RQ1). In the meantime, we believe that showing exclusively the results collected through a question giving affirmative and negative response possibilities would represent only partial or incomplete information about the concept.

Therefore in order to have a better understanding on how spread in this work organization technique among German manufacturing enterprises, we present some other characteristics and feature relative to teamwork implementation in production, being the answer to our second research question (RQ2).

Table 2.2.2 shows how common teamwork in production is for establishments having more than 20 employees. In general, almost two out of three enterprises (62,9%) of our

sample use teams in their production process (including process engineering, production, assembly or quality control). These figures are sensitively higher than those found in Gittleman's et al. (1998), who show that 14,2% of all establishments and 32% of those having more than 50 employees use worker teams. Osterman (1994) using a sample of US manufacturing establishments and data from 1992 found that teams were used in 50,1% at any percent level of penetration in manufacturing, and 54,5% in all establishments, the practice of self-directed teams being surprisingly widespread. European study (Benders et al., 2000; 2001) including Germany among UK, Denmark, Italy, Spain, etc. shows highest figures of group delegation for Sweden, ranking Germany on the fourth place with 26% of workplaces implementing practice.

Table 2.2.2: Distribution of teamwork in production by economic sector and size

	Use of teamwork in production					
	Number of firms			Percentage distribution (%)		
	No	Yes	Total	No	Yes	Total
Economic activity						
Rubber and plastic products	56	86	142	39,4	60,6	100
Finished metal products	132	197	329	40,1	59,9	100
Machinery	135	259	394	34,3	65,7	100
Electric/electronic products	126	204	330	38,2	61,8	100
Motor vehicles, parts / other transport	23	50	73	31,5	68,5	100
Size classes – employees						
Up to 99	297	423	720	41,3	58,8	100
100 to 249	91	177	268	34,0	66,0	100
250 and more	84	196	280	30,0	70,0	100
Total	472	796	1268	37,2	62,8	100

Some methodological considerations are behind the question referring to the year of introduction or first year of use. Previously reviewed surveys (CIS, EPOC) most often formulate "Did your enterprise during the last three years introduce …". In some cases, referring to both technologies and organizational concepts, having historical past, respondents could be confused and might answer 'no' while they did not introduced the technique during the asked period, even though they make use of it and have previously implemented it. In our view, opting for asking the concrete year of introduction is one way of avoiding confusion and reducing the bias.

Table 2.2.3: Teamwork in production – year of introduction

	Teamwork's first year of use in production			
	Min	Max	Mean	SD
Economic activity				
Rubber and plastic products	1970	2003	1994	7,89
Finished metal products	1950	2003	1992	10,34
Machinery	1950	2003	1992	9,51
Electric/electronic products	1950	2003	1994	6,67
Motor vehicles, parts / other transport	1973	2003	1995	7,20
Size classes – employees				
up to 99	1950	2002	1992	9,61
100 to 249	1962	2003	1994	7,44
250 and more	1960	2003	1994	8,15
Total	1950	2003	1993	8,77

The importance of the year of introduction relies in the fact that most often organizational concepts have larger time periods of implementation and spreading compared to technology, for example. The year 1950 is the lower extreme for establishments belonging to finished metal products, machinery and the electric and electronic product sector, as well as those having less than 100 employees. Latest introduction corresponds to the year 2003 coinciding with the year of conducting the survey. On average, it is the beginning of the '90s when teamwork in production is introduced or first used (see Table 2.2.3). Even authors often mention the same showing no empirical or factual evidences, our data points to the same.

As mentioned before, previous surveys relative to innovation or work organization often tend to collect scarce and aggregate level information on different concepts. One of our contributions is the effort in trying to overcome and compensate such gaps. In line with that are the two following characteristic of teamwork, namely its potential use and the ratio of staff working in teams (Table 2.2.4 and 2.2.5).

We asked participant establishments to estimate the used potential of certain technologies or organizational concepts, meaning that an approximation of share of actual use of these techno-organizational concepts at the most efficient usage opportunity in the company was

asked. In the case of teamwork in production lowest levels move between 5 and 10 percent, maximum level achieving 100%.

As for our concern, average used potential exceeds half measure efficiency (58,72%), higher mean values are characteristic to motor vehicle, parts and other transport material producing sector and medium sized companies.

Authors like Durand et al. showing a comprehensive table on the state of employee relations at different automobile manufacturers (p. 413) include the concept of degree of implementation of teamwork and measure it on a numeric scale from 0 corresponding to the traditional Ford model to 10 for the Japanese type ideal and the Kalmarian model. Their results in German automotive plants show the figure of 2 for VW Hanover and 8 for four different Mercedes plants.

Table 2.2.4: Teamwork in production – potential use (percentage share of actual use)

	Percentage share of actual use			
	Min	Max	Mean	SD
Economic activity				
Rubber and plastic products	5	100	59,82	31,62
Finished metal products	5	100	55,49	29,15
Machinery	5	100	59,91	28,17
Electric/electronic products	10	100	55,82	28,64
Motor vehicles, parts / other transport	10	100	73,94	25,76
Size classes – employees				
Up to 99	5	100	57,73	28,78
100 to 249	5	100	60,04	28,90
250 and more	5	100	59,63	29,72
Total	5	100	58,74	29,00

Our other measure of teamwork penetration or usage (Table 2.2.5) is the ratio of staff expressed by the percentage share of employees working in teams. The results show that on average 53,02% of the employees are involved. Following Osterman's (1994) definition of flexible work organization where at least 50% of the core workers participate, German manufacturing enterprises on average comply with this criterion. Even argued by the author that 50,1% of manufacturing establishments declare using teamwork (at any

penetration level) the figure drops down considerably (32,3%) when setting the 50% or higher level of participation.

Table 2.2.5: Teamwork in production – ratio of staff working in teams

	Percentage share of persons working in teams			
	Min	Max	Mean	SD
Economic activity				
Rubber and plastic products	5	100	48,44	28,41
Finished metal products	1	100	52,49	28,78
Machinery	5	100	52,83	28,75
Electric/electronic products	7	100	53,60	27,20
Motor vehicles, parts / other transport	10	100	65,13	24,85
Size classes – employees				
up to 99	2	100	54,58	27,80
100 to 249	1	100	50,50	28,71
250 and more	5	100	53,19	28,58
Total	1	100	53,28	28,21

The last quantitative characteristic on teamwork implementation and use is the average number of employees forming a team. The figures collected in Table 2.2.6 show that at least 2 and, on the other extreme, 35 persons make up a team.

Table 2.2.6: Teamwork in production – Average number of employees in a team (number of persons)

	Number of persons forming a team			
	Min	Max	Mean	SD
Economic activity				
Rubber and plastic products	2	28	6,21	4,66
Finished metal products	2	30	5,64	4,04
Machinery	2	30	6,31	4,88
Electric/electronic products	2	25	5,88	3,91
Motor vehicles, parts / other transport	3	35	9,05	5,78
Size classes – employees				
up to 99	2	20	4,45	2,67
100 to 249	2	35	6,77	4,86
250 and more	2	30	9,61	5,45
Total	2	35	6,20	4,54

This might be contradictory to the team definition made by Hoegel and Gemuenden (2001) saying that "Following the literature, a team can be defined as a social system of three of more people, which is embedded in an organization (context), whose members perceive themselves as such and are perceived as members by others (identity), and who collaborate on a common task (teamwork)". Still, we consider valid answers those reporting 2 person teams, while the average by sector, size and region always exceeds the cut-off point of 3.

Fuxman (1999), when describing the Japanese and the Scandinavian team models, indicates small teams formed by 4-6 people at Toyota in the Japanese team structure and 15-20 people at Volvo meaning large teams for the Scandinavian team structure. Although conceptually closer to the Scandinavian team model, the German team's size is more similar to the Japanese one. One should be aware that Fuxman's examples refer to automotive productive environments, while our results concern different core industry sectors.

2.2.5.2. Model estimation and results

The results of the regression about whether or not firms introduced teamwork in production are summarized in Table 2.2.7.

The equation shows moderately good predictive power with almost 70% of correct predictions meaning that the model correctly classified 70% of the firms between those who implemented teamwork and those who did not. The value of Nagelkerke's R^2 is .18 which is quite reasonable for a qualitative dependent variable model. Furthermore, the computed value of the likelihood ratio (535,67) is much larger than the critical value of the chi-squared statistic with 18 degrees of freedom. This suggests that the null hypothesis, that all the parameter coefficients (except the intercept) are all zeros, is strongly rejected. Consequently the model is significant at the 1 percent level.

The results discussed in the followings are based on the signs and significance of the coefficients of explanatory variables.

Table 2.2.7: Estimated logistic regression model of factors affecting teamwork implementation in production

Dependent variable: Use teamwork in production (Yes/No)		
Independent variables	Coefficients (ß)	P. value[a]
Flexibility		
Best ranked: Delivery on schedule/short delivery times	0,488	0,020**
Best ranked: Customized products	2,255	0,007***
Complexity		
Multi-part products with complex structure or complex systems	1,941	0,009***
Sum of all types of qualified people	1,008	0,113*
Openness		
Co-operation for (vocational) training	1,234	0,359
Production cooperation	1,098	0,677
Sales to Europe and abroad higher than country and region	1,125	0,713
Quality		
CIP - Continuous Improvement Process: use	1,217	0,427
ISO 9000:2000 certification: use	0,834	0,472
Best ranked: Quality	1,368	0,159
Rework/ scrap (%)	0,987	0,397
R&D		
Share of R&D expenditures of turnover	1,019	0,300
R&D, design	0,972	0,036**
New products	1,614	0,037**
Cooperated in R&D	1,832	0,022**
Organizational and production concepts		
Regular individual potential review/ development discussion: use	1,296	0,261
Breakdown of production: use	2,102	0,001 ***
INTERCEPT	0,294	0,011***
Number of cases: 469 Chi-square (df): 64,68 (17) Nagelkerke's R^2 (Pseudo R^2): 0,18 Percentage of correct predictions: 69,5%		

a *, **, *** indicate that variable is significant at 10%, 5% and 1%, respectively.

The likelihood that a firm introduces teamwork in production increases as the number of qualified people increases. As for the dichotomous variables, the results indicate that firms that base their competitive strategy on customized products are more likely to introduce teamwork in production. This fact might be explained by teams' multi-skills and rotation

capability necessary characteristics in environment of rapid change and high customization. Similarly, those firms that introduced new products or products with significant technical improvements are more likely to introduce teamwork in their production settings. The same is true for those opting to cooperate in R&D with suppliers or customers or other companies. Finally, those firms that broke down their production in customer or product related segments have a higher likelihood to introduce teamwork.

The results in Table 2.2.7 show that there is no significant relationship in either of the proxies for openness and quality.

To conclude this section, the regression model shows that in the presence of a series of characteristics or circumstances there is a higher probability of teamwork introduction in production. We refer to flexibility in terms of customized products, complexity in terms of product and knowledge, R&D cooperation and new product, and the introduction of other production concepts. Interestingly R&D (the share of R&D expenditures of turnover and people dedicated to R&D/design) as such shows no statistically significant relationship to teamwork implementation in production. Still, the interpretation of this fact is conditioned by the quality of data for the case of the latter. Anyway the sign shows negative and its interpretation would be that as R&D and design personnel decreases in number the probability of teamwork introduction increases. A possible explanation could be the relationship between decreasing R&D and design personnel and increasing production personnel; from this prism the interpretation of the negative sign makes sense. Otherwise, it is interesting to detect the positive relationship of R&D cooperation and new product as a result of the R&D effort deployed by the firms, when the R&D investment (in terms of budget) is not significant. It might be the case that R&D investment is an important determinant for technological innovations (new products and processes) but it is rather the investment's result that acts as a determinant in the case of an organizational innovation such as teamwork.

2.2.6. Conclusions

The present paper had the aim to shed some light on the topic of teamwork implementation in production in terms of spreading, characteristics and determinants. Initial hypothesis were contrasted with data collected during 2003 from manufacturing establishments in Germany.

Some of the contributions of this work rely in methodological issues concerning teamwork and the difficulty and high quality data on such an immaterial phenomena. Therefore, the recent, complex and representative coverage dataset with high degree of detail on teamwork implementation and characteristics is a strengthen of the present essay.

Our intention was also to contribute and respond to Benders' and collaborators' call for more research in order to overcome the "anecdotal empirical evidences" for teamwork, on the one hand side. On the other hand side, Osterman's affirmation "systematic studies on the determinants of adoption are extremely sparse" as well as his statement that "there is little or no research that takes work organization as the dependent variable" made us detect a still existing gap on such.

Still, it is worth mentioning that no intention of generalization is intended. The work would gain in richness if German data would be contrasted in a more international framework and comparatives would contextualize better the state of teamwork implementation in production. The study explores some previously mentioned determinants in the literature and their link with teamwork in production; still, no conclusions on determinants of organizational innovations can be drawn, while empirical evidences only refer to teamwork. Although descriptive statistics include 1268 cases, in the model enter 469 cases. This is one of the limitations of the model.

Other limitations refer to the fact that no cultural variables are introduced while in the literature it often appears that "different understandings of the concept of teamwork across national and organizational culture" exist (Gibson and Zellmer-Bruhn, 2001) and previous comparative studies show very different degrees in the technique's dispersion. Some

authors often relate it to the organizational/corporate or even national culture. The present work includes only manufacturing teams although teams in services are quite usual.

Finally, there are still lots of open future research horizons relative to the topic of teamwork in manufacturing, its diffusion degree, its characteristics and determinants and technological and organizational innovation or technologies and organizational concepts relation is a challenging area.

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3 University entrepreneurship

3.1. Spin-offs as a University Technology Transfer Strategy: Lessons from European Best Practices

3.1.1. Introduction

The importance of science and its outcomes for a country's economic competitiveness is widely recognised. The majority of OECD member countries, in a context of strict public deficit control, emphasise the role of public research in responding to national needs. Research has, therefore, sought to provide more immediate economic results; in a word, research has sought to be more market oriented. The detection of the "European paradox" in the mid-90s, and the subsequent actions taken by the European Commission are examples of the political concern to drive public research into economic results. At the turn of the century, European priorities once again emphasised the link between R&D and the market, and efforts were stepped up to reduce European deficit in R&D investment and propel the European economy into a competitive position in the knowledge economy (Commission of the European Communities, 2000).

The role of the universities has changed dramatically. At the start of the 21st century, the universities are undergoing a second major revolution. The first took place at the end of the 19th century and led to research being added to teaching as an institutional objective. The second began at the end of the 20th century and entailed the incorporation of a third function: universities are required to promote economic development through university-company technology transfer (Etzkowitz, 1994; Etzkowitz, 1998). In this new scenario, researchers should continue to contribute to the growth of knowledge through research. However, they should also strive to facilitate the entry of this new knowledge into the market. The role of universities has changed: fostering links and cooperation with the business sector seems to be a must. In turn, businesses are increasingly keen to harness the outcomes of public research. Internally and externally generated knowledge plays a crucial role in achieving competitive advantage. Businesses have different, in amount and variety, reasons to wish to exploit public research results (Rosenberg, 1990; Mansfield, 1991;

Rosenberg and Nelson, 1994; Narin et al, 1997; Nightingale, 1998; Forbes and Wield, 2000).

Some authors define the present situation as a move towards the "academic capitalism" (Slaughter and Leslie, 1997). Others see the "new university" emerging from this context as the "entrepreneurial university" (Matkin, 1990; McQueen and Wallmerk, 1991; Mian, 1997). Whatever the case, one thing is clear: the university is increasingly bound up with its surrounding industrial-entrepreneurial context and with commercial application of research outcomes.

In addition to providing qualified human resources, the university's contribution to knowledge transfer at present occurs (Torkomian, 1998) through teaching, through joint university-company research projects, through services, consultancy work and venture or spin-off creation. Former research in this area has identified common mechanisms to transfer technology through the above-mentioned mechanisms (Allen and Norling, 1991; Baldwin, 1996; Fernandez de Lucio and Conesa, 1996; Fritsch and Lukas, 2001; MacLean et al., 1998; Meyer-Khramer and Schmock, 1998; Roberts and Hauptman, 1986; Zucker et al., 1997). Indifferently of the commercialization mechanism, technology transfer management and the technology transfer units play a central role.

The origin of the present research is related to the analysis of the situation of academic entrepreneurship and university spin-offs in Spain. In this country, the innovation system and its components show a qualitative and quantitative growth in the recent decade, but the degree of development is still far from being satisfactory compared to other European Union countries. Entrepreneurial innovation efforts show continuously increasing trend/values, but the number of enterprises using this mechanism in order to improve their competitiveness is still under the European figures, representing approximately half of it (COTEC Foundation, 2004). Both fields, enterprises –on the one hand- and science and technology –on the other hand-, have characteristic strengths and weaknesses that determine spin-off creation as a linking bridge and appropriate solution combining business and academia. Spin-offs represent a solution, while they are a key issue for the increase of entrepreneurial culture of innovation and innovation management. Moreover, they represent new R&D cooperation strategies and contribute to improve the interest in protecting the rights of university intellectual and industrial property.

In such a framework, the main objective of the present work is to identify features of technology transfer offices/units belonging to active universities in the field of spin-off creation and promotion, in higher education European institutions that could be qualified as "best practices" in terms of research and technology transfer strategy. The analysis of such spin-off practices could be useful for policy makers in order to better promote technology transfer via spin-offs.

3.1.2. Modalities of University-company R&D Transfer (and Spin-offs)

3.1.2.1. Push and pull modalities

University technology transfer can be categorised into three main groups: joint university-company R&D contracts, patent-licensing and spin-off creation.

R&D contracts, which have traditionally played an important role (Link, 1996; Hall et al., 2000; Cohen et al., 1998; Caloghirou et al., 2001), are a "pull" approach in which knowledge is transferred on the company's initiative. Companies contact universities in order to meet their innovation needs. In this bottom-up approach, the market directs the technology transfer process. Companies seek solutions in public research that will enable them to cut down their production costs and/or to improve their products' quality.

On the other hand, patent licensing and spin-off creation represent a "push" strategy. The university's technology transfer unit plays a highly active role and develops a body of skills and knowledge in the area –they "push" the process. In other words, it is a top-down approach; the innovator identifies an opportunity for technology, for which there is not yet a clearly defined market. This process may even lead to the development of an entirely new market. The procedure is, to some extent, driven by governments and their belief in the strategic importance of basic public research. In a "push" model of technology transfer, research institutions themselves set out to transfer research outcomes to the market. To succeed, public scientific institutions need to understand the scope of the technology they develop and its future potential, they should detect potential uses and markets and they should evaluate whether the technology is valid for these purposes. In the meantime, they

should have the ability to convince the manufacturer (and also the end user) of its value and, finally, provide support for the process of adaptation and uptake.

Joint R&D research projects have proven relatively limited in scope over the last 20 years, largely due to problems of demand. In addition, universities have restrictions in their offer. Some authors (Rodriguez et al., 1999; Conesa, 1997) suggest that research groups, limited as they are by the nature of the undertaking, soon reach saturation point in joint R&D research projects. Therefore, to increase technology transfer, universities promote "push" strategies, which enable them to benefit from their own publicly funded research independently of external company commissions.

Technology transfer via spin-offs is the most complex form of university-market technology transfer (Brett et al., 1991). This complexity mainly arises from the twofold role played by the researcher: as generator and applier of the technology. In this second role, i.e., commercial application of the research, researchers do not normally have enough entrepreneurial experience. The same is true for universities. Providing support and managing fledgling companies has not been central to the traditional university remit. Nevertheless, despite its complexity, the spin-off is increasingly recognised as an efficient means of technology transfer (Jones-Evans and Klofsten, 1997). However, only universities with a sufficiently consistent research basis can hope to run efficiently transfer programmes or units. Therefore, promoting technology transfer through spin-offs will demand support for basic research. Universities cannot separate one policy area from the other, at least not in the mid and long-term.

3.1.2.2. The role of the researcher

Support for spin-offs has gone hand-in-hand with an increasing interest by scientists in economic issues, which in turn has the effect of strengthening the links between public research and the market (Stephan and Levin, 1996). The most classical approach, defended by sociologists of science, is that the main motivation of scientists is the research process itself and the search for recognition within the scientific community (Dasgupta and David, 1994). These continue to be valid motivations. Still, the more economics-based approach should be mentioned, which holds that scientists, like other economic actors, are mainly

motivated by money. Other factors may also account for this new desire of scientists to bring their research to the commercial market. For example, the difficulty of achieving public funding often creates a need to seek alternative private support. And public funding restrictions have had the effect of making researchers more commercially competitive: competition for public R&D funding is harsh –applications often resembling a private sector business plan– and any funding received must be administered as it would be in a private firm. In addition, the latest generations of scientists are more willing to enter the world of industry (Van Dierdonck et al., 1990). And finally, in certain scientific fields, time elapsing between discovery and application of technology has been reduced, not only due to technological but also economic reasons. Today risk-capital investors are prepared to invest in small high-technology companies far in advance of actual entry of products into the market.

3.1.2.3. Spin offs

Not all transfer mechanisms are equally effective for all university technologies. Use of one as opposed to another depends on such issues as researcher profile, the nature of the invention, its academic field of origin (for instance life sciences or physical sciences), the volume of non-codified knowledge associated with the invention, the industrial sector, whether the technology is mature or emergent, intellectual property protection systems, the resources and time needed for manufacture and marketing, the inherent difficulty of each transfer modality, and the existence or otherwise of university support programmes. Together, these factors will determine whether a researcher or group should provide consultancy services, undertake collaborative R&D work with external companies, patent and license the product, enter into an alliance with external companies, or try to create their own, independent spin-off.

The more traditional literature defines a spin-off as an entrepreneurial initiative by a professional from a non-entrepreneurial field. Three types of spin-offs are distinguished in terms of the origin of the entrepreneur and the technology: university, company and institutional spin-offs (Lindholm, 1997). Under this classification, a university or academic spin-off is an entrepreneurial initiative on the part of one or various members of the university staff, aiming to commercially harness their acquired knowledge and research results.

A more precise definition can be achieved by employing additional criteria. First, in terms of type of support provided by the university. Here we can define two types of university spin-off: *planned spin-offs* – the result of organised endeavour on the part of the originating institution, and *spontaneous spin-offs* –the result of the personal tenacity of an entrepreneur who detects a market opportunity and establishes a company with little or no institutional support (Steffensen et al., 1999). Our research concentrates on planned spin-offs.

The factors determinants in the success or otherwise of a spin-off are entrepreneur's profile and the economic resources that can be obtained. Studies show these factors to be more important than the actual technology underlying the spin-off (Gregory and Sheahen, 1991). Finding the right researcher-entrepreneur who is willing to face all the challenges and risk associated with company set-up, is not easy at all. In fact, the correct combination of qualities is very rare: it is estimated that only between 4 and 5% of researchers have the potential to launch a spin-off (Allen and Norling, 1991). In addition, both the entrepreneur –when undertaking commercial applications of the developed technology, and the university –when deciding which initiatives to support and invest in, must consider other factors which may have a bearing on success. One of these factors is whether the university has appropriate support structures. The support structure is vital, but also important are the resources, experience and results obtained by the units responsible for technology transfer. Another factor is the existence in the immediate external context of additional support and service structures and risk-capital bodies, for example.

3.1.3. The research

There are the two main areas that our study explores: the university's technology transfer unit, on the one hand, and the external support structures and/or actors, on the other hand. Special emphasis is placed on university spin-off support units. In our view, this is the area - more than the researchers or the spin-off itself- generating key decisions for future strategic development and science policy.

The overall aim of this research is to provide tools, which will facilitate decision-making and choice of appropriate support strategies for university spin-offs.

From a more practice oriented view, the collection of European experiences served –in the framework of the regional innovation plan - the local Government in its task of designing policy support measures. Concretely, these measures are mainly related to technology-based new venture creation and to establishing strategies in the technological trampoline[2] network.

In order to achieve the above-mentioned aims and objectives, we followed and present in the next section a body of procedures and guidelines representing the methodology.

3.1.4. Methodology

3.1.4.1. Methodological approach

We focus our analysis on eleven cases of European universities, which are especially active in the area of spin-offs and located in the UK, Sweden and Ireland. We selected these universities because, from our point of view, each country could represent a model of technology transfer via enterprise creation. It is worth noting, that the analysis is made at the level of the technology transfer unit/office, and not at university level as in Tornatzky et al. (2002).

Recent work explores the different incubation strategies of spinning-out companies employed by European research institutes (Clarysse et al., 2005) differentiating between three distinct models of managing the spin-out process: 1) *Low-Selective*, 2) *Supportive* and 3) *Incubator*, all serving different goals and objectives. In the meantime these models are different in terms of resources –financial, organizational, human, technological, networking-, activities and objectives.

We conducted semi-structured personal interviews that follow principles and practices of successful business incubation described in Rice and Jana (1995) and Molnar et al. (1997). Table 3.1.1 summarizes the main areas of our interest.

[2] Technological Trampoline – a technology transfer unit specialized in spin-off creation and support

Table 3.1.1: Interview guidelines

Promoting the entrepreneurial culture and achieving a steady deal flow of projects
Pull and push initiatives
Obstacles in founding spin-offs
Measures to insure deal flow
Partners, institution, stakeholders
Others
Selecting spin-off projects
Benchmarking
Key success factors
Selection criteria and flexibility
Errors identified
Different stages and potentials of the project
Others
Creating an enterprise and supporting a newly created enterprise
Strengths of the incubation process
Evaluate, manage, supervise the incubation process
Support and non-support services needed
Project management, education, skills, team creation
Mistakes, reasons to fail
Seed financing, financial sources, business angels
Others
Growing experience, organization managing and recommendations
Type and structure of the organization
Objectives and mission
Ramping-up process, targets and objectives
Others

3.1.4.2. Selected universities

In the following sequence, we try to identify some of these features of the selected universities and/or countries (Table 3.1.2). During 2002, we carried out in-depth interviews addressed to the head of technology transfer and/or spin-off support unit in the selected higher education institution. An exhaustive analysis of information provided by the institution or available on its webpage supplemented the interview.

Table 3.1.2: Participant units in the selected universities

Unit	University
United Kingdom	
Isis Innovation, Ltd.	University of Oxford
Centre for Enterprise and Innovation - CEI	University of Southampton
Technology Transfer Office	University of Cambridge
Technology Transfer Office	University of Newcastle
Leeds Innovations, Ltd.	University of Leeds
UMIST Ventures, Ltd.	University of Manchester
QUBIS, Ltd.	Queen's University of Belfast
Sweden	
Centre for Innovation and Entrepreneurship - CIE	University of Linköping
Chalmers Innovation	Chalmers University of Technology
Innovation and Commercial Services Office	University of Göteborg
Ireland	
Research & Innovation Services	University of Dublin, Trinity College

The next paragraphs describe the reasons underlying the decision of selecting these units.

Seven of the eleven cases were from the United Kingdom. This is because UK universities tend to be very active in spin-off creation. In the view of certain authors, the universities from the UK are even more active in this field than those of the United States, where private sector provides science with sufficient resources for entrepreneurial initiatives without the need of institutional support (Hague and Oakley, 2000).

This is not the case of Sweden, where teaching activity is the basis of spin-off creation, ideas are promoted and in consequence, the *low-selective* model of incubation applies, maximizing the number of entrepreneurial ventures in line with entrepreneurial mission of the research institute to which the unit is attached.

We ground our decision of including the Irish case because of a possible resemblance with Spanish reality, in term of recent organizational changes within science, technology and innovation institutions, plans, responsibilities and structure, and the focus on high value knowledge driven industry, more investment in education, mostly higher education.

The main mechanisms employed by the technology transfer units analyzed are technology patenting and spin-off creation. These units are assigned specific functions into which their generally limited resources are channelled. Proactive in outlook and approach, they focus on detection and evaluation of university technologies with market potential and, above all, on provision of specialised services needed to bring technologies to the market. No unique, universally applicable model of technology transfer or spin-off creation can be imported from the cases analyzed, but in our opinion can help identifying field, area, issues and strategies that can be adapted to local circumstances.

3.1.5. Lessons learned from university spin-off strategies

3.1.5.1. General overview

The university's decision to invest in new research-based companies is motivated by three main reasons: technology-transfer reasons, economic reasons and researcher reasons (Matkin, 1990). Regarding the latter, an active role on the part of the university serves to smooth any tensions that may appear when teaching staff wish to operate on a commercial basis and may avoid them leaving the institution. In addition, spin-offs create an air of excitement in the university which is also transmitted to students and serves as a motivating factor.

The economic reasons are self-evident: universities hope to make money from their participation in spin-offs (Bray and Lee, 2000). Spin-offs provide employment opportunities for universities, given that, at least in the initial phase, they tend to outsource their R&D work. In addition, they have a highly positive influence on research and teaching, in that they create opportunities for doctoral theses and projects. Spin-offs are also a reflection of the university's urge to play a role in local economic development, and university support for a new company means that the company will remain in the local setting (Matkin, 1990; Brett et al., 1991; McQueen and Wallmark, 1991; Steffensen et al., 1996). The new companies create employment and subcontract specialised tasks and services; they rent premises and employ other shared services such as transport, schools, etc. As highly dynamic, technology-based companies, spin-offs may also contribute to the renewal and diversification of the regional economy (McQueen and Wallmark, 1991).

Public policy programmes for spin-offs also play a role. And, as mentioned earlier, the shortage of public resources for research has led to development of an entrepreneurial outlook among scientists. Researchers have learned to compete for limited funding resources; they fill out funding applications which resemble business plans and all funding received must be administered in an increasingly business-like manner (Stephan et al., 1996).

Finally, the spin-offs also benefit from their association with the university. Location in a university campus facilitates their initial development, providing them with access to premises, equipment and specialised services, as well as advice on business and protection of results. In return, the university expects the spin-off to contribute to research. Companies also have better access to the university's continuing education programmes and are able to employ qualified staff, being in permanent contact with future graduates. Similarly, the relation between the university's scientific staff and company stuff helps to develop a stimulating climate. In addition, when the useful life of the first products produced by the spin-off has ended, university research may be an excellent source for new ideas. Finally, the university's reputation also helps the company's development, since its stakeholding serves as a guarantee for other investors, which may prove vital in the early stages of company development, when it does not yet have sufficient credibility or economic resources (McQueen and Wallmark, 1991).

A supportive incubation strategy applies, in the case of UK as an alternative to licensing tending to generate profit-oriented spin-offs with potential growth opportunity. In this model well functioning Intellectual Property department and contract research unit, project manager and a minimum critical mass of support personnel tend to be the key. Spin-offs tend to need external capital at a very early stage, usually after passing a selection process. In the context of high education institutions achieving their third mission, in the way of becoming entrepreneurial universities spin-off creation represents an alternative that can be strengthen on diverse alternatives, as it is teaching and/or research; the case of the UK we identify spin-off creation mainly based on research, is the way of "taking research to market" (Tang et al., 2004).

Table 3.1.3: Functions assumed by the eleven units

University	Unit	Juridical personality	Activities					
			Public research management	Contract management	Patent licences	Promotion of entrepreneurial culture	Spin-off support services	Incubation space management
Oxford	ISIS Innovation	Yes	No	No (1)	Yes	No	Yes	No
UMIST	UMIST Ventures	Yes	Yes	Yes	Yes	No	Yes	No
Leeds	Leeds Innovations	Yes	No	No	Yes	No	Yes	No (2)
Belfast	QUBIS	Yes	No	No	No	No	Yes	No (3)
Chalmers	Chalmers Innovation	Yes	No	No	No	Yes (4)	Yes	Yes
Southampton	Centre for Enterprise and Innovation	No	No	No	Yes	No	Yes	No
Cambridge	Technology Transfer Office	No	No	No (1)	Yes	No	Yes (5)	No
Newcastle	Technology Transfer Office	No	Yes	Yes	Yes	No	Yes (5)	No
Linköping	Centre for Innovation and Entrepreneurship	No	No	No	No	Yes	Yes	No
Göteborg	Innovation and Commercial Services Office	No	No	No	No	No	Yes (5)	No
Dublin	Innovation Services	No	Yes	Yes	Yes	No	Yes (5)	Yes

(1) – Isis' and Cambridge's Technology Transfer Office are not involved in the management of R&D contracts, but still provide related consultancy and advising services

(2) – Leeds Innovations don't manage spaces, although it is located in the incubator promoted and managed by the university

(3) – QUBIS looks for appropriate space to locate its spin-offs inside the university

(4) – Chalmers doesn't necessarily organize courses, but is still active in the field of coordinating and informing about activities concerning the promotion and enhancement of entrepreneurial culture

(5) – Cambridge's, Newcastle's, Göteborg's and Dublin's services are limited. They are more informative rather than supportive

In Sweden, Government urges university to collaborate with business and other organizations. Behind the process of enhancing collaboration and networking among innovating organizations relies a relatively recent major reorganization of the national innovation system, spread in the industrial, research and economic policy. In the context of this model, universities through teaching activity form future entrepreneurs by mean of programs and subjects related to the stages of a spin-off/star-up creation, facilitating well-consolidated support schemes and wide network of contacts, advisors and consultants, giving the opportunity of transforming original ideas or new approaches of existing concepts into effective solutions.

In Ireland, spin-off creation in the studied cases appear as a complementary procedure to R&D contracts or licensing. Technology transfer offices assume supportive activities in

terms of research management, R&D contracts, assessment and consultancy, activities enhancing entrepreneurial culture, education and training on entrepreneurship and business plan creation, administration of incubator location, etc.

3.1.5.2. Associated risks

The cases studied highlight that university support and stakeholding in spin-offs may involve certain risks.

Firstly, the university community in general may misinterpret the institution's relation with the spin-off, and may see it as an unbalanced predilection for a given researcher.

Economic problems may arise due to the university's entrepreneurial inexperience. There may also be problems in detecting promising investment opportunities and in managing their own shareholding role. An initial investment in a spin-off may entail a moral commitment to continued investment in the future, to keep the company afloat in the early days.

Company performance may also have a bearing on the university's reputation. For example, when a university decides to support an entrepreneurial initiative by one of its teaching staff, external investors read this as an indication of the company's potential. However, should the company fail to match expectations, investors will tend to distrust further spin-offs from that university. Labour disputes, environmental issues or tax problems may also have a negative effect on the university's reputation.

Solving these problems requires, on one hand, establishment of spin-off support programmes within the university, and, on the other, control regulations (Matkin, 1990). Rather than simply reacting to a single opportunity, the university must carefully study and plan the venture creation as a strategy and then establish an appropriate support programme, applicable to all the institution's research staff, and involving accurate appraisal and selection of initiatives, along with a set of regulating procedures for the entire process. What is needed is proactive, not reactive, action. Although it may seem paradoxical, the best way for the university to avoid legal problems with its spin-offs is to

be totally involved with them and not become isolated from the commercial aspects (Matkin, 1990; Gregory and Sheahen, 1991); even more true, since the volume of support provided by the university is one of the factors determining spin-offs' success. Regarding control regulations, in order to avoid serious conflicts of interest and accusations from the rest of the university, the link between the university, the company and the entrepreneur must be absolutely transparent. This means providing accurate information concerning these links (Matkin, 1990).

Use of intermediary management agencies may help to reduce problems. Such intermediaries serve as shock absorbers between the institution and the business activities of its researchers. The extent of the insulation provided will depend on the intermediary's relative independence of the university. Therefore, it is important to seek a balance between the correct level of autonomy which will ensure the spin-off's chances of survival, and sufficient control to prevent developments which may not be in the university's interest (Matkin, 1990). The last section of this chapter describes key features of these support offices.

3.1.5.3. Location of spin-offs

University authorities, responsible for establishing a model for spin-off support programmes and drafting the relevant regulations, must bear in mind that it is not necessary for the main researcher to leave the university in order to establish the spin-off. The support units will appoint staff for daily management of the company, while the researcher will act as a scientific consultant, based at the university. This ensures that the universities do not loose their best researchers.

The study also suggests that universities which are active in the field of spin-offs also tend to have company incubators. These are not managed by the technology transfer office and their role is to provide high valued-added services designed to help development of the fledgling companies. Certain universities have adopted imaginative approaches which could be replicated in other institutions without great cost: for example, university campuses may be converted into a company incubator, and spin-offs may be located in near proximity to

the research groups whose work led to their creation. When these companies reach consolidation, the university campus becomes a science park.

3.1.5.4. Economic returns and universities as stakeholders

University technology transfer, by means of patent licensing and spin-offs, demands support units with qualified staff whose profile is different to that of traditional technology transfer unit personnel.

Consequently, universities establishing technology transfer programmes can only expect economic benefits in the mid and long-term. Heads of technology transfer offices must also be aware of this need for an investment of time and quantity when defining and defending their units' economic needs to university policy-makers.

The economic demands of technology transfer make it difficult for these management units to be self-financing. Spin-offs may generate some considerable economic return through sale of shares, however, this will only occur within five to ten years of the university's initial investment. Economic return for the universities from spin-offs however, does not stem so much from share sales as from R&D contracts signed with other companies.

When undertaking support programmes, universities have two priorities: providing a service –in accomplishing institutional objectives and contributing to general economic development, and secondly, functioning as an enterprise –generating income. Case studies show that achieving both is often difficult.

In any case, to ensure a return on intellectual property, universities need to combine an active traditional patent licensing programme with institutional spin-off support.

All the cases we have studied highlight the importance of the university being a stakeholder in its spin-offs. The best approach for the university is to accept shares in return of support provided, for university permits, for the fact of being a spin-off, etc., and, secondly, to

grant the spin-off a license for the use of technology. Income resulting from the licensing is distributed in accordance with the institution's royalty's policy, invariably allocating a significant proportion to the main researcher; while income arising from shares held is allocated to the institution alone. The universities, via their technology transfer offices, must have the necessary resources for participation in the management of their spin-offs, with a twofold purpose: control and support. However, this active participation in spin-off management has the effect of dramatically increasing the university's responsibility.

Whether individually, in conjunction with government bodies or private companies, universities must ensure the existence of investment firms prepared to invest in new knowledge-based companies. In fact, two types of venture capital are needed: at first, seed capital, and then later investment for consolidation and growth.

3.1.6. New roles for technology transfer offices

Within the present framework of "academic capitalism" and entrepreneurial universities, the technology transfer offices are confronted with a strategic problem: they must define their marketing approach and strategy, adapted to this new framework.

The technology transfer offices studied channel their efforts through patents and spin-offs. They represent a new model of technology transfer office. They are assigned a highly specific set of objectives, to which they devote their generally limited resources. Their task entails proactive detection and evaluation of university technologies which have market potential and, above all, application of specialised services enabling transfer of these technologies to the market.

Management activity is reduced to the minimum and all peripheral tasks are outsourced or subcontracted. The bodies studied are not responsible for administration or management of the university's employment programmes. However, some of the units studied do have responsibility for the management of the university staff's consultancy contracts. Nor do they manage the institution's public research programmes, which are seen as an area with entirely different objectives and requirements. Finally, they are not responsible for fostering entrepreneurial culture within the university or for managing spin-off incubators.

University spin-offs (and patent licensing) demand support units with specialised staff, of a very different profile to that of the personnel traditionally responsible for other administrative university units. These specialists must understand both the research process and the market. They must have had previous entrepreneurial experience. Such project managers then follow each technology on its way to the market, whether via spin-off or patent licensing. In certain cases, they may be permitted or even encouraged to join spin-offs as managers. This professional profile means that the new technology transfer offices have high operating costs.

These units have their own business strategies adapted to their institution. We detected strategies based on project detection, on assembling as many technologies as possible, and on identification of potential projects at very early stages. This level of adaptation to the features of each institution seems to optimise the university technology transfer activities.

When considering a technology's or invention's potential transfer to the market, these offices must bear in mind the researcher, the nature of the invention –whether it may lead to a radical or incremental innovation, and whether it will affect a product or process, the type of sector –whether mature or emergent, the nature and availability of the necessary additional resources, the time required for development and marketing, the possibility of codifying all the knowledge associated with the invention, the type of intellectual property protection required, applicable laws and regulations, the existence or otherwise of appropriate support structures within the institution, and the existence of risk capital bodies in the immediate environment.

In the area of spin-offs, the technology transfer units must take on another set of specific responsibilities. The starting point is an internal promotional phase to detect new technologies with market potential. The offices studied were not active in this area. The limited human resources available only permitted support to initiatives which had already been detected. Nevertheless, the projects with most potential seem to reach the units despite non-existence of this promotion phase. Indeed, the absence of this phase could be seen as a preliminary filter stage in the appraisal process.

Once the project has been detected and appraised, the process continues with proactive provision of services on the part of the technology transfer office. This is the responsibility of the project manager.

The unit should work to ensure that the new company is equipped with the necessary management skills. Several approaches exist to this area. The office may seek an external expert. Alternatively, the project manager may leave the university office and join the spin-off, as manager. A third possible approach is to seek a business partner for the spin-off, who, in addition to management will also provide added resources (in marketing, manufacturing, etc.). In our vision, the most inappropriate scenario is letting management exclusively in the hands of the researchers.

Another stage entails providing the company with sufficient capital for consolidation. In this area, the technology transfer units must work with university policy makers to ensure availability of venture capital firms willing to invest in its spin-offs. Different forms of investment are required at different stages of the company's development. The management of these seed and venture capital bodies should also play a role in project appraisal, since this will aid development of the institution's spin-offs.

The technology transfer offices must defend the role and interests of the university. University researchers tend to minimise the value of the institution's contribution. The negotiation process must bear in mind that the know-how at the basis of the spin-off's creation is usually the property of the university, that being a university spin-off brings certain advantages and that the university support services also have a certain value. One of the universities presented in table 3.1.2 establishes an initial profit distribution of 60% for the university and the remaining 40% for the research group. Without reaching this extreme, the results presented in this work suggest that the university should participate as a partner in the initiative. One approach helping to avoid university problems with negotiation is to acquire a certain fixed proportion of shares in all its spin-offs.

Furthermore, the university can maximise its economic return from spin-offs by maintaining a distinction between intellectual property rights and company shares. This

involves receiving royalties in return for a patent license, and shares in return for services provided, for being a spin-off, etc.

Finally, as the number of a university's spin-offs increases, the technology transfer units must prepare the institution to be in a position to be able to monitor and manage its investment.

Many European universities are developing support programmes for university spin-offs; active spin-off creation policies are being established, and specialised incubators are appearing; venture capital companies for investment in new high-technology ventures are being promoted and universities are being encouraged to become stakeholders in their spin-offs; more and more science and technology parks are appearing, the main aim being to facilitate transfer of public research outcomes to the market.

There are many types of technology transfer office and spin-off support units, yet study of these cases indicates that they share certain key characteristics. We have focused especially on the characteristics and approaches of technology transfer units within universities which are exceptionally active in the field of spin-off initiatives. This only represents the tip of an iceberg of an unstoppable process taking place in all universities with a significant level of basic research. The support provided to spin-offs entails new management, funding and organisational modalities which have the effect of changing traditional practice and in many cases leading to major organisational change. The overall aim is efficiency and the application of criteria of entrepreneurial excellence in keeping with the dynamic new profile of the entrepreneurial university.

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3.2. Research commercialization via spin-off: the case of a non-elite university

3.2.1. Introduction

University-based scientific inventions that translate into spin-off companies represent a potentially important and increasingly utilised option to create wealth from the commercialisation of research (Carayannis et al., 1998; Clarysse et al., 2005; Lockett et al., 2005; Siegel et al., 2003; Vohora et al., 2004). The conventional route to transfer knowledge from university to market has been generally through two means: 1) licensing the rights to use technological discoveries controlled by university owned patents (Intellectual Property-IP) and 2) contract research. In recent years, university spin-off companies have become an increasingly popular way of exploiting potentially valuable research and knowledge; however, understanding this phenomenon remains limited. There are some factors that justify the necessity to explore these entrepreneurial processes and the spin-off companies (Wright et al., 2004a, 2004b).

First, a growing policy debate has led governments to increase pressure for technology transfer in the form of spin-offs companies to generate wealth for both, universities and the regional economy. University spin-offs are not only seen as contributors to a regions' economic development but also as sources of employment (Pérez and Martínez, 2003), as mediators between basic and applied research (Autio, 1997) or as change agents of the economic landscape moving towards a knowledge-based economy.

Second, difficulties in transferring or licensing new scientific discoveries for which markets are undetermined, yet to emerge or nonexistent has led to find new ways of exploiting this knowledge. Moreover, instead of licensing to established firms, a spin-off offers incentives of a greater share of the wealth created eventually being returned to the original academic institutions and academic inventors (Wright et al., 2004b).

Finally, there are different typologies of spin-offs emerging from public research institutions (PRIs) depending on several factors such as their relation to the parent organisation, type of technology transferred, and resources available in the PRI, etc. Therefore, traditional pioneering studies of new technology-based ventures have identified

several typologies like: start-ups, spin-ins, research-based spin-offs, new high technology ventures, and joint-venture spin-offs among others (Hindle and Yenken, 2004; Mustar et al., 2006; Parhankangas and Arenius, 2003). The Lambert Review and other commentators have observed that there is a distinction between the founding of spin-offs per se and the creation of spin-offs that create significant wealth (Lambert, 2003; Clarysse et al., 2005). Recognition of this point draws attention upon the need of understanding more about the processes, resources and capabilities required for developing spin-off companies and how this may be different depending on the typology of spin-off company (Wright et al., 2004a).

This research is motivated, in general terms, by the need to learn more about university start-up companies and particularly those created on the basis of technology developed in universities. Moreover, relatively little is known about the nature of the relationship between the PRIs and their spin-offs (Parhankangas and Arenius, 2003; Roberts and Malone, 1996; Steffensen et al., 2000). Concretely, nothing is known about the different incubator strategies that PRIs in Catalonia employ to achieve their objectives in terms of resources and activities undertaken.

In the research commercialization literature there is an unbalanced situation between case studies describing, on the one hand side, elite universities or analyzing successful single case universities, and on the other hand side, non-elite universities. We understand the importance of the former, but in our view the latter are still important in order to have a holistic view on research commercialization. Contrasting the results of a regional and/or local university with an elite and/or best performing large public institution would generate an uneven situation. Therefore, our intention by providing the case of a non-elite university is to contribute to the existing cases generating a -rather modest in volume, but solid in consistency- framework for possible comparisons.

In this research we adopt a multi-dimensional approach to study the incubation strategy for spinning-off companies of the University of Girona (Catalonia – Spain). Various reasons underlie the choice of selecting this particular university. A recent report on entrepreneurship (GEM, 2005) shows that Catalonia is above both Spanish and European averages in terms of the total early stage entrepreneurial activity during 2003-2005 and second best, after Ireland in the European framework. Among the four Catalan provinces, the region of Girona concentrates the highest number of technological new ventures after

Barcelona. At the end of the '90s, when Catalonia was lacking a clear technology transfer model, different elite universities were visited and analyzed in order to draw the best possible model for university research commercialization through spin-off modality. Up to some extent, the University of Girona was a pilot university in implementing this model proposal.

This subchapter attempts to answer the following questions:

- What is the regional environment for spin-offs emerging from PRI in Girona (Spain)?
- How does the actual model of technology transfer employed by the TT of the University of Girona work and how has it evolved since its foundation?
- What are the internal resources for supporting spin-off creation at the University of Girona?
- Which is the predominant incubation model of managing the spin-off process at the University of Girona?

We base our analysis on two streams of literature, namely the resource-based view and the institutional theory. First, the resource based view (RBV) helps us to identify the variety of resources contributing to the nature and outcomes of the PRI; the resource-dependence view contributes when analyzing the relationship between the PRI and spin-offs. Second, we use the institutional theory applied to the field of entrepreneurship in terms formal and informal factors at both PRI and regional level as shapers of spin-off companies. Third, the taxonomy of incubation strategies identified at European research institutions gives us a reference when willing to situate our university in a larger, European context.

3.2.2. Conceptual framework

First, we make a brief note on the definition of spin-offs due to the complexity and multiple facets of this phenomenon. We adopt the definition of university spin-off provided by Pirnay et al. (2003:356) and supported by the majority of the scholars:

"*new firms created to exploit commercially some knowledge, technology or research results developed within a university*"

However, we expand this definition taking Nicolau and Birley's (2003:340) definition that stresses that the founding member(s) may include the inventor academic(s) who may or may not be currently affiliated with the academic institution. We divided these spin-offs in two categories: start-ups[3] and spin-offs[4].

3.2.2.1. Resource-based view

The resource-based theory has emerged as one of the most influential frameworks in strategic management research (Barney et al., 2001). Hence, we use the resource-based and the resource-dependence theory as a starting point for our inquiry.

The choice of these theoretical perspectives may be justified in the following way. The resource-based approach is particularly helpful in shedding light on the factors contributing to the nature and outcome of a spin-off arrangement (Parhankangas and Arenius, 2003:465). Especially, this theory seeks to explain the outcome of the resource sharing relationship (learning and competence development) in terms of similarity and complementarity of resource bases of the PRI and the spin-off.

Like the resource-based approach, the resource-dependence view maintains that organisational survival and performance depends on the organisation's ability to acquire and maintain resources (Aldrich, 1979; Pfeffer and Salanick, 1978; Thompson, 1967). Since the organisations are rarely self-sufficient, they enter into relationships with other organisations in order to obtain critical resources (Parhankangas and Arenius, 2003). The resource-dependence theory is mainly concerned with the acquisition of resources from outside of an organisation, for example via PRI in the case of spin-offs. In fact, the usefulness of the resource-dependence theory for our study lies on identifying forces driving changes in the PRI-spin-off relationship.

[3] Companies set up by former or present university staff and/or former students drawing on their experience acquired during their time at the university, but which have no formal IP licensing or similar relationships to the university (Hindle and Yencken, 2004)

[4] The rest of the companies different from "start-ups"

In Table 3.2.1, we review the main studies related to the process of spinning-off ventures within PRI that have applied resource-based view and resource-based dependence view. Among these studies, the authors emphasise different aspects such as: organisational, social, financial, physical, technological and human resources (Brush et al., 2001).

Table 3.2.1: Areas covered in the resource-based view applied to spin-offs

	Organizational	**Human**	**Physical**	**Financial**	**Technological**	**Networking**
Autio (1997)					X	X
Autio and Lumme (1998)					X	
Carayanis et al. (1998)		X	X	X	X	
Clarysse and Moray (2004)	X	X			X	
Clarysse et al. (2005)	X	X	X	X	X	X
Druilhe and Garnsey (2004)		X		X	X	X
Fontes (2001)		X		X	X	
Franklin et al. (2001)	X	X		X		
Heirman and Clarysse (2004)		X		X	X	
Hindle and Yencken (2004)	X	X		X	X	
Lindelöf and Löfsten (2004)						X
Lockett and Wright (2005)	X				X	
Mustar et al. (2006)	X	X	X	X	X	X
Nicolaou and Birley (2003)	X					X
Parhankangas and Arenius (2003)	X				X	
Pérez and Martínez (2003)	X				X	X
Pirnay et al. (2003)	X	X			X	
Shane and Stuart (2002)		X		X	X	X
Vohora et al. (2004)		X		X	X	X
Walter et al. (2005)		X				X
Westhead and Storey (1995)		X	X			X
Wright et al. (2004a) – Literature review	X	X	X	X	X	X
Wright et al. (2004b)	X	X	X	X	X	X
TOTAL	12	16	6	12	18	13

The category "technological resources" refers to the firm-specific products and technology. The category "human resources" refers to attributes of the founding team, the management team and the personnel of the company. The category "networking", also known as social resources, refers to the network or the social capital of the company. The "financial resources" refers usually to the amount and type of financing of the firm, which can be divided into two groups: external and internal. The category "physical resources" refers to assets such as firm's plant, equipment and placement (Grant, 1991). But also to machinery, trucks, or office space that can be considered utilitarian in producing a product or service. Finally, the category "organisational", also named link, refers to the internal structures, processes, and relationships in the spin-off but it also includes its link with the Technology Transfer Office (TTO) and its support structure, which is also related to the

institutional framework. This last type of resources is complex, knowledge-based and defined as the systems, the routines and the relationships embedded in the company (Brush et al., 2001). Some scholars also call these resources dynamic capabilities (Amit and Shoemaker, 1993; Teece et al., 1997; Eisenhardt and Martin, 2000). In fact, these dynamic capabilities are organisational and strategic routines by which firms achieve new resource configurations (Eisenhardt and Martin, 2000).

Drawing on the previous categories of resources, Table 3.2.2 summarises the key elements (variables) of each category when studying the PRI.

Table 3.2.2: Key elements and grouping in the resource-based view applied to spin-offs

Categories	**Public Research Institution**
Technological	Technological focus vs. non-technological Conditions of knowledge transfer from PRI Quality and legitimacy of R&D Mode of transfer (formal IP vs. informal)
Human	Size of the TTO's team Team quality (Background; Experienced professionals "in-house"; Commercialization competences) Team variety (Public vs. private oriented; variety of backgrounds and professional experience; vble to evaluate business plans)
Networking/social	Contacts with industry and finance Contacts with surrogate entrepreneurs and other human resources Science parks and other R&D infrastructures Type of relationship with the spin-off
Financial	Capital (internal vs. external) Strategy of funding Availability of VC (associated VC fund) Level of investment
Physical resources	Space (offices) Laboratories and other equipment
Organisational (link and nature)	Organised vs. spontaneous support Processes of direct and indirect assistance (commercial, managerial and product development) Paths dependencies (PRI's history)

3.2.2.2. Institutional theory

Recent work on the heterogeneity of *research-based spin-offs*[5] (Mustar et al., 2006) describes the institutional perspective of RBSOs as the relationship and the embeddedness with their parent organisation, which has its own culture, incentive system, rules and procedures. In order to be more specific, the institutional theory (North, 1990, 2005) puts together the

[5] RBSOs

above concepts and defines institutions as "the rules of the game in a society, or more formally, institutions are the constraints that shape human interaction" (North, 1990:3).

Institutions include any form of constraint that human beings devise to shape human interaction. Institutions can be either formal - such as political rules, economic rules and contracts - or informal - such as codes of conduct, attitudes, values, norms of behaviour, and conventions, or the culture of a determined society. North attempts to explain how institutions and institutional context affect economic and social development.

In this sense, but applying this theory in the field of entrepreneurship, according to Urbano (2006), formal factors include all the institutions and support schemes referring to new ventures, namely government policies, the demand and offer of support mechanisms, the evaluation of new venture creation supporting programmes and their impact, as well as all economic and non-economic support mechanisms oriented to assist new entrepreneurs. The informal institutional factors embrace the society's attitudes towards venture creation, e.g. culture as a barrier or favouring factor, entrepreneurial spirit, the recognition of the entrepreneurial function, the social status of the entrepreneur and the fear to failure.

In Table 3.2.3, we review the main studies related to the process of spinning-off ventures within PRI that have applied institutional theory.

The institutional perspective puts an especial emphasis on the support structures including incentives and TTO's quality, as well as on environmental related matters like local norms of reward systems and IP policies. All these elements constitute the structure that needs to be embedded in a supportive context. This context is related to the institutional and policy environment, the culture and the history that has unfolded within the academic institution (Debackere and Veugelers, 2005). In this context, funding sources of universities, the dynamism of public research system, the autonomy of universities and regional development are among the most important factors which have played and still play a principal role in favouring the exploitation of research results at universities (Chiesa and Piccaluga, 2000). On the contrary, some obstacles such as negative impact on basic research and incompatibility between university mission and administrative and bureaucratic reasons hamper the process.

Table 3.2.3: Studies on formal and informal institutional factors applied to spin-offs

Paper	Formal	Informal
Autio (1997)	X	X
Autio and Yli-Renko (1998)	X	X
Bozaman and Boardman (2004)	X	
Carayanis et al. (1998)	X	
Chiesa and Piccaluga (2000)	X	X
Clarysse et al. (2005)	X	X
Chrisman, Hynes and Fraser (1995)	X	
Di Gregorio and Shane (2003)	X	X
Debackere and Veugelers (2005)	X	
Degroof and Roberts (2004)	X	
Ferguson and Olofsson (2004)		X
Fontes (2001, 2005)	X	
Franklin et al. (2001)	X	X
Gibb (2005)	X	
Harmon et al. (1997)		X
Heirman and Clarysse (2004)	X	
Henrekson and Rosenberg (2001)	X	
Hindle and Yencken (2004)	X	
Jacob et al. (2003)	X	
Jones Evans et al. (1999)	X	X
Kennye and Goe (2004)		X
Krücken (2003)	X	X
Lindelöf and Löfsten (2004)	X	X
Link and Scott (2005)	X	
Mustar and Larédo (2002)	X	
Mok (2005)		X
Nicolaou and Birley (2003)	X	X
Siegel et al. (2003)	X	X
Steffensen et al. (2000)	X	
Upstill and Symington (2002)	X	X
Wright et al (2004a)	X	X

Additionally, several scholars have also proposed suggestions to improve policies that promote entrepreneurship based on empirical studies. On the one hand, Gibb (2005) and Degroof and Roberts (2004) propose general recommendations for new firm formation. On the other hand, Chrisman et al. (1995), Bozaman and Boardman (2004) and Fergusson and Olofsson (2004) offer specific measures: policies linking government and industry to university; measures to improve the role of research centres; and the study of scientific parks, respectively.

Although culture appears as one of the institutional factors, and its particular influence on the spin-off creation process goes beyond the objectives of the present work, it attempts to measure at which point "entrepreneurial culture" characterises local universities.

Other academics such as Jacob et al. (2003) describe a reflection of successful entrepreneurial transformation in the case of Chalmers University of Technology in Sweden. The researchers concluded that universities, in order to be able to meet the demands of the society, have to be assisted by facilitating institutions. These institutions included technology bridge foundations, university holding companies or the Swedish Agency for innovation systems.

Table 3.2.4: Key elements and grouping in the institutional perspective applied to spin-offs

	Region	**Public Research Institution**
Formal	Institutions and infrastructure • Regional development agency • Technology and Innovation promotion organisms • Government's regional representatives	Technology Transfer Office Technological Trampoline Science Park Business Incubators
	Legislation • Territorial Autonomy Act • Catalan University Law	Spin-off creation and promotion rules IP regulation
	Programmes Financial mechanisms (banks, business angel network) Grants for entrepreneurs Incentives for becoming an entrepreneur Contests and prizes	Programmes Spin-off investment fund
	Entrepreneurial region • Innovative firms • Industry – university collaborations • R&D budget • National and regional innovation system • FDIs and multinational companies established	Entrepreneurial university • Number of spin-off companies • Number of subjects, courses and postgraduate programs relative to entrepreneurship • Availability of training for teachers willing to become entrepreneurs • TTO's information diffusion activities
Informal	Role models – gazelle companies	Spin-offs as role models Organizational structure University community's perception on teachers/researchers' entrepreneurial activity Teachers/researchers' awareness about the functions and support a TTO can offer when creating a spin-off The pressure of "publish or perish" Students attitude on starting a business Employment conditions and opportunities

All these previous experiences should be the starting point to analyse our local institutional framework, although we understand that they function in a well-defined historical, geographical, social and economical context. In Table 3.2.4 we identify the main formal

and informal institutional factors used when studying regions and PRIs, concretely, universities.

3.2.2.3. Taxonomy of incubation strategies

There are very few studies trying to shed light on the different existing taxonomies of European Research Institutions according to their objectives, strategies, resources and activities undertaken. After reviewing the scarce literature on this topic, Clarysse et al. (2005) offered a good comparative framework of taxonomies detected within European Institutions to map the activities, resources and activities undertaken. Based in an in-depth analysis of the seven cases from 13 European regions, Clarysse et al. (2005) identified three distinct incubation models[6] of managing the spin-off process: *Low Selective*, *Supportive*, and *Incubator*.

Each model serves different goals and objectives. In terms of objectives, the Low Selective model has a mission oriented towards maximizing the number of entrepreneurial ventures in line with the entrepreneurial mission of the research institute(s) to which the unit is attached. These ventures tend to be self-employment oriented start-ups, which only rarely grow beyond a critical size of employees. The Supportive model is oriented towards generating spin-offs as an alternative to licensing out its IP. This model tends to generate profit-oriented spin-outs, with potential growth opportunity. Finally, the Incubator model makes a trade-off between the use of a body of research to generate contract research versus spinning-off this research in a separate company.

To validate these three models, forty-three random cases in the same regions were selected to compare to these models in terms of resources and activities. This validation process identified two categories that departed from the reference models, namely, the Resource-Deficient group and the Competence-Deficient group which represent two broad kinds of deviations from the initial models.

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[6]Like Clarisse et al. (2005), we employ the UK Business Incubator (UKBI; www.ukbi.co.uk) definition of business incubation, being a dynamic business development process encompassing one or more of the following functions: (1) encouraging faster growth and greater survival rates of new companies, (2) helping to identify investment opportunities, (3) facilitating the commercialization of university or corporate research and new ideas and (4) helping to create jobs and wealth and to tackle specific urban or rural economic development problems.

3.2.3. Research design

A three-stage methodology is employed. First, an extensive literature review of existing studies of spin-offs from PRI and informal meetings with directors of PRIs in Catalonia was used to identify and explain the different incubation models of the spin-off activity and to build our model. Second, a qualitative approach was used to identify the strategy of the UdG's Technological Trampoline in terms of resources and activities and how the process of spinning-off ventures is organised. In this stage, several methods of data collection were used to address these issues, enabling to cross-check results. Finally, we pattern matched our findings with Clarysse et al. (2005) typologies with the aim of classifying UdG's incubation strategies in the context of European research institutions and we also analysed how well they fit with the environment.

In performing this study we followed procedures commonly recommended for conducting case study research (Eisenhardt, 1989; Yin, 1989). Data collection was performed at different levels and using a mix of techniques, avoiding common method bias. Our multi-dimensional dynamic approach involves two main different levels of analysis: the local environment at the PRI and the PRI with particular emphasis on the Technological Trampoline and a secondary one, the spin-offs that emerged from the TT since its foundation in 2001.

Next, we examined the organisation of incubation spin-off services from the perspective of the parent institute. This entailed looking at two interrelated levels: the internal activities geared towards spinning-off companies and the context in which resources are employed. At this stage, in order to track, analyse and identify resources, activities and changes over the time a history approach was necessary. Herein, the tracing of historic PRI documents (e.g. plans, contracts, etc.) was central and complemented with extensive interviews about the PRI's history and current operations. Thus, we carried out semi-structured interviews with the former and the current head of the TT and the two present business development assistants.

Afterwards, we interviewed representatives of the spin-offs that emerged from the TT at UdG, focusing on the start-ups history and resource acquisition. Since the foundation of

UdG's TT, ten companies have been created and we focused on understanding better the dynamics of venture formation and development as it is embedded in this particular PRI.

These in-depth face-to-face interviews ranged from two to three hours in length and were recorded and then transcribed. All these interviews were held on site at the UdG and at the businesses from May to September 2006. Triangulation was aided by the collection of archival data (Yin, 1989). To avoid confirmatory biases, one of the authors kept a distance from the field observations and focused on conceptualisation and analysis of the interpretations developed by other researchers (Vohora et al., 2004). Responses from the interviews and other data were developed in a case study database, which included the use of tables to record data (Miles and Huberman, 1994). These tables ensured that the data collection was focused on the research questions and verified the same information was being collected for all cases. Cross-case analysis, pattern matching and other content analysis techniques (Eisenhardt, 1989; Yin, 1989) were used.

3.2.4. Results and discussion

3.2.4.1. The role of the region for spin-off creation at PRI

Regional environment: Catalonia

The region hosting the research site is *Catalonia* (Comunitat Autònoma de Catalunya), a region with an area of 32,000 squared kilometres and a population of seven million people. The regional government is competent in designing technology policy, innovation system and research plans for the region, considering its idiosyncrasy. In fact, the functioning of a "Comunitat Autònoma" in Spain is similar to that of a Federal State (US) or a Land (Germany).

The main distinctive characteristic of the regional R&D system of Catalonia is its level of resources, above the Spanish average, but still far from other scientific regions/countries of excellence (CIDEM, 2006). The population with university studies in Catalonia is slightly higher than in Spain, UE-15, East Midland and Lombardy. Employment in medium-high and high-tech manufacturing puts the region in the second best position just after

Lombardy. Furthermore, in 2003, Catalonia spent 1.38% of its GDP in R&D activities and it had 6.42 researchers per every 1,000 inhabitants.

In Catalonia, the business sector represents the backbone of its innovation system with 67% of the total expenses, the other triple-helix poles, like administrative bodies and government, provide them adequate environment and tools, while universities and public centres are a valuable source of external knowledge (CIDEM, 2006).

Catalonia together with Madrid and the Basque Country are the main pillars of the Spanish innovation system, representing 73% of the business expenses in R&D in 2002. With only one sixth of the Spanish population, Catalonia generates more than one third of its high-technology exports (34.6%) and almost a quarter of the R&D expenses (22.84%) as well as a quarter of the industrial GDP (25.52%).

Concerning formal factors in the context of the Institutional theory, similarly to Sweden (Jacob et al., 2003), in Catalonia, universities are largely public and state-owned. After the "third mission" was defined and outlined along the commercialization of research, some legal solutions and efficient institutions (Henrekson and Rosenberg, 2001) were supposed to facilitate the process and act as a bridge between academia and businesses. In Catalonia there are basically three institutions that design and execute these policies: CIDEM (at regional level), MCYT and CDTI (at national level)

First, the *Centre for Innovation and Business Development* (CIDEM), established twenty years ago by the regional government, was created with the aim of improving the competitiveness of the Catalan industrial sector mainly dominated by SMEs. CIDEM initially focused its efforts on enhancing the quality of the Catalan industry and strengthening its presence on international markets. At present, CIDEM is concentrating its efforts in innovation, the backbone of its industrial policy. The positive results obtained by the CIDEM have been acknowledged by the European Commission, which uses the Catalonia Innovation Plan as a role model for businesses (EC, 2002).

Their actions are carried out within six programs, one of which emphasises actions related to new venture creation support. In this last programme, the specific activities include: a)

advice and assessment for technology-based entrepreneurs; b) *concept capital*[7]; c) *genesis capital*[8] and d) several financial resources like *Invertec*[9], *Invernova*[10], Private Investors Network, non-refundable grants and other incentives to create a company like loans below market prices (CIDEM, 2006).

Second, the *Ministry of Education and Science* (MCYT), launched a nation-wide Innovation Plan for 2004-2007 including among other measures: the call for support of new technology-based firms' creation through incubators and venture capital, improved coordination between public and private sector (with specific measures targeting scientific and technological parks), additional support to TTO's and other technology centres. Furthermore, the Ministry's Torres Quevedo Programme provides subsidies for enterprises and other organisations, like scientific parks, that employ researchers and PhD students.

Third, the *Centre for the Development of Industrial Technology* (CDTI) is a national public organisation whose main objective is to assist Spanish companies to increase their technological competences. Among its activities, we highlight: a) the promotion of technology transfer and technological cooperation between enterprises and b) support in the development of new technology-based firms, through the Neotec initiative. The Neotec actions go from financial aid, training services or expert advice, up to the design of specific actions to facilitate the interaction between entrepreneurs and investors.

All the above-mentioned institutions and their support are part of the public system. However, there are private actors that also promote mechanisms and programmes that complement the public ones. The main ones are foundations (Fidem, CP'AC, MITA, CEDEL) that focus on specific targets such as women entrepreneurship, young people, unemployed managers and ethnic entrepreneurship, respectively. Furthermore, informal factors are also relevant for the creation of spin-offs, specifically referred to the Catalan culture and the values and attitudes towards entrepreneurship. In our case, although the

7 Concept Capital is a participative loan, up to € 100,000, for new technology-based companies spinning-off from PRI with at most 2 years of existence.

8 Genesis Capital is a grant provided to new technology-based entrepreneurs used to evaluate the feasibility of the project within its first year of operation

9 Invertec is a company that makes short-term capital investments in technology-based companies at the seed phase of the project

10 Risk Capital Fund to invest in innovative technology-based companies at an early-stage

family tradition and the prestige of the entrepreneur are surprisingly not determinant factors in the new firm decision process, role models and success experiences are very important for the optimum climate to entrepreneurship in Catalonia. Additionally, not enough incentives for research, too much bureaucracy and non-entrepreneurial mentality of the university system are perceived as the main barriers to entrepreneurship.

Local environment: Girona and its university

During its historical industrial evolution the province of Girona is characterised by certain dynamism, meaning a progressive and continuous growth. In the meantime, it has been complemented with high capacity of structural transformation–passing from industry to services-, with the sustained help of the local agents characterised by entrepreneurial spirit (Girona Chamber of Commerce, 2006a).

All these elements contribute to the province's position in the regional and national context. The latest economic yearbook (La Caixa, 2005) ranks Spanish autonomous communities and provinces by their income per capita using 10 intervals of earnings. In this configuration, the region of Catalonia and the province of Girona are clearly surpassing Spain, the latter being among the best ranked province.

The main industrial sectors of Girona include meat products (mainly pork), cork, and machinery and metal products. Moreover, due to its location, tourism and related services represent and important economic component. These characteristics are reflected in the distribution of its labour force by economic activity where people employed in services account for more than 60% of the occupied labour force and an unemployment rate below 5.5% (Girona Chamber of Commerce, 2006b).

Hosted by the city of Girona, with a population of over 100 000 and situated a hundred kilometres northern Barcelona, the University of Girona was founded in 1991 in accordance with the Establishment Act approved by the Parliament of Catalonia. At present, the university has 15 000 students and almost one thousand academics specialised in different fields as human sciences, social sciences, architecture, life sciences and engineering among others (University of Girona, 2006). Table 3.2.5 shows the main figures of the UdG.

Table 3.2.5: General information of the UdG

Indicators		**Indicators**	
Faculties	18	Spin-offs	11
Departments	20	Scientific and Technological park	Yes
Research groups	100	Electronic bulletin on research	Yes (monthly)
Research institutes	8	Bachelor degrees	21
Other institutions	19	Bachelor degrees with entrepreneurship subjects	1
Academics	970	Master degrees	25
▪ Full professors	6.8%	Master degrees with entrepreneurship subjects	2
▪ Associate professors	25.5%	PhD programmes (own + interuniversity)	6 + 11
▪ Assistant professors	12.4%	Postgraduate and PhD students	2,417
▪ Full-time teaching assistants	7.8%	Contract research (M€) in 2003	3.02
▪ Part-time teaching assistants	43.4%	External research funds (M€) in 2004	9.57
▪ Miscellaneous other ranks	4.0%	Internal research budget (M€) in 2004	1.21

In Catalonia, similar to the Basque Country (Moso and Olazaran, 2002), the creation and consolidation of a R&D structure happened in two phases: 1981-1990 and 1991-1996. The majority of the universities in these regions founded their technology transfer offices in the first period.

The UdG shows a continuous and sustained growth of R&D contracts, the most used technology transfer channel among academic researchers. For example, in 1993 there were 20 R&D contracts that represented €390 000 and in 2004 there were 164 contracts with the business sector representing €3 020 000 (Technology Transfer Office, 2005).

The UdG applies for a specialised and decentralised model of technology transfer. Located in the main campus, together with science and engineering faculties, the Technology Transfer Office (TTO) provides administrative and supporting services relative to the different transfer modalities. Their functions are divided in two main areas a) specific activities of managing research incentives such as information, promotion, application and registration of European, national and regional research funds; b) technology transfer and knowledge management, acting as a bridge between industry and academia, promoting knowledge exchange basically through three mechanisms: R&D contracts; intellectual property, licensing and patenting; and spin-off creation.

Figure 3.2.1: Main units of UdG's science-based and technology transfer activity

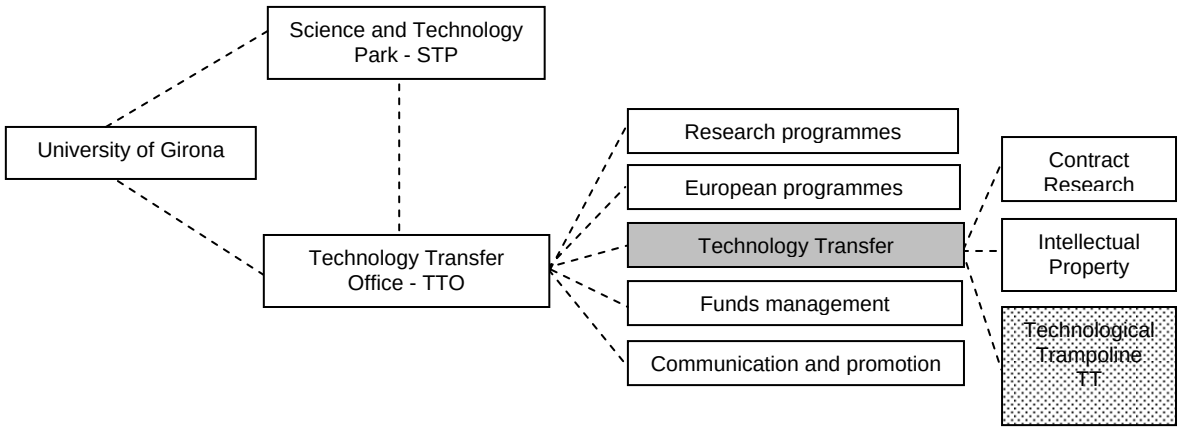

Figure 3.2.1 describes its main units: 1) research programs; 2) European programs; 3) technology transfer unit including the *Technological Trampoline* (TT); 4) funds management; and 5) research communication, promotion and diffusion.

The Technological Trampoline (TT) is a public independent entity integrated in the TTO and responsible for promoting technology and knowledge exchange basically through spin-off creation. Although the TT is linked to the TTO in terms of office spaces and other physical resources, its functioning and budget are independent from both the University and the TTO.

Since 2002, the UdG jointly with the Ministry of Science and Technology and the regional government are promoting a scientific and technological park to foster technology transfer between the academics and the business sector. Currently, this park is still under construction and situated 1.5 km. from the campus. It has approximately 50 000 square metres available from which 8 000 square metres are been built. From those, 3 600 square metres will be reserved to locate ventures spun-off from university.

3.2.4.2. The role and the resources of the TT-UdG

Strategy, objectives and evolution of the TT

The TT from University of Girona has a clear technological focus. According to both the former and the current head of the TT, it follows the recommendations from CIDEM to select the projects that would be given support:

- A differentiating/unique technology
- Global market-oriented
- Venture capital-oriented

Although since the founding of the TT in June 2001 the main criterion to select projects has been to have a differentiating technology susceptible to be patented (see Table 3.2.6), this criterion has not always been followed strictly, especially in the beginning. According to the former director of the TT:

Table 3.2.6: Criteria to select projects

Criteria to select projects	**Mean**
To which degree the selected projects can receive venture capital? (1=none, 2=low, 3=medium, 4=high, 5=always)	3,75
To which degree the selected projects have a differentiating technology susceptible to be patented? (1=none, 2=low, 3=medium, 4=high, 5=always)	4,13
To which degree the selected projects are product-oriented? (1=product; 5=service)	1,5
In what markets do they operate? (1=local, 2=regional, 3=national, 4=European, 5=international)	4,13
Time to breakeven (1 < 1 year, 2= 1-2 years, 3= 2-3 years; 4= 3-4 years; 5 > 4 years)	3,67*
Time to venture capital	2,67*

** 3 responses*

"…In the beginning we had to select some projects that were more service-oriented, otherwise we would not have supported any project. Actually, we received very few projects because researchers did not know what a spin-off was and how our TT could support them in commercialising their research…We had to change their culture, we had to teach them that there were other means to commercialise their research apart from contract research and patenting…"

According to the former director of the TT, time to breakeven and time to venture capital were not criteria to select projects because they did not have the expertise to evaluate them. Still, the TT network in Catalonia has no expertise in evaluating these criteria. Furthermore, these criteria can not be applicable to some projects that need a long time to develop their technology/products. For example, the TT is supporting a biotechnology spin-off which the average time to develop a new product is 10-15 years.

Since June 2001, the TT has evaluated approximately 101 projects from which 29 have received support. From those, 12 have received public funding (1.7 M€ in total) even

though they have not been legally constituted as a firm. Only 10 spin-offs have been legally constituted, which makes a ratio of 1 every 10 projects evaluated. The half of these spin-offs have received venture capital (2.6 M€ in total) and only two owned one or more patents. They are mainly situated in the incubation stage of development and none of them has reached the breakeven.

The historical evolution of the TT in Girona has gone through 4 main stages, as it is shown in Table 3.2.7.

Table 3.2.7: Historical evolution of the TT

Stages	Main activities
Concept (1999-2001)	Exploration and planning phase. The TT was not formally constituted and research on the topic was being done. A spin-off was created as a role model for the future functioning of the unit
Creation (2002-2003)	Formal constitution and organisation of the unit and integration in the TT network. The services provided by the TT were not still consolidated and the main objective was to create awareness within the academic community
Consolidation (2004-2005)	Consolidation and routinisation of the services and activities provided by the TT. Incorporation of new personnel. The academic community accepts this new mode of technology transfer (institutionalisation of the unit) and the creation of UdG Iniciatives, SL to participate in the spin-offs
Growth (2006)	The first results are obtained (some of the spin-offs receive venture capital)

Activities and services provided by the TT

The TT uses different instruments to promote its activities and attract new spin-off projects. First, they organise one or two workshops per year with over 100 people audience where they explain what a spin-off is and promote the services provided by the TT. Second, the TT participates in the organisation of two contests of new ideas in the region. Third, the TT has a stand in an industrial fair yearly organised in the engineering faculty. Fourth, the TT organises 10 seminars per year on IP protection, entrepreneurship and management. These seminars are oriented towards the fulfilment of the entrepreneurs' formation needs, however, academics and researchers are welcome to take part in them. Fifth, TT's personnel periodically visit the best quality research groups at university (there are 110 research groups from which 24 provide 80% of the total contract research income at UdG). Lastly, the TT has its own website where entrepreneurs can find any information they need about the functioning of the TT.

In the following table (Table 3.2.8), we indicate the services provided by the TT, number of users, if it was offered during its first year of operation, the average importance of this

activity according to TT's personnel and the valuation of this activity in comparison to other TT from the network.

Table 3.2.8: Activities and services offered by the TT

Activities and services	**Initially offered**	**Users***	**Importance ****	**Valuation*****
Seminars and workshops oriented to explain what entrepreneurship is and its process	No	400	3	1.5
Postgraduate course in technological entrepreneurship	No	20	3.5	1.75
Office spaces and other services (fax, meeting rooms, etc.)	No	6	4	1.5
Presence of TT's personnel in the spin-off	Yes	20	5	2.75
Evaluation of the spin-off's projects	Yes	101	4.5	2.5
Assistance in the business model definition	Yes	29	4.75	4
Assistance in writing the business plan	Yes	29	3.75	4.5
Assistance and management of IP rights	Yes	10	4.25	2.5
Information and assistance in applying for public funds	Yes	12	4.75	4
Search for external capital (seed, business angels, vc, etc.)	Yes	5	4.25	3.25
Workforce selection for the spin-off	No	5	2.75	2.25

* Since the TT was founded in 2001 till December 2005
** 1=non-important, 2=scarcely important, 3=average, 4=important, 5=very important
*** 1=below average, 2=average, 3=slightly above average, 4=above average, 5=highly above average

Interestingly, the services that the TT's personnel consider more important to support the process of venture creation are: 1) the presence of TT's personnel in the spin-off in its early stage of development; 2) the assistance in the definition of the business model; 3) information and assistance in applying for public funds and 4) evaluation of the spin-offs proposals.

It is also noticeable that the activities and services that were not offered in the beginning of the TT but are presently offered are not considered very important for its workforce (education, training and office space). Additionally, there are some services provided in a non-systematic way and sometimes by external individuals such as: legal, administrative, labour and tax consulting services and search for partnerships and suppliers both with and importance rate of 3.5. Furthermore, the TT considers extremely important to assist the spin-offs putting their products/services in the market and the marketing of such products (5). However, when the same question was asked to the spin-offs founders, almost all of them considered that it was impossible that any TT knew every market so they considered this service not very important.

Currently, the process of supporting spin-off creation has three main stages:

Diagnosis/evaluation phase, where the business idea is evaluated and classified as spin-off (exploit research results and knowledge obtained by these researchers while working at university) or start-up. During this phase the TT decides whether the initiative is feasible, according to both internal (UdG) and external (CIDEM) requirements.

Pre-incubation phase, where the project can benefit from all the services provided by the TT. A project manager is assigned to the project and with external advisors they constitute a pseudo board of directors that simulates the real functioning of a board. Once the business plan is written, the TT presents a report to the research vice-chancellor at UdG where they recommend whether or not to support the project and the specific conditions of the agreement with the promoters.

Incubation phase, where the promoters have to sign an agreement with the UdG for the shares and call options they would hand out to the TT for the services provided. In this stage the project receives continuous support from the TT, especially in the consolidation of the entrepreneurial team, marketing and sales and new sources of funding. This incubation phase lasts approximately three years, depending on the project and a post-incubation phase is expected.

Structure and human resources of the TT

In the beginning, there was only one full-time and a part-time worker in the TT unit. This situation remained until March 2002 when another full-time assistant was incorporated. During April-September 2005, two full-time business development assistants were incorporated and in December 2005, the director left the unit and promoted one of the assistants for this position. Currently, the team is composed by three members in a very horizontal non-hierarchical organisation. Each member takes a project from the beginning till the post-incubation phase, providing all the support and resources required.

Surprisingly, none of the members of the team has technological background although one of the main criteria to select projects is their differentiating/unique technology. All of them have a master's degree in economics and they also have background in entrepreneurship. For example, the director of the TT has a MBA. The team is very young, with an average age of 32, ranging from 26 to 38 years old. Their experience in the business world in areas

like manufacturing, sales or R&D is quite limited, they have mainly worked in financial departments as it is shown in Table 3.2.9.

Table 3.2.9: Technological Trampoline team's experience

Technological Trampoline's team experience (years)	**A**	**B**	**C**
Experience in R+D	0	0	0
Experience in manufacturing/production	0	0	0
Experience in sales, marketing or business development	2	0	0
Experience in finances	4	2	8
Experience in legal aspects	0	0	2
Experience in engineering or consulting	3	2	0
Experience in management (CEO, CTO, director, etc.)	5	0	2
Experience in supporting entrepreneurship	4	1	1

Unexpectedly, none of them have created a venture of their own before and none comes from the academic world. Their main competences are: the support in the development of the business plan, support in obtaining public funding, patent management and other consultancy services. However, they lack competences in marketing and sales, a factor that the literature considers can influence the success of the supporting process. In order to overcome their lack of competences in certain areas, the TT has joined the public Catalan network of Technological Trampolines (XTT) created by CIDEM.

The TT has developed a methodology to self-evaluate projects that addresses to the TT looking for support. This methodology works for the majority of projects (80%) but for the rest of the projects the TT uses external advisors from venture capital firms.

Technological resources

Although the main criterion to select projects has been to have a differentiating technology susceptible to be patented, it has not always been strictly followed, especially in the beginning (see Table 3.2.10). For example, although the TT's team affirms that the selected projects should have a differentiating technology/knowledge, they did not rigorously follow this rule. Only 3 of the 10 spin-offs created had a completely new technology, 2 of them employed existent technology and the rest presented different degrees of newness. In addition, two of these spin-offs hold six patents and other three have IP protections (know-how license and notary acts on software).

Table 3.2.10: Comparison between the theoretical technological selecting criteria and the evaluation of the technology of the spin-offs created

Technological criteria	**Mean**
Theoretical selecting criteria	
To which degree the selected projects have a differentiating technology susceptible to be patented? (1=none; 5=all of them)	4,13
To which degree the selected projects are product-oriented? (1=product; 5=service)	1,5
Evaluation of the technology of the spin-offs created	
To what extend the selected projects use existing knowledge to develop their first product? (1=all knowledge was new; 5=nearly all used knowledge/technology existed)	2,75
To what extend the selected projects synthesize existing knowledge to develop their first product? (1=no synthesis; 5=a lot of synthesis)	3
What was the scope of your know-how/ technology? (1=specific product; 5=platform technology with many applications)	3,03

With respect to quality and legitimacy of the R&D, six of the spin-offs created were grounded on the results obtained in a previous research project (with an average of 4.25 years working in the project), one of them was motivated by a contract research with a private company and the rest did not have any research project nor contract research with an external. The TT at University of Girona has no technological specialisation, assisting any kind of technology developed in this PRI. Nonetheless, the former director of the TT tried to establish close links with the best performing departments of the university.

Interestingly, the majority of the projects came to the TT and were given support from the idea/opportunity recognition phase (50%) and 40% from the first prototype phase. Only one project was given support after the legal constitution of the firm, when it had already developed its products.

Regarding Intellectual Property protection, there are at least three acts, directives and by-laws that regulate the process of transferring IP from universities to academics or ventures. We describe the main acts and directives related to IP protection at three levels: national, regional and local (UdG).

The 20th article of the national IP act (Law 11/86) deals with the ownership of the IP rights of the inventions developed by researchers and academics at universities as a result of their research activity. Concretely, this article establishes that the IP rights belong to university and that academics have the right to participate in the royalties obtained by the exploitation

of such an invention by university or by the transfer of rights. Each university has the right to establish the conditions and amount of such participation in its by-laws. However, if the researcher's invention is a consequence of any kind of contract research with either public or private entities, this contract should specify which party would hold the property rights.

The 67th article of the Catalan Universities act (Law 1/2003) leaves the autonomy to regulate IP rights to each Catalan university. This act only establishes that the competent regional department in university affairs has to promote IP protection programmes within the university community in Catalonia.

In table 3.2.11, we describe the main regulatory differences between spin-offs and start-ups at University of Girona:

Table 3.2.11: Regulatory differences between spin-offs and start-ups at UdG

	Spin-offs	**Start-ups**
Promoters of the venture	Researchers, academics and other fellowships	Any worker, student, ex-student from the UdG
Participation of the UdG in the equity	Up to 20%	Up to 10%
Type of participation	In exchange of the services and IP rights provided by the university (the UdG would not pay out any money for its shares, only services)	In exchange of the services provided by the university (the UdG would not pay out any money for its shares, only services)
Board of directors	Proportionally to its shares, but at least 1 representative elected by the rector (with no vote)	No
Technology, license or other IP transfer to the firm	Yes	No
Other requirements	Preferential relation with UdG in contract research	No

Financial and physical resources

The TT is exclusively funded by the CIDEM. Its current budget is €150 000 per year[11] rising from €90 000 in 2002. The reason why the TT is exclusively funded by CIDEM is historical. Initially, neither the TTO nor the UdG had considered supporting spin-off creation as an activity for commercialising research. It was a new concept that needed a cultural change at University; the UdG was still in its "ivory tower" in 2001. CIDEM was

11 It does not include physical resources such as office space and equipment which are provided by the TTO for free.

the real promoter of this initiative among Catalan universities so it had to provide funding to overcome University's initial barriers.

Currently, the TT has also €25 000 provided by the UdG to be used for IP protection. The TT forecast that in 2-3 years time they will be financially self-sufficient. Their incomes will come from the profits generated by the spin-offs they have participated and the public grants they apply for.

One of the main barriers that the literature stresses in the process of creating a new firm is the lack of funding, especially for science-based firms that need significant amounts of money to be able to develop their products. To assist in overcoming this entrepreneur's initial barrier, the UdG participates in Invertec, SL, a seed capital fund promoted by the regional government and coordinated by CIDEM. The aim of this fund is the promotion of Catalan technology-based firms by participating in their equity. It invests up to €300 000 in those firms spun-off from PRI that have the support from Technological Trampolines. In addition, in 2006 the UdG has created its own network of business angels formed with local actors such as business men.

Due to the difficulty that universities have to directly participate in the equity of the spin-offs, the UdG created a company, UdG Iniciatives, SL, to articulate its participation. At present, this instrument has already participated in five of the spin-offs created by the UdG and has options to participate in the rest. Its participation varies from 3 to 10% of the equity. The UdG does not have any seed capital fund of its own.

Apart from this, the UdG also offers office spaces below market prices (6 €/square metre) to spin-offs. In some exceptional cases, the UdG provides equipment and laboratory facilities. However, the most common arrangements for these facilities are via contract research with specific research groups or departments at university.

At present, the UdG lacks office spaces, laboratories and other equipment for the spin-offs they are supporting. In the mid-term, this problem will be solved with the complete construction of the Scientific and Technological Park of the UdG.

Organisational and networking resources

The organisation and functioning of the TT is clearly marked by the CIDEM. This regional development agency monitors and evaluates the TT's activities. During the TT's five years of existence (2001-2006), CIDEM changed its evaluation criteria. At present, qualitative aspects complement the initial quantitative ones.

The TT offers a range of support activities and services, but to complete the internally lack of resources, they use their social network. This network includes firms, consultants and institutions specialised in technological development, commercial activities, venture capital and financial entities, management and business administration and R&D projects. Although we are aware of the existence of both formal and informal agreements between the TT, our attention focuses on the formal ones due to the difficulty of monitoring the latter.

The TT developed its own network of advisors and assessors; during its evolution it became more complex and diversified. We perceive continuity -showed by the number of formal contracts with the agents- in domains like technological development, management and business administration. In the meantime, a growing trend characterises all other concepts where the number of collaborative firms and institutions doubled. Major changes happened at the level of venture capital and financial entities, where initially the TT signed formal collaborative agreements with three agents, while in the present this figure has grown to ten. The network is mainly made up by local and regional agents (CIDEM), though in more complex matters networking happens at national level.

3.2.4.3. Typology of incubation strategy at University of Girona

Based upon the data collected, the following section outlines the model followed by the UdG and classifies it according to the models identified by Clarysse et al. (2005).

Activities

- *Opportunity search and awareness creation*

The TTO hosts the contracting of research activities, the IPR activities and the spin-off support of the UdG. Most opportunity recognition happens in an indirect way. Usually,

since it is a small university, the TT's personnel periodically and informally meets with every quality research group director in order to inform of the spinning-offs possibilities of their research. Furthermore, the TT has also accepted many projects coming from outsiders, for example ex-students and end-of-contract researchers. In these cases, the criteria to select projects based on a differentiating/unique technology coming from the PRI has not been strictly followed. This statement is supported by the data collected in the interviews with the founders that describes their technological relationship with the UdG as "scarce".

Overall, the trigger to spin-off is thus quite complex and staged in this case. It is especially oriented towards professors and researchers that can have a career at the UdG but many outsiders also benefit from their support. In certain cases, spin-offs present an alternative to employment at an established firm, especially for end-of-contract researchers. According to Clarysse et al. (2005), in terms of opportunity search and awareness creation the UdG follows a mixed model, Low Selective and Supportive.

- *Strategic choice how to commercialize R&D*

The selection criteria are limited, and projects eligible for funding are at a very early stage in the spin-off funnel. However, the spin-off services not only give advice during the phase of project validation like in the Low Selective model but also in later phases. Since its creation, the TT at UdG has received 101 projects, of which the selection committee approved 29 but only 10 spin-offs have been legally constituted. Moreover, there are clear selection criteria though sometimes are left a part, especially in technology matters. Typically, researchers have to prepare a business plan to be selected by the spin-off service. This results in an acceptance rate of about 29%, but a creation rate of 10%. According to this data, the UdG follows the Supportive model.

- *Intellectual property assessment and protection*

Although the IP department is not the heart of the technology-transfer service via spin-off creation, proprietary technology is likely to be the key trigger to spin-off a company. However, this criterion has not always been followed and, in reality, it appears not to be the result of a strategy designed to create value from R&D strategy but of the entrepreneurial

mission of the university. Nonetheless, only 20% of the companies owned a patent. In this sense, the UdG follows the Supportive model with traces of Low Selective model.

- *Incubation and business plan development*

Incubation and business plan advice are key activities in this model. The researchers are assisted in writing a preliminary business plan, which can be defended in front of a public or private seed capital fund. Incubation facilities also include space and sometimes access to equipment. However, the UdG is currently resource-deficient in physical resources until the Scientific and Technological Park is fully built. Support includes business advice and coaching among other activities. All this piece of advice and activities are regulated in a contract in exchange of a part of the equity of the spin-off. In this sense, the UdG follows the Supportive model with traces of Incubation model.

- *Funding process*

The UdG grant public money to these early stage projects, mainly through CIDEM and CDTI. However, the UdG also makes great use of public/private partnership funds, which are usually organised as a seed capital fund (INVERTEC) where the UdG participates. The amount of money invested ranges from €100 000 to €300 000 per spin-off. This fund tends to invest in earlier stages and lower amounts than a typical VC, it will hold equity in the company after separation with the percentage of equity taken varying but never comprising a majority. The UdG also participates in three business angels' networks. Therefore, the UdG follows the Supportive model with traces of Low Selective model.

- *Control over the process after the spin-off of the company*

The amount of money available is limited and is usually only sufficient for a couple or three years. Most companies founded through this process are likely to seek complementary revenues through short-term contract research or consulting. In the UdG, 50% of the spin-off companies have already received seed capital financing but only 20% of the firms have received external capital via VC or business angels. In this sense, the UdG follows the Supportive model with traces of Low Selective model.

Resources

The Technological Trampoline (TT) is a public independent entity embedded in the Technology Transfer Office (TTO) and responsible for promoting technology and knowledge exchange basically through spin-off creation. Although the TT is linked to the TTO in terms of office spaces and other physical resources, its functioning and budget are independent either from the University and the TTO. These characteristics can be mainly found in the Supportive model.

The spin-off unit employs a small team of people familiar with existing government grant programmes. Their human capital is thus more public than private oriented. This team consisting of 3 people is also assisted by the TTO's team (17 people approximately) in terms of contract research, IP and research programmes. This multidisciplinary team has links to the financial world to be able to evaluate the business plans (a ratio of 48:1 researchers to TTO officers but a ratio of 323:1 researchers per spin-off creation officers).This team is typically found in a Supportive model but also in the Incubation model.

The spin-off service has a clear technological focus, but irrespective of technological area. However, it focus on the best performing departments of the universities, mainly applied research based on previous research projects, PhDs and contract research with industry. These characteristics are typically found in a Supportive model.

Currently, office space and infrastructure are organised within the university and do not play a determining role. However, in the short term the Scientific and Technological Park with its incubation centre will devote more physical resources to spin-off creation. The lack of office space and other equipment have been identified as one of the main pitfalls of the service, either by TT's personnel or entrepreneurs. It is expected that in this matter the UdG will move from a Low Selective to a Supportive model.

Regarding financial resources, the spin-off service have certain control over a public fund, which can distribute grants or at least have close contacts with other public sector initiatives. In total, the TT has been able to rise 1.7 M€ in public finance and 2.6 M€ in private funds for the 10 spin-offs, either via seed capital or VC.

The success of the UdG depends upon the social network which the spin-off service has developed with various public agencies and the teaching curriculums of the university. Furthermore, the UdG also uses a sort of board of directors as the principal selecting mechanism for spin-offs projects. This board is constituted by business men, academics and the director or the TT. This board is complemented by external advisors (VC directors) when the evaluation is out of the scope of the TT's personnel. Links with local industry, specialised advisors and the VC community are important. Since the value added to equity investment will essentially come from second-round financing by VCs, the success of the spin-off service is quite dependent upon the "entrepreneurial context" of the region. However, the degree to which the government is willing to sponsor entrepreneurial initiatives is even more important in determining efficiency of the service. Probably, the characteristics of the network developed by the UdG are mix between a Low Selective and Supportive model.

3.2.5. Conclusions and future research

Our main contribution is an in-depth analysis of the spin-off creation unit with special emphasis on its variety of resources and activities. In our attempt of giving a holistic view on the matter, we focused on both past and present characteristics. Moreover, we situated the TT in its immediate environment describing its links with the TTO and the PRI, broadening the analysis up to the regional level.

The findings highlight that the region of Catalonia is highly entrepreneurial in Spain, but still far from other European scientific regions of excellence like Baden-Würtenberg or Ile-de-France (Clarysse et al., 2005). At the university level, the commercialisation of research happens similarly to the one described in Debackere and Veugelers (2005), but having different magnitudes. The regional environment clearly impacts on the resource acquisition process of the TT and its spin-offs. Concretely, the regional government is financially supporting this unit and at the same time is creating a network of advisors, business angels, IP specialists and other resources and capabilities to help in the success of such companies. Still, support mechanisms mainly come from the regional level, rather than local (city council, chamber of commerce), national or international levels.

Similarly to Germany (Krücken, 2003), where either the regional government (Lander) or the National Ministry of Science and Research were the main driving forces of the TTOs' institutionalisation process, the motivation of creating a spin-off support unit at UdG was twofold. On the one hand, a general interest of a limited group of people to follow the international trend, including transfer-oriented professors and technology transfer officers. On the other hand, the regional government's initiative to help universities create the adequate structures to facilitate the commercialisation of research via spin-off creation. By that time, the university and its managers were still in the "ivory tower". This resulted into a *laissez-faire* university policy, where the TT followed its own path towards developing and diversifying its activities and finding resources in order to continuously assist and support researchers to carry out their ideas. Lately, the TT in Girona has already gone through a consolidation stage where an institutionalisation of the unit and routinisation of its services has been achieved.

The elements of the three typologies of incubation strategies in European research institutions can be identified at the University of Girona. Nevertheless, the predominant typology at the UdG is the Supportive model. This model stems from the general idea of commercialising technology developed at the RI through other means than licensing or contract research. Hence, the spin-offs are an alternative option to create value from technology and their returns are based on economic profitability rather than financial gains for investors upon exit. Once the TT decides to commercialise technology through a spin-off, the team of researchers is intensively coached, including help with looking for money.

However, in the beginning the TT had to create awareness, entrepreneurial culture and role models, thus the spin-offs created did not follow their selection criteria and initial objectives. Therefore, we still can observe a mixed model between Low Selective and Supportive. According to Clarysse et al. (2005:212) "…*it is important for RIs to be very clear about their objectives and specify clearly the resources that are needed/activities performed to meet these objectives*". The lack of clarity about the TT's objectives results in hybrid types that can be either resource or competence deficient. In fact, we have observed a hybrid model as a result of the continuous change in its objectives as a consequence of a learning-by-doing, try-and-error process and lack of sufficient competitive research.

As suggested before, another problem identified at the UdG is its shortage of competitive research, which hinders any support to technology transfer activity. In fact, the UdG is only capable of spinning-off one or two technological companies per year, the rest may not be based on a differentiating/unique technology. Thus, the main point at the UdG lies on whether the applied model and the resources employed are worth used. In our opinion, it appears to be inappropriate to acquire the resources required to perform a Supportive model and then try to perform activities associated with a Low Selective model because their research outcomes are not sufficient.

Implications/recommendations

Our research suggests that the University of Girona should have a deeper pool of research with commercial potential. There is a need to first become a research university, with high quality of research (knowledge exploration and creation), and regional, national or international recognition. This can be stimulated through: 1) the recruitment, retaining, and development of star scientists; 2) partnership with leading industries in the region; 3) further investment and resources for research activities; and 4) a change in its incentive structure, especially for tenures.

Next, the process of cultural transformation aiming at converting the university into a more entrepreneurial should happen at different levels: teaching centres, including students and professors, administration and institution government. A major diffusion and a higher number of subjects on entrepreneurship and new venture creation are part of this transformation.

Third, although the TT followed a positive development path strongly guided by learning-by-doing that can be observed in both activities and resources, some recommendations are needed:

- A project selection methodology based on well-defined concepts and procedures is needed. Although the criteria and objectives regarding technology are very clear, the results are not completely successful. A clear methodology would automatically drive to resource savings and a better and more efficient allocation of them.

- Recruit more technology transfer officers with an appropriate private sector background and links with the local industrial districts in order to discover new opportunities, including experience of starting a business.
- At the university level, an incentive mechanism targeted at research groups and individual researchers should be designed by this embedded institution taking into account: academics profile, specific needs and regional industrial districts. Knowledge on existing practices in European research institutions having a more advanced entrepreneurial culture might be a starting point when designing incentive structures and schemes for local academics willing to start a business.
- Although the decentralised organisation gives the TTO freedom of actuation by establishing their goals, mission and objectives, there are no monitoring mechanisms of the impact of their activities in the local environment. Despite spin-off companies are commonly used as a performance indicator, they should be a tool and not an aim when creating regional welfare.

Fourth, our analysis shows a high variety of institutions aiming to support and promote innovation in both enterprises and universities in the region. A frequent, regular and devoted process of continuous information about the existence and activities of such institutions and their initiatives (with special emphasis on national and European context) concerning spin-off creation and promotion could be a solution in enhancing the number of science-based entrepreneurial ventures.

Finally, a number of limitations and areas for further research can be noted. First, examination of the broader technology-transfer strategies of the UdG and the research incentive structure was beyond the scope of this study. Further research should examine the rest of technology-transfer strategies and the balance of spin-offs versus other modes of technology transfer such as licensing and contract research. This study would help us to analyse in-depth the competitiveness of the research at the UdG and its relation with the model adopted for spin-off support. We consider this issue of major importance because it may have important implications for further policies of spin-off creation in Spain.

Second, our research does not deal with an in-depth analysis of the organisational or entrepreneurial culture within the PRI and the local environment. Further research may

usefully examine how structural changes can be made and which cultural transitions are necessary to select and to provide incentives to new academics towards research quality and entrepreneurial activities.

Third, the cultural transition of becoming entrepreneurial at both regional and university levels is a complex issue, and a more-detailed analysis based on historical, social and other criteria would make the analysis complete. Although we attempted to take account of dynamic aspects, the spin-off process in the UdG and many other PRI in Spain is still evolving. Moreover, the majority of the companies spun-off from the UdG are still in their early-stages of development, making quite difficult to evaluate their success. Further research might examine the extent to which the model is successful within this PRI.

Fourth, we do not show the results of the analysis aimed at characterising and analysing the success of the spin-offs created at this PRI. This is part of an undergoing research with the main objective of confronting both sides and show discrepancies if any in the model used by the TT and the expected results.

Finally, a main limitation and a primary future research field refers to the analysis and comparison of the resources, activities and success of the rest of PRI's incubation strategies in the same region (Catalan universities), then broadening the analysis to PRI's located in other regions within the Spain.

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4 R&D outsourcing

4.1. Building bridges between academia and industry: Exploring barriers in Catalonia

4.1.1. Introduction

Early innovation policy documents identified the importance of collaborative research involving the Triple-Helix participants, insisting on the participative role of each. During the last two decades, a continuous effort on measurement and monitoring has been, and remains to date, on the institutional agenda. In this context, the EU revisits the role of Universities in the context of a knowledge-driven society (EC, 2003), stating that growth depends on the production of knowledge, its transmission and dissemination through various channels, and on its use in new industrial processes and services. This implies that the study of both knowledge generators and knowledge users, as well as their linkages, is an important issue in order to find the reasons –motives and barriers- underlying different intensities of cooperation.

In light of the above, European, national, and regional initiatives aim to foster entrepreneurial cooperation with academia getting closer to business environments. These include the various European Frameworks, as well as specific networks like EUREKA for market-oriented, industrial R&D. In Spain there are the ATYCA and PETRI projects, defined to promote the transfer of scientific and technical knowledge from universities to the production, service, and public sectors, as well as fiscal incentive schemes for innovation. In Catalonia, the Ministry of Industry promotes innovation and designs special support schemes, normally linked to CIDEM, the agency in charge of promoting business innovation and development.

Firms' motives for engaging in research partnerships are also important. Under the pressure of fast environmental change, companies tend to seek complementary sources of information in order to achieve higher degrees of innovativeness and competitiveness (Bayona et al., 2002). Engagement in research partnerships is one of the solutions they opt for.

Despite the political support for cooperation with different partners, and the a priori positive attitude from industry, the statistics reveal that these efforts do not translate into high collaboration rates. Cooperation on R&D differs mainly at the country level, but also at a more regional level. The proportion of firms engaging in cooperation was only 10% in Spain and 8% in Catalonia, while the EU average was 19% (EC, 2004; Valls et al., 2004). Considering the type of partner, Universities and other higher education institutes are partners in 4% of the cases for Spain and Catalonia, while they represent 9% of the cases in the EU-15 average. These figures raise the question of the reasons for low cooperation rates in Catalonia and in Spain. What is preventing industry from cooperating with academia?

Thus, our main research question is "What are the barriers hindering cooperation between industry and partners?", as well as finding answers to "What are the factors acting as major obstacles or barriers[12] when collaborating with universities?" We speculate as to whether universities fail to provide enough satisfaction in their partnerships with firms, whether there is a negative attitude of firms towards collaborating with universities, or whether the barriers to cooperate with universities are higher than barriers to cooperate with any type of partner.

In Spain, different authors focus on R&D cooperation between knowledge creators and technology users, or those in the "ivory tower" and those interested in short term results. Most recent studies (Bayona et al., 2001; 2002) try to understand the reasons and motivations that lead companies to cooperate with different partners, especially research based institutions, another presents Spanish innovation cooperation compared to other European countries (Navarro, 2002). Some research based on a survey (Pérez and Martínez, 2003), describes barriers to technology transfer from the academic environment side, in terms of the lack of financial resources, small size of market, high degree of risk, the lack of information on potential business partners, lack of information on know-how and the lack of trust among partners.

We believe that exploring the reasons for low cooperation in Catalonia may contribute to community understanding in several ways: first, to inform policy makers and universities in

[12] We consider that barriers and obstacles are mainly synonyms.

the formulation of strategies to promote cooperation and technology transfer; second, to respond to the call for more empirical research on cooperation in general (Hagedoorn et al., 2000); and finally, to help explain the barriers that industry finds in cooperating with universities, currently lacking in the literature as we will explain in the next section.

The present work extensively refers to research partnerships, broadly defined, as innovation-based relationships involving a significant effort in R&D (Hagedoorn et al., 2000). In particular, we investigate the attitude and barriers encountered by firms towards research partnerships with universities. Our study, using a sample of 15 manufacturing SMEs located in the Catalan region of Spain, makes a distinction between the barriers perceived by firms when collaborating with different partners, and the specific barriers to industry-university collaborations. This research is part of a more general research on the outsourcing of R&D in Catalan 'gazelle' firms as contracted by CIDEM.

4.1.2. Literature review

Those in the 'ivory tower' vs. those only interested in short term results

There is a general interest in analyzing cooperation and research partnerships from several perspectives. Cooperation literature concentrates around a variety of thematic groups:

- Theoretical approaches – transaction cost theory, strategic management, industrial organization (Hagedoorn et al., 2000; Bayona et al., 2001).
- Institutional orientation and models – 'triple-helix', 'ivory-tower', 'third stream' activities and mission (Leydesdorff and Etzkowitz, 1996; Krücken, 2003).
- System and network view – regional and national innovation system, partner selection (Lundvall, 1999; Sorensen and Reve, 1998).
- Technology driven or knowledge based institutions, motives and benefits (Jones-Evans et al., 1999; Tether, 2002).

Due to the abundance of both theoretical and empirical studies on partnerships in general, our first attempt in summarizing cooperation literature was replaced by the review of those making an effort in studying the barriers or factors hampering them. In order to be more

comprehensive, our research includes both industry and partners' inhibitors as found in the literature.

Beforehand, it is worth mentioning that although the literature recognizes the practice of two main types of research partnerships (Hagedoorn et al., 2000) - formal and informal - , empirical studies mainly focus on formal ones. Exceptions still exist; a study investigating major motives of academic researchers for maintaining interaction with industry (Meyer-Krahmer and Schmoch, 1998), results of which show that informal contracts get the second highest position in the ranking of types of interaction between universities and industrial firms after collaborative research. In a more recent study of German universities (Krücken, 2003), the author affirms that technology transfer from and to industry and academia relies heavily on informal patterns of transfer. His interviewees roughly estimated a ratio of nine informal projects to every formal one. Still, this type of information is available only in ad hoc studies or those focusing on universities, while research investigating business environments usually works with data collected in the framework of national or international surveys (Tether, 2002, Bayona et al., 2002) having as a main objective the study of innovation and related activities. In these circumstances, data coming from the above-mentioned studies, with no primordial aim of studying cooperation, can only help indirectly understanding the reasons and barriers of cooperation.

Our literature review focuses on the motivation, partners, benefits, and factors hindering or acting as barriers in knowledge and technology transfer. Few studies center the attention on barriers in general and with universities in particular. The unequal balance of the citations with more available work on the university demonstrates the perceived importance of partnerships by academia. Exceptions include work differentiating between cooperation within the supply chain and beyond the supply chain (Tether, 2002) or the distinction between cooperation partners in terms of customers, manufacturing suppliers, other firms and publicly founded research institutions (Fritsch and Lukas, 2001). Therefore, one of our contributions is the use of the case study methodology to research the barriers encountered in collaboration with other partners.

The aim of this section is to highlight some of the main barriers, since this work will explore whether the barriers already identified in the literature – see Annex 4.1 – apply to our own sample and context. The reviewed works do not ask explicitly for hindering

factors or barriers for R&D cooperation, except for Meyer-Krahmer and Schmoch, 1998; Hall et al., 2001; Krücken, 2003. However, some barriers can be inferred from the motives and benefits explored in these articles.

Unresponsiveness to industry needs

Although only a short time has passed since the 'second revolution' in universities, where increasing importance is placed on the commercialization of research in addition to teaching and basic research, they still concentrate on fundamental research and the education of students (Jones-Evans et al., 1999). The authors are aware of the case in Swedish universities where industry is generally unable to provide problems that are of direct interest to many academic departments. On the other hand, universities are often seen as unresponsive to industry needs (Tether, 2002). It is not just a matter of their intrinsic nature as knowledge creators, but also a lack of academic recognition of commercialization and a lack of incentives to bring closer academy and industry. Moreover, the authors recognize the need to market the university in a more professional light.

Inapplicability of the projects

Projects where universities are involved– by the basic nature of the research carried out – are more complex, long-term, and with no immediately applicable results (Hall et al., 2001; Hall et al., 2003). It was found that the factors hindering the exploitation of research results in Italian universities rely in the fact that basic research is generic, but it creates variety and feeds the activities with marketable results (Chiesa and Piccaluga, 2000). Some differences still exist depending on the technological complexity of the industrial sector (for example electronics and microelectronics, computers, biotechnology, chemistry) which prefer universities due to the high cost and complexity of research they need for product and process development (Bayona et al., 2001; 2002; Meyer-Krahmer and Schmoch, 1998).

Inefficiency in tasks and schedule

Cumulative institutional differences result in the so-called 'cultural gap', which acts as a barrier between business and academia. Specifically, business' perception on university is sometimes described as 'slow' (Tether, 2002), while others identify non-cooperation as a result of mistrust in the ability of academics to perform tasks efficiently and to a predetermined schedule (Jones-Evans et al., 1999). On the other hand, universities find

industry partners as looking for short-term contracts in which they require 'quick and dirty' solutions to concrete problems. Efficiency in academic environments has different measures that in profit-driven ones; factors such as privileged status, life-long employment and freedom associated with academic life can act as disincentives to entrepreneurial initiatives (Chiesa and Piccaluga, 2000).

Inadequateness of existing infrastructure

We have identified infrastructure problems due to insufficient resource allocation. Additional funds can be achieved by universities through collaboration with business partners. Other benefits of industry links include (Jones-Evans et al., 1999): an increase in funds resulting in high-technology equipment, skilled teaching, and top class training normally used to solve 'real' industrial problems. The literature reviewed detects a lack of infrastructure mainly at TTO (need explanation of term) level. Lack of skills and knowledge, small number of individuals, institutional support and professional infrastructure are only some of the noted shortcomings (Krücken, 2003).

Previous negative experiences

The cultural differences between academics and business can result in unsatisfactory experiences, perceived mainly on the business side. These unsatisfactory events, or series of events, can act as a barrier and generate negative attitudes for collaboration and behavioral patterns. Different authors maintain that the interaction between industrialists and academic researchers occurs on the basis of trust. Having either individual (Krücken, 2003) or institutional (Jones-Evans, 1999) trust can eliminate uncertainty. There is a lack of research on the degree of collaboration satisfaction with partners and a need for more empirical research on this matter in order to identify trust-creating environments and factors, which will in turn have an impact on the decision of partner selection or reselection.

Administrative and bureaucratic burdens

Although there is a consensus at institutional level for universities, and local and regional promotion agencies and initiatives exist for enhancing industry-university interaction, there is still a lack of information on the formal aspects concerning them. In a comparative study of Ireland and Sweden focusing on the activities, mission and organization of the Industrial

Liaison Office (ILO) – a bridge between industry and academia- most ILOs indicate the need for national initiatives which provide guidelines for industry to work with university (Jones-Evans et al., 1999). The number of bureaucratic and administrative layers depends on the type of technology transfer office and its degree of centralization. Sweden is a good example, whereby its entrepreneurial universities and decentralized ILOs, even at department level, result in frequent industry collaboration. Although these infrastructures serve universities in commercializing part or all of their research results, in some circumstances they are perceived as additional bureaucratic layers (Krücken, 2003).

Result sharing and confidentiality

The motives underlying research partnerships are most often: uncertainty and cost sharing, joint efforts on complex technological developments and motivations relative to market access and opportunity searching (Bayona et al., 2001). While an imbalance in inputs may occur with no effect on the partnership, clear regulation about outputs resulting from the joint effort should be established. Some U.S. authors bring valuable evidence from the Advanced Technology Program, designed to assist business in creating and applying generic technology and research results in order to enhance competitiveness of industry (Hall et al., 2001; 2003). They demonstrate that intellectual property issues between the two worlds do exist and, in some circumstances, they act as insurmountable barriers. The same study describes the issue of intellectual property vis-à-vis the relationship between firms and university, determined by different, increasing to conflicting, objectives each might have: university research as public good exploited via publications versus other more commercial oriented solutions, like following the path of spin-off creation. Making public the results of joint research partnerships, confidentiality relative problems seem obvious.

Absorption

Firms have difficulties in trying to absorb novel and complex knowledge, so characteristic of academic research. In this case, the literature recommends possible solutions for both sides: companies should have a well-established R&D structure, as well as specific personnel like champions or gatekeepers to help conduct absorption-related activities. For universities, as in the case of the UK, government has pressured academia to shift from traditional science knowledge generation to knowledge production based on problem solving (Tether, 2002).

Geographical distance

Physical proximity between cooperation partners is an advantage relying on the ease with which the relationship is kept under control (Bayona, 2002). Moreover, the authors believe that geographical proximity may help to alleviate the differences in aims, management styles, and culture between business executives and academics. Besides distance, history and the localization of the university might have effects on the exploitation of public research results (Chiesa and Piccaluga, 2000). Recently funded universities, or the ones localized in areas of industrial decline, or having an industrial vocation tend to adapt more entrepreneurial strategies.

4.1.3. Sample and methodology

Having established the main theoretical framework, we will now consider the sample and the methodology employed to conduct our analysis and support our findings.

4.1.3.1. Sample

The data used in this study is part of a larger sample of 59 manufacturing, small and medium-size firms (SMEs) studied in 2002 located in one of the highly entrepreneurial and innovation oriented regions of Spain, namely Catalonia (Solé et al., 2003). The Catalan system of innovation shows specific features that have demonstrated strong efficiency in a catching up economy in Europe (EC, 2002). Local entrepreneurs take advantage of framework conditions offered by local, national and international institutions, with public policy systematically supporting innovation in academic and business environments. In these conditions, companies form the backbone of the local economy, also reflected by the distribution of R&D expenses between 'triple-helix' participants: government 0,10, higher education 0,28 and enterprises 0,81 summing 1,19[13] as the percentage of Catalan GNP in 2002, a figure higher than 1,03 corresponding to Spain[14] (Statistical Institute of Catalonia).

Moreover, fast-growing companies who are able to achieve success through various means over a lasting period - the so-called "gazelle" firms- together with new business ventures

13 1.628.004 thousands €

14 7.193.538 thousands €

are important for the economic development of countries and regions. Their significance relies on three main characteristics: i) they concentrate high shares of employment; ii) they are often the foundation of competitive industrial regeneration (Hernández et al., 1999); and iii) gazelle firms' innovation related experiences serve policy makers in highlighting innovation best practices for average companies, as well as transmitting to them the message that sustained, fast growth is the result of devoting managerial efforts and resources to both product and process innovations (Ribera et al., 2002).

For our study, in an attempt to identify the barriers encountered by companies when subcontracting either part or all of their R&D activities, we selected those giving valid answers for the following questions:

- How important are the following factors as barriers or obstacles for outsourcing R&D? Where the possible answers are the ones presented in Table 4.1.3.
- In the case of collaborating with universities, how important are the following barriers or obstacles? Where the possible answers are the ones presented in Table 4.1.5.

Through these selection criteria, the firms we refer to sum 15. Due to the small number, we make a cautious interpretation of the results, while our conclusions are merely recommendations. We do not claim generality for either the population or geographic location. However, case studies may not be statistically significant but it is a valid method for exploring new topics, and may bring ideas that are novel and testable in wider samples (Eisenhardt, 1989).

4.1.3.2. Methodology

The main method of collecting data during this study was face-to-face semi-structured interviews with general managers at their place of work. The interviews lasted between one and one and a half hours depending on the willingness of respondents to give information. Prior to the interview a short description of the study was sent out, followed by a telephone call based on written guidelines for establishing the interview's exact date and terms.

The research team, formed by a senior and a junior researcher, conducted a conversation based on the following five areas of interest:

- Sector characteristics (industry entry barriers, competitive factors)
- Firm characteristics (approximate number of products and product lines)
- Innovation process (R&D, sources of ideas, knowledge and technology management including reasons underlying the decision of outsourcing, types of subcontracted R&D, barriers to outsourcing)
- Innovation results (share of new product sales in total sales, distribution of R&D expenses by type of innovation, impact of innovation on results)
- Information relative to the firm (human resources, training activities, year of foundation, export shares, etc).

In the final part of the conversation, participants had to fill in a prepared checklist containing relevant quantitative factors. This step was important in order to ensure the capture of the interviewee's exact perception on important matters. After every interview, the team discussed the data collected. A database, for all, and a case report, for each, were the two instruments for codifying and saving the notes from the visits.

Although previous questions give hints, whether interviewees consider R&D outsourcing necessary in order to maintain and increase their competitiveness, as well as the number of contracts formalized with universities, we decided to ask all participants about the motives and barriers. We considered important questioning all managers –not only those who collaborated in R&D- because, in our view, there could be absolute barriers preventing firms from collaboration – and their effects result in no collaboration. Conversely, relative barriers do not necessarily prevent firms from cooperation but make it more difficult.

Managers had to evaluate 12 items for R&D outsourcing and 11 for university collaboration using a 10-point Likert scale (0 meaning not a barrier, 5 for a surmountable barrier, 10 for an insurmountable barrier). The importance of barriers to cooperation in general, and barriers when cooperating with universities in particular, were investigated. We present the empirical analysis in the next section.

4.1.4. Results

4.1.4.1. Descriptive analysis

The 15 firms surveyed belong to the manufacturing sector. The distribution among subsectors, according to the OECD's classification of manufacturing industries based on technological intensity, and some descriptive data, are presented in Tables 4.1.1 and 4.1.2. There are 8 firms in the medium-high technology industries (MH), 5 in the medium-low technology industries (ML), and 2 in the low-technology industries (L). The small number of firms in the L group will force us to be very cautious with the average figures presented. Further, the sample explored is not statistically representative of the gazelle population, therefore our results will refer to the sample and can not be used for statistical inference to the population. However, these case studies should be considered exploratory for the attitude and barriers perceived by manufacturing firms towards cooperating with universities.

Table 4.1.1: General descriptives by subsector and technological intensity groups (2002)

	No. of Firms	**Employees**	**Turnover (M€)**	**Total Exports (% of sales)**	**Exports-UE (% of sales)**	**Exports-non UE (% of sales)**
Medium-high technology industries	**8**	**141**	**23,56**	**30**	**23**	**7**
Chemicals excluding pharmaceuticals	2	133	20,434	24	21,5	2,5
Machinery and equipment, n.e.c.	3	98	19,06	55	43	12
Electrical machinery and apparatus, n.e.c.	1	240	30,05	22	11	11
Motor vehicles, trailers and semi-trailers	2	92	24,695	18	15	3
Medium-low technology industries	**5**	**105**	**13,238**	**38**	**30**	**8**
Rubber and plastics products	3	75	10,267	33	25	8
Other non-metallic mineral products	1	130	12,02	45	45	0
Basic metals and fabricated metal products	1	110	17,429	35	20	15
Low-technology industries	**2**	**141**	**27,045**	**53**	**34**	**19**
Food products, beverages and tobacco	1	70	18,03	30	30	0
Manufacturing, n.e.c.	1	211	36,06	75	37,5	37,5
Total	**15**					

Table 4.1.1 shows that the average size is bigger for the firms in group L, with a similar number of employees than group MH and higher revenues. The smallest average size is for the ML firms. Export orientation decreases with technological intensity, being higher for

the firms in group L. The degree of internationalization, measured by the percentage of exports to non-EU countries also decreases with technological intensity.

Table 4.1.2: R&D and cooperation descriptives by subsector and technological intensity groups (2002)

	Firms	R&D effort (% of sales)	Internal %R&D	External %R&D	Number R&D contracts
Medium-high technology industries	**8**	**4,73**	**73**	**27**	**3,33**
Chemicals excluding pharmaceuticals	2	7,00	42,5	57,5	6,50
Machinery and equipment, n.e.c.	3	3,67	62	38	1,33
Electrical machinery and apparatus, n.e.c.	1	4,00	95	5	3,00
Motor vehicles, trailers and semi-trailers	2	4,25	92,5	7,5	2,50
Medium-low technology industries	**5**	**1,70**	**84**	**16**	**1,44**
Rubber and plastics products	3	2,55	77,5	22,5	2,33
Other non-metallic mineral products	1	0,40	77	23	2,00
Basic metals and fabricated metal products	1	2,15	100	0	0,00
Low-technology industries	**2**	**3,00**	**59**	**41**	**3,50**
Food products, beverages and tobacco	1	1,50	85	15	3,00
Manufacturing, n.e.c.	1	4,50	33	67	4,00
Total	**15**				

The results in Table 4.1.2 refer to R&D characteristics. The R&D effort, as a percentage of sales, is higher for the MH group, followed by the L group. The outsourcing of R&D, and the number of contracts signed with universities and other public research institutions are higher for the L group, followed by the MH firms. Thus, we note that in our sample, the grouping of firms into the standard technological intensity groups does not imply any monotonic relationship with R&D effort, neither with general R&D outsourcing, nor with university contracting.

4.1.4.2. R&D capacity

1) Main sources of information for innovation by technological intensity

We asked firms about the main sources of information for innovation, distinguishing between internal and external sources. We considered the managers, the personnel specialized in innovation, the R&D department, the marketing department, the operations department, the competitive surveillance system, and other internal departments as internal sources. The results aggregated by technological intensity groups reveal that the three most important sources for firms in the MH group were the managers, the R&D department,

and the personnel specialized in innovation. For the ML group, the three main internal sources were the marketing department, the specialized personnel, and the R&D department. For the L group, the two most important sources were the marketing department and the competitive surveillance system, on an equal basis, and the third source was the managers of the firms.

The external sources considered were the customers, suppliers, consultants, universities, other research centers, professional conferences and publications, fairs and exhibitions and patent information. The aggregation of results reveals that for all groups, the two main external sources of knowledge were the customers, and fairs and exhibitions. The third source varies across groups: research centers for the MH firms, suppliers for the Ml firms, and professional conferences and publications for the L firms.

2) External knowledge acquisition

Knowledge may be obtained through several mechanisms: the acquisition of technology, machinery or equipment; recruiting specialized personnel; asking customers, and suppliers for input to the innovation process; outsourcing parts of the product development process; outsourcing complete R&D projects; engaging in cooperative research with universities; acquiring patents and brands; cooperating with other firms; investing equity in innovative firms; or acquiring small high-technological firms. Our research found that the main two ways to acquire knowledge were the acquisition of technology, machinery or equipment, followed by cooperative research with universities. These two mechanisms were significant for the three groups. The other important mechanisms were outsourcing of R&D projects for the MH firms, recruitment of specialized personnel for ML, and outsourcing parts of the product development process and outsourcing R&D projects for L.

3) Reasons for outsourcing R&D

Within the HM there was consensus regarding the three main reasons for outsourcing R&D: i) the increasing complexity of research projects; ii) institutional support for research cooperation; and iii) the need to complement internal R&D or technological capabilities. In the ML group, the results do not indicate an agreement in the motives for cooperation, while in the L group the main reason was also the need to complement internal R&D.

4) Types of outsourced R&D

None of the interviewed firms engaged in outsourcing basic research. Three firms declared not having externalized any R&D. The remaining 12 responded that they externalized applied research or technological developments. Further, most of them did not outsource complete projects but only the steps which could not be done by the internal R&D departments because of their lack of technological resources. It is worth mentioning that, for most of the firms, routine processes or tasks of less added-value were not externalized.

5) Intensity of cooperative research

We measure the intensity of cooperative research with universities and public research centers by means of the number of contracts formalized in the last three years. The responses range from 0 to 10 contracts for the whole period. As presented in Table 4.1.2, the group with higher number of contracts on average is L, followed by MH, and lastly the ML group.

We think that the experience in cooperation with universities may have an influence on the attitude towards this cooperation and the barriers observed to initiate or manage these relationships. Therefore, we will distinguish three levels of cooperation:

- inexistent cooperation - no contract with university (3 firms)
- low cooperation intensity - up to 3 contracts in the last three years (9 firms)
- medium-high cooperation intensity - more than 3 contracts (3 firms).

6) Firms attitude towards R&D cooperation

All firms except one responded that they believed R&D outsourcing is required in order to maintain or enhance their competitiveness. To investigate this phenomenon in greater detail we interviewed the firms about their satisfaction with previous cooperation partners. We considered five types of partners: universities, other public research institutions, consultancy firms, other firms, and others. The result of the survey indicates that the satisfaction was positive and similarly high for two types of partners – universities and other firms – with no clear dominance of one over the other. Conversely, the satisfaction with other public research institutions and consultancy firms was lower.

From this response, we infer an overall positive attitude towards R&D cooperation, and particularly to cooperation with universities. We can state that universities are not at a disadvantage regarding general attitude in comparison to other types of partner.

7) Barriers perceived by firms when outsourcing R&D

The surveyed firms responded to the importance of each barrier through a scale ranging from 0, not a barrier, 5 for a medium importance, surmountable barrier, and 10, for an absolute, insurmountable barrier preventing cooperation. As a first finding (see Table 4.1.3) none of the hindering factors totaled an average 5 points. In other words, all barriers perceived by firms when outsourcing R&D were evaluated as surmountable. The three most important barriers (with an average mark over 4) are the difficulties to absorb and profit from the new knowledge, the difficult and costly management of R&D outsourcing and the need for an established internal R&D to achieve complementarities. Within the MH group, external factors such as economic factors, market needs, and instability of the environment were also important. In the ML and L groups, the lack of mechanisms to analyze and monitor the environment was highlighted. The difficulty in commercially exploiting the results and achieve returns on investment was also evident by the ML group, and is the fourth highest barrier in the overall ranking. In the L group, some different barriers were also perceived, especially the differences with partners in processes and structures, and the lack of size to formalize R&D outsourcing.

Table 4.1.3: Ranking of barriers perceived by firms when collaborating by technological intensity (2002)

Rank	Barrier	Total	Medium-high technological intensity	Medium-low technological intensity	Low technological intensity
1	Absorption	4,27	5,38	3,60	1,50
2	Difficult management	4,20	4,38	3,40	5,50
3	Internal R&D necessity	4,20	4,25	3,40	6,00
4	Achieve returns on investment	3,60	3,38	4,40	2,50
5	Environment surveillance	3,60	2,25	5,20	5,00
6	Partner differences	3,20	2,50	3,40	5,50
7	External factors	3,13	4,50	1,00	3,00
8	Firm dimension	3,07	3,00	2,40	5,00
9	Achieve internal R&D	2,93	2,50	4,20	1,50
10	Legislation	2,93	3,25	3,00	1,50
11	Previous negative experiences	2,73	2,75	3,00	2,00
12	Other	0,33	0,00	1,00	0,00
	Number of firms	**15**	**8**	**5**	**2**

Source: own elaboration (0 not a barrier, 5 surmountable barrier, 10 insurmountable barrier)

On the whole, four out of the first five barriers in the ranking refer to internal characteristics of the firms. Only the costs and management of outsourcing count among the important barriers perceived. In addition, some supposed barriers were not found important: the need to exploit existing internal R&D capacity, legislation and normative burdens, and disappointment from previous cooperation.

Table 4.1.4 presents the results organized by cooperation intensity groups as previously defined. We are interested in the different perception of barriers from firms with and without cooperation. Further, we think it is interesting to analyze whether some barriers are perceived differently as cooperation increases in intensity.

Table 4.1.4: Ranking of barriers perceived by firms when collaborating by cooperation intensity (2002)

Rank	Barrier	Total	Medium-high cooperation intensity	Low cooperation intensity	Inexistent cooperation
1	Absorption	4,27	2,33	4,11	6,67
2	Difficult management	4,20	3,67	5,44	1,00
3	Internal R&D necessity	4,20	1,33	4,56	6,00
4	Achieve returns on investment	3,60	4,67	3,56	2,67
5	Environment surveillance	3,60	2,33	3,33	5,67
6	Partner differences	3,20	3,67	3,11	3,00
7	External factors	3,13	1,67	3,89	2,33
8	Firm dimension	3,07	2,67	3,44	2,33
9	Achieve internal R&D	2,93	0,67	3,00	5,00
10	Legislation	2,93	3,33	2,67	3,33
11	Previous negative experiences	2,73	0,33	3,56	2,67
12	Other	0,33	0,00	0,56	0,00
	Number of firms	**15**	**3**	**9**	**3**

Source: own elaboration (0 not a barrier, 5 surmountable barrier, 10 insurmountable barrier)

The results show that firms with inexistent cooperation give the highest marks in the table, indicating that they perceive some barriers as more insurmountable than firms with experience. In particular, the difficulties to absorb and profit from the new knowledge, and the need of a previous internal R&D to achieve complementarities have a mark of 6 or higher. Two other barriers have a mark of 5 or higher: the lack of mechanisms to analyze and monitor the environment, and the need to to exploit the existing internal R&D capacity.

Regarding severity, high barriers (more than 4) decrease as cooperation increases: there are 4 cases in the group with inexistent cooperation, 3 cases in the low cooperation group, and 1 within the medium-high cooperation. For some type of barriers, they decrease when cooperation increases, such as absorption difficulties, the need of an internal R&D, the lack of environment surveillance, and the need to exploit existing R&D. On the contrary, the perception of two barriers increases with cooperation intensity: the difficulty to exploit the results commercially and achieve returns on investment, and problems due to partner differences.

8) Barriers to R&D cooperation with universities

Given that the literature identified different motives underlying the decision of firms to cooperate, we understand that barriers may be different by type of partner. Tables 4.1.5 and 4.1.6 contain the summary of results on firms barriers' when cooperating with universities – the first organizes by standard technological groups and the second by cooperation intensity groups.

Table 4.1.5: Ranking of barriers perceived by firms when collaborating with university by technological intensity (2002)

Rank	Barrier	Total	Medium-high technological intensity	Medium-low technological intensity	Low technological intensity
1	Unresponsiveness to industry needs	5,40	5,25	7,20	1,50
2	Inapplicability of the projects	3,33	3,50	4,20	0,50
3	Task/work inefficiency and schedule	3,20	2,88	4,20	2,00
4	Inadequate infrastructures	2,80	3,13	3,20	0,50
5	Confidentiality	2,60	2,75	3,20	0,50
6	Previous negative experiences	2,33	2,50	2,80	0,50
7	Bureaucratic	2,27	2,63	2,20	1,00
8	Absorption	1,93	2,38	1,40	1,50
9	Results sharing	1,80	2,00	2,00	0,50
10	Geographical proximity	1,07	1,50	0,60	0,50
11	Other	0,33	0,00	1,00	0,00
	Number of firms	**15**	**8**	**5**	**2**

Source: own elaboration (0 not a barrier, 5 surmountable barrier, 10 insurmountable barrier)

We will analyze the results by technological intensity and by cooperation intensity. The main observable result in Table 4.1.5 is that, except for the first barrier, the others have less importance than the general barriers to R&D outsourcing analyzed before. We now focus in depth on each of the three main barriers found.

Table 4.1.6: Ranking of barriers perceived by firms when collaborating with university by cooperation intensity (2002)

Rank	Barrier	Total	Medium-high cooperation intensity	Low cooperation intensity	Inexistent cooperation
1	Unresponsiveness to industry needs	5,40	5,33	4,33	8,67
2	Inapplicability of the projects	3,33	3,00	3,11	4,33
3	Task/work inefficiency and schedule	3,20	5,00	2,78	2,67
4	Inadequate infrastructures	2,80	3,33	3,00	1,67
5	Confidentiality	2,60	3,67	2,56	1,67
6	Previous negative experiences	2,33	0,33	1,67	6,33
7	Bureaucratic	2,27	1,00	3,22	0,67
8	Absorption	1,93	0,33	2,89	0,67
9	Results sharing	1,80	0,33	2,33	1,67
10	Geographical proximity	1,07	0,67	1,56	0,00
11	Other	0,33	0,00	0,56	0,00
	Number of firms	**15**	**3**	**9**	**3**

Source: own elaboration (0 not a barrier, 5 surmountable barrier, 10 insurmountable barrier)

A) The main barrier: Unresponsiveness to industry needs

For the whole sample of 15 firms, the most significant barrier perceived is the unresponsiveness of university to industry needs, with an average over 5 which we interpret as a significant barrier. Individual level results show that only 5 firms rate this barrier below 5, with ten firms over 5, reaching values of 8, 9 or 10 for 5 of them. This indicates a generalized opinion that cooperation is hindered by the university's lack of a deep and realistic knowledge of the industrial world. By technological intensity groups (Table 4.1.5), this barrier is very important for the medium-low intensity group, because of a general consensus of the 5 firms in that group. In the high-medium intensity group, the average is also high, but results are dispersed for the 8 firms in the group.

Considering the cooperation experiences of firms provides a different interpretation of the results (Table 4.1.6). The perception of unresponsiveness to the needs of the industry is very high for the 3 firms with inexistent cooperation with universities, with a mark over 8 – approaching the view of an insurmountable barrier. This may be understood as the reason – objective or subjective – for not cooperating with universities. For firms at the other end of the scale, the 3 cases with medium-high cooperation, the results are lower but still over 5. The group having low cooperation intensity shows varying opinions, but mainly with an average slightly lower than 4.

Thus, we may conclude that this barrier is appreciably important, significant enough to prevent cooperation in some cases, and although this negative perception diminishes when cooperation is established, it is still perceived as the main barrier to cooperation with universities.

B) The second barrier: Inapplicability of the projects

The second barrier in importance is the inapplicability of the projects, with an average appreciably below 5, indicating that it is a barrier of less than medium importance. This barrier is more important in the opinion of firms in the ML technological intensity group (Table 4.1.5).This perception is higher for the group of firms with inexistent cooperation with universities, and diminishes as cooperation intensity increases (Table 4.1.6).

On the whole, this barrier is significantly lower than the previous one, and we interpret from the scores that this negative perception does not prevent cooperation. Further, the barrier reduces as cooperation increases.

C) The third barrier: Inefficiency and schedule problems

This barrier is similar to number 2 and explains different work paces or rates between the university and the firms and the lack of trust to comply with schedules and deadlines. This barrier is higher for the firms in the ML technological intensity group (Table 4.1.5). In contrast to the former two barriers that decreased as cooperation increased, this barrier is perceived as becoming higher when cooperation increases (Table 4.1.6). We interpret this as once cooperation is established, distrust with the efficiency and compliance with schedules increases. For this reason we argue that this barrier is more relative than the previous two.

Other barriers have low marks in general, their average rarely over 3, indicating a lower degree of importance. However there is an important exception in the analysis of the results by groups of cooperation intensity. The group of firms with current inexistent cooperation find that disappointment with former cooperation is an important barrier, with an average mark over 6. For this group, this is the second highest barrier, approaching the view of an insurmountable, absolute barrier.

4.1.5. Conclusions

4.1.5.1. Discussion of the main findings

In comparison with other possible partners, universities are not at a disadvantage in the satisfaction they provide. However, previous cooperation with other public research institutions is ranked as less satisfactory. As for perceived barriers to the general outsourcing of R&D, they are mainly due to the internal characteristics of firms. They are higher than barriers related to university cooperation, except one, the unresponsiveness of university to industry needs. This is also the only barrier perceived as having more than medium importance.

The results analyzed by technological intensity group, commonly defined across many studies, provide no monotonic relationships with the level of cooperation, the satisfaction from previous cooperation, and the perception of barriers. None of these factors therefore change as technological intensity increases. Conversely, groups formed by the intensity of cooperation, measured by the number of contracts signed with universities and other public research institutions, show some monotonic relationships. The two first barriers to cooperation with universities, i.e. the perception of unresponsiveness to industry needs and the applicability of the projects, decrease when cooperation intensity increases. The third barrier, inefficiency and schedule problems, is less important for firms with inexistent cooperation and increases as cooperation increases.

We think that the change among groups in the importance of the barriers may be significant in terms of distinguishing between the nature of the barrier, which can be absolute or relative. Absolute barriers tend to prevent cooperation, while relative barriers just make the occurrence less likely and management more difficult. The first barrier, unresponsiveness to industry needs, and disappointment with previous cooperation, may be considered as more absolute barriers. In our opinion, their tendency is coherent with the nature of absolute barriers, since their importance decreases as cooperation increases. The third barrier mentioned, inefficiency and schedule problems, can be considered as being more relative, because it received low scores by firms with no cooperation and decreases

when cooperation increases, showing that it is a barrier more prevalent once cooperation is established.

The same trends may present another analysis regarding the possible bias in the preconceptions about cooperation with universities. The first two barriers may involve a pessimistic attitude, since the perception is greater than the reality, and decrease when cooperation increases. The third barrier may involve an optimistic attitude, since it becomes worse as cooperation increases.

4.1.5.2. Implications for the formulation and implementation of technology transfer strategies by the university

There are some barriers which make it difficult to establish R&D outsourcing in general, and which consequently also affect cooperation with universities. Although these barriers were graded as not highly important, it is worth noting that they were mostly related to internal characteristics of the firms, such as the difficulties to absorb and profit from the new knowledge, the need for an existing internal R&D to achieve complementarities, the lack of mechanisms to analyze and monitor the environment, and the lack of size.

Reducing these obstacles is mainly out of reach of the universities; it depends on the size of the firms and their R&D focus. Only public policies are in a position to provide incentives and general conditions to address such obstacles. Nevertheless, learning from these barriers may highlight to universities that cooperation agreements are more likely to be obtained when firms satisfy some minimum conditions, related to the capacity of the R&D departments, the level of R&D investment, or the absorptive capacity of the firm. This may guide the direction or intensity of the efforts that universities dedicate to different types of firms.

The specific barriers encountered in cooperation with universities have more implications for technology transfer strategy formulation and implementation. The reduction of perceived barriers is the responsibility of the university in the first instance. Our results indicate that universities should especially consider addressing the perception that they do not respond to industrial needs. There are three main reasons for this priority: it is the most

significant barrier, it is graded as having more than moderate importance, and it may be an absolute barrier, preventing cooperation altogether. Investing in this area will not only affect the perceptions of industry, which may be biased in some cases, but will result in driving research closer to industry interests. The first task is probably already in the agenda of most industrial liaison offices. However, there is no easy roadmap to achieve the latter, since there are also obstacles posed by academia to work out the type of solutions that industry demands. Universities may contribute to bring research closer to industry demands by promoting specialized research centers, participating in science parks, and creating an entrepreneurial culture within academia, facilitating and justifying the implication of research in the transfer of technology.

The second barrier observed was the lack of project applicability. In our opinion, when formulating strategies, this barrier is intrinsically linked to acting on the perception of unresponsiveness to industry needs, when aiming to close the gap between university research and industry needs. Thus, acting on the first barrier will have a positive effect on the reduction of the second. As for problems related to the third barrier, the perceived inefficiency and schedule problems, we think that it is less strategic, although it still has an influence on the satisfaction with the university as a partner for cooperation. Therefore, to facilitate cooperation and invest in long-term trust, improvements in the work paces of cooperation projects should be part of the continuous improvement objectives of the university.

Our research is based on case studies of a sample of 15 gazelle manufacturing firms in Catalonia. We note again that we can not statistically infer conclusions to the whole population, but we contend that some findings can help us to think about the factors preventing and hindering the cooperation between industry and university. Further research should help to prove the degree of generality of our results, to wider samples, to wider economic regions or cultures.

While some authors debate whether technology transfer between public research and industrial research is a "one way bridge" and make efforts to convert it into the concept supporting a "two way bridge" (Meyer-Krahmer and Schmoch, 1998), our results tend to show that: i) the bridges for exchanging knowledge between the two worlds are still under construction; ii) some barriers are still closed, preventing free access.

Annex 4.1: Literature review and barriers identified

Paper	Focus	Barriers identified	Method	Sample size	Perspective	Geographical coverage
Meyer-Krahmer and Schmoch, 1998	Major motives of academic researchers for maintaining interaction with industry according to discipline	■ Short term orientation ■ Limited industrial basis ■ Restrictions to publications ■ Less interesting topics ■ Administrative problems ■ Unfair terms of contract	Questionnaire	433	University Academic researcher	Germany
Jones-Evans et al., 1999	The role of universities in developing innovation and entrepreneurship	■ Lack of financial resources and property ■ Lack of defining culture of entrepreneurship ■ Lack of academic recognition for commercialization and rewards for publications as opposed to patents ■ Industries unable to provide projects of direct interest to academic departments ■ Poor incentives for working with industry ■ Short term orientation of collaboration ■ Lack of trust in the ability of academics to perform tasks efficiently and to a pre-determined schedule	Case-studies	9	University Industrial Liaison Office	Ireland Sweden
Hagedoorn et al., 2000	Important reasons why firms participate in research partnerships and why government encourage them	Mainly focuses on motives and benefits	Theoretical focus		Databases related to research partnerships Empirical research issues	US, EC, Japanese policies towards research partnerships
Chiesa and Piccaluga, 2000	Exploitation of research results in universities	■ Strong focus on exploitation possible negative impact on basic research ■ Commercialization vs. publication ■ Disparities between those with commercial results and the others ■ Direct exploitation non compatible with university mission ■ Legal problems with universities ■ Lack of competencies and complementary assets for commercialization activities	Questionnaire	45	University Spin-off	
Fritsch and Lukas, 2001	The propensity to maintain different forms of R&D cooperation	■ Lack of a gatekeeper, person who systematically monitors external information that could be relevant for a firm's innovation activities or conductive to R&D cooperation	Questionnaire	1800	Business	Germany
Bayona et al, 2001	The factors which determine why firms cooperate in R&D (motives)	■ Basic and applied research ■ Uncertainty and cost ■ Market access ■ Search for opportunities ■ Size ■ R&D capacity	Questionnaire	1652	Business	Spain
Hall et al, 2001	Barriers, intellectual property concerns in particular, inhibiting industry from partnering with universities	■ Intellectual property issues	Questionnaire	38	Business ATP projects including University as partner	US

Paper	Focus	Barriers identified	Method	Sample size	Perspective	Geographical coverage
Tether, 2002	Patterns of cooperation arrangements for innovation with external partners	■ Universities as contributors to the supply of new scientific and technological knowledge ■ Universities useful for basic, long-term and expensive strategic research ■ Slow to act ■ Unresponsive to industry needs	Questionnaire	1270	Business	UK
Bayona et al., 2002	Understanding of reasons that lead companies to collaborate in R&D	■ Need of specific knowledge oriented to problem-solving, product design and development. Universities and research centers are not yet equipped to respond ■ Specialized staff and internal structure ■ Physical distance ■ Differences in aim, management styles, culture	Questionnaire	747	Business	Spain
Krúcken, 2003	Institutional barriers to the diffusion of 'third mission'	■ Legal environment (few incentives to promote TT, property, lack of institutional support and a professional infrastructure) ■ TTO as a political role model (transfer gap between potential supply from university and the potential demand from industry, perception on the TTO as an additional bureaucratic layer, rapid institutionalization process) ■ Institutional identity ■ Personalized transfer	Case-studies	41	University Technology Transfer Office	Germany
Pérez and Martínez, 2003	The role of entrepreneurship and innovation networks on the dynamics of technology transfer	■ Lack of financial resources ■ Small size of market ■ Too risky ■ Lack of information on market features ■ Lack of time ■ Lack of information on potential business partners ■ Lack of information on know-how ■ Lack of trust among partners	Questionnaire and case-study	10	University Spin-off – funding entrepreneur	Spain
Debackere and Veugelers, 2005	Fostering and effective commercialization of the academic science base	■ Knowledge: highly uncertain and non-codifiable nature of scientific know-how ■ Intellectual property rights regime and regimes of appropriability ■ Lack of understanding of the other partner's culture and conflictive objectives	Case-study	1	University Technology Transfer Office	Belgium

4.2. The accumulation of knowledge in small and medium-sized firms: The role of type of knowledge and absorptive capacity

4.2.1. Introduction

Both creating knowledge and converting created knowledge into new products and services are critical activities for a firm (Subramaniam and Venkatraman, 2001; Leonard-Barton, 1995; Nonaka and Takeuchi, 1995). This is especially true for the survival and growth of Small and Medium sized Enterprises (SMEs) in a variety of countries (Cohen and Levin, 1989) which has been providing evidence against the hypothesis advanced in Schumpeter (1950) as firm size as a determinant of R&D spending and the rate of technological advance. SMEs vary widely in the way they scan the technological environment (Julien et al., 1999), adopt innovations outside their boundaries (Sikka, 1999) and create and convert knowledge inhouse (Birchall et al., 1996; de Jong and Vermeulen, 2006; Koch and Strotmann, 2006).

Some studies of knowledge accumulation among SMEs in Europe have been conducted or sponsored by national and regional public institutions aimed at designing R&D and innovation policies. Most of these studies take a descriptive approach (CORDIS 2002, 2003; EIMS, 2000). Moreover, and more importantly, as argued in Kleinknecht (1987) they are normally based on data from official surveys that tend to underestimate R&D activities in SMEs. In addition to understating the absolute level of R&D activities, the findings of these studies regarding organization of R&D activities may poorly generalise to SMEs. The as innovation in small and medium size firms is differently organised than in big corporations; in the former, clearer division of labor and greater specialisation eases the measurement of formal innovation activities. SMEs however are characterized by lower degree of specialisation, and a greater use of informal organisation. The lower degree of specialisation that tends to characterise small and medium size firms, besides making it more difficult to identify R&D activities, may also have implications for the R&D sourcing decisions of SMEs as their transaction costs of externalising R&D, as well as their absorptive capacity of internalising R&D might be very different from those in larger, professionally-managed firms (Teece, 2000: pp 117). In addition, privately held SMEs, with the presence of owner-managers, may view knowledge accumulation differently than other

organisations. For instance, the presence of owner-manager has important implications on firm's activities, including those related to technology and knowledge (Julien et al., 1999).

In this study we aim to add to the richness of extant knowledge management literature. Specifically, this study aims to shed light on the R&D activities of SMEs based in the Spanish region of Catalonia. In addition we also test the generalisability of extant literature to these firms. Specifically, we seek to investigate two aspects of R&D decisions in small and medium size firms: how much do SMEs invest in R&D and, how do SMEs decide between internal and external sources of R&D. Our data set provides us with valuable information on R&D activities that firms do not report in official surveys when these are not accepted for obtaining tax advantages. In the process, we bridge a gap in current literature by focusing on the R&D activities of private (and sometimes family-controlled) SMEs,

4.2.2. Literature review and hypotheses

4.2.2.1. The Type of Knowledge and the Intensity of R&D in SMEs

Innovation is easier in some industries than in others. A most used approach to explain differences in resources devoted to R&D across industries has been to classify industry by the type of knowledge. This approach was introduced by Scherer (1965), which finds evidence of the relationship between innovation activity and "technological opportunity", this latter related to advances in scientific and technological knowledge.

In this line of research, Scott (1984) classifies industries into technology groups according to the type of knowledge and finds that this classification helps explain variance in R&D intensity; and Cohen et al. (1987) find variables measuring technological opportunity (for instance, closeness to science) to explain a substantial part of the variance in R&D intensity. Cohen and Levin (1989) reviews how studying the relationship between R&D intensity and fundamental industry characteristics, like technological opportunity, has been replacing studying the relationship between R&D intensity and market concentration hypothesized by Schumpeter. In recent work, Revilla et al., 2005 describe the main features

of knowledge: the creation process and the transfer process. They point out the necessary conditions in which knowledge is created through research joint ventures.

Based on the above referred evidence, we run two tests to learn about the relationship between type of knowledge and technology intensity, at industry and at firm level, for SMEs in Catalonia. First, we check whether resources spent by SMEs on R&D verify the OECD classification of industries by R&D intensity; this latter is based on evidence from SMEs as well as big corporations. This will allow us to check for major differences in R&D intensity between SMEs and big firms. Second, we test whether variance in R&D intensity is related to the type of knowledge, measured by variables representing technological complexity at firm level. To do so, we use the definition in Singh (1997), which defines a complex technology as "an applied system whose components have multiple interactions and constitute a nondecomposable set."

Hypothesis 1: There is a relationship between R&D intensity and technology groups.

Hypothesis 2: There is a positive relationship between R&D intensity and technological complexity.

4.2.2.2. The Type of Knowledge and the Sourcing Decisions of Technology in SMEs

The type of knowledge does not only affect R&D intensity but also the sourcing (internal or external) of technology. Winter (1987) proposed a taxonomy with the following eight pairs of attributes of knowledge: articulable or tacit, teachable or unteachable, articulated or non-articulated, observable or non-observable, simple or complicated, system-independent or system-dependent, context-independent or context-dependent, monodisciplinary or transdisciplinary. The first and second elements of each pair refer to forms of knowledge that make it easier or more difficult to transfer, respectively. In the case where knowledge is difficult to transfer, firms will normally resort to internal sources of R&D; in the opposite case, where knowledge is easy to transfer, firms will decide between developing technology in-house and/or outsourcing it.

The type of knowledge is not an exogenous parameter to which firms react. Cohen and Levinthal (1989) argue that whether or not knowledge is codified (and thus more easily transferable) depends both on the nature of specific knowledge and on economic factors (strategies of the firms involved). Winter (1987) and Nonaka (1991) emphasize that the act of making knowledge tacit or explicit (and thus easier to transfer) is a managerial decision rather than an attribute of knowledge itself. A firm may be interested in keeping its knowledge in tacit forms to diminish the chance that competitors can use it. Similarly, Arora and Gambardella (1994) argue that it is an economic decision of firms to decide between investing in general and abstract (easier to transfer) rather than tacit and context-dependent knowledge. Arora et al. (2001) study the existence of markets for technology and argue that a market can not exist if a technology requires too many adaptations to a firms' specificities; firms might be interested in keeping it this way to avoid increased competition in the industry (that is, if the technology needs to be developed in-house, it can remain a competitive advantage and lower competition in an industry).

The strong influence of firms' R&D policies on the existence of a market for a technology, suggest that the analysis of technology outsourcing is a complex one where multiple factors intervene simultaneously. We focus on the case of SMEs, an interesting group if we take into account that transferring technology, as much as transferring any asset, involves transaction costs; and that transaction costs differ between SMEs and big corporations. For instance, Veugelers and Cassiman (1999) study the make and buy R&D decisions in a sample of Belgian manufacturing firms, using data from a Community Innovation Survey (CIS) including small and large firms. They find that small firms are more likely to restrict their innovation strategy to either make or buy, while large firms are more likely to combine both.

We will start by studying whether there are differences among SMEs' technology sourcing decisions owing to the complication (as in Winter 1987) of the knowledge and its context-dependence, then we will examine the related effects of spillovers looking at absorption capacity and the appropriability of technological development; and we will end by examining evidence of the "not-invented-here" syndrome.

Kogut and Zander (1992) define the knowledge of the firm as the knowledge or technology that is embedded in to organisational routines and which is broader than the knowledge of

individuals in the organisation. The knowledge of the firm can not thus be transferred simply by employee turnover. Using measures of codifiability, complexity and teachability of the technology, Kogut and Zander (1993) found that firms are more efficient vehicles to transfer difficult to codify or teach and complex technology. The same argument can be applied to complicated knowledge. For instance, Von Hippel (1994) explains how sticky, or context dependent, knowledge is difficult to transfer across organisations and thus encourages vertical integration. Knowledge can also be tacit or codified, which affects its cost of transfer (Teece, 2000; pp 13).

To test for the existence of the two effects, we set hypotheses 3 and 4 to measure the relationship between two characteristics of knowledge (complication and context-dependence), on the technology sourcing decisions of SMEs in our sample.

Hypothesis 3: There is a positive relationship between the complication of knowledge and the external acquisition of technology.

Hypothesis 4: There is a positive relationship between the context-dependence of knowledge and the in-house development technology. Firms employing context-dependent technology will externalise less.

We next focus on appropriability of the knowledge accumulated by organisations. The difficulty of appropriating rents arising from innovation was first studied in Arrow (1962). The intangible nature of knowledge makes information flows (or spillovers) a crucial issue in R&D decisions. Spillovers may have dual, opposite effects: on the one hand, spillovers may reduce a firm' incentives to own R&D as competitors may benefit from the innovations achieved (when appropriability is limited); on the other hand, firms that invest in own R&D will be more capable of benefiting from research from others (absorption capacity effects).

The concept of absorption capacity was introduced by Cohen and Levinthal (1989, 1990). They point at how evaluating technologies and being able to use them requires substantial in-house scientific and technological expertise. Nieto and Quevedo (2005) show relevant research on the variable absorptive capacity giving examples of authors, the sample they use, measures of the concept and main findings. For example, Veugelers (1997) examines

the relationship between internal and external R&D expenditures on a sample of Flemish R&D-active firms. It finds that R&D cooperation and R&D contracted out have a positive effect on R&D when absorptive capacity exists.

The empirical literature on spillovers is vast (Mansfield 1985; Jaffe 1986, Griliches 1992). However, it has not yet been clearly showed empirically which effect of spillovers, incentive (absorption capacity) or disincentive (appropriability) of R&D, prevails. The inconclusiveness owes partially to difficulties in measuring. A broadly used indicator of appropriability is patents. However, patent data has some flaws. Scherer (1965) explains how the propensity to patent varies across industries. Mansfield (1986) also provides evidence of how the effectiveness of patents varies across industries. The Levin et al. (1987) survey verifies these results on patents and, more importantly, confirms that secrecy, lead time and investment in complementary sales and services efforts can be more effective means of limiting outgoing (these results are consistent with what we found out throughout our interviews).

Based on the referred literature, we establish hypothesis 5 to obtain evidence of the absorption capacity effect in SMEs and hypothesis 6 to test whether appropriability considerations are significant in our sample.

Hypothesis 5: There is a positive relationship between the acquisition of technology and the absorptive capacity of the firm.

Hypothesis 6: There is a positive relationship between the appropriability of technological development and internal R&D.

The "not-invented-here" (NIH) syndrome occurs when research groups become isolated from external sources of knowledge, growing increasingly complacent of their own work and cutting their exposure to new ideas. A widely used approach in the empirical literature on NIH syndrome attempts to measure it by studying the relationship between group tenure and job performance, the hypothesis being that research groups that have been together for a long time tend to isolate themselves and communicate less with professionals outside their group. This approach is used in Shepard (1956), Smith (1970) and Katz and Allen (1982).

In this study, we attempt to identify those situations where, due to the influence of an internal own R&D department on the firm's R&D decisions, firms decide to produce technology in-house although the same technology is available outside at lower prices. We asked firms directly whether the existence of an own R&D department was a barrier in the process of outsourcing technology. To test the robustness of their answers, we will check that there are no industry effects in the sourcing decisions of technology.

Hypothesis 7: The existence of own R&D department may limit the externalisation of R&D, even when it would be economically more efficient to contract out.

4.2.3. Data and methods

4.2.3.1. The sample

The data for this study is obtained from the data bank used in Solé et al. (2003), who conducted direct interviews with 59 firms. Our database comprises small and medium-sized firms in industrial sectors in the Catalan region. We were interested in obtaining a sample that is representative of the more dynamic and successful firms in this group. We were interested in explaining the nature of R&D that occurs, its relation to knowledge, and how it is absorbed, rather than studying why some firms innovate and why others don't. Therefore, we concentrated on firms reporting the best results in the past years. The criteria that we used to determine what a successful firm is, is similar to the criteria applied in another regional study (Hernández, Amat, Fontrodona and Fontana, 1999). The selected firms met the following criteria:

- Growth in sales: minimum, 6 % annually (during the period: 1997 - 1999)
- Profitability: minimum, 5 % annually (during the period: 1997 - 1999)
- Gross sales: 2.5 million euros in the past year (during the period: 1997 - 1999)

After eliminating firms that didn't match selection criteria (not, strictly speaking, industrial; did not meet the conditions of small and medium-sized European firms; or, had less than twenty employees (because it is more difficult to analyse innovative activity in very small firms), followed by an exhaustive revision process we ended up with almost 60 registers, each corresponding to one selected firm. The interviews were structured in accordance

with a pre-designed questionnaire, based on OECD's (1997, 2002) guidelines and included both open and "closed" questions.

The classification of sectors is based on the technological intensity of the particular manufacturing sector (Table 4.2.1). It is a classification designed by the OECD according to the average investment in R&D by the different sectors. The classification of the manufacturing sectors according to technology is: *low*, *medium-low*, *medium high* and *high* technology. Because there are only two firms from our sample belonging to *high* technology industries, we decided to add them to the group of *medium high* technology firms, keeping the name, *medium high.*

Table 4.2.1: Classification of firms by technological intensity ("Classification by technology") and main indicators

	Number of firms	Percen-tage of firms	Average sales *	Average number of employees
Medium-high/high technology	18	30.51	17.316	117.11
Manufacture of electrical machinery and apparatus n.e.c. (31) Manufacture of medical, precision and optical instruments, watches and clocks (33) Manufacture of machinery and equipment n.e.c. (29) Manufacture of motor vehicles, trailers and semi-trailers (34) Manufacture of chemicals and chemical products (24)				
Medium-low technology	22	37.29	13.286	81.86
Manufacture of rubber and plastics products (25) Manufacture of other non-metallic mineral products (26) Manufacture of basic metals (27) Manufacture of fabricated metal products, except machinery and equipment (28)				
Low technology	19	32.20	13.390	103.47
Manufacture of food products and beverages (15) Manufacture of textiles (17) Manufacture of paper and paper products (21) Manufacture of furniture; manufacturing n.e.c. (36)				
Total	**59**	**100**	14.664	100.81

Note (1): * - thousands of €

Note (2): the number in parenthesis following the name of each sector, corresponds to the United Nations Inventory of International Economic and Social Classifications, namely the International Standard Industrial Classification of all Economic Activities, Revision 3.1 (ISIC Rev. 3.1). This code has its Spanish equivalent, CNAE – The Spanish National Classification of Economic Activities

Descriptive analysis in terms of firms' distribution by workforce and sales (Table 4.2.2) shows that the manufacture of basic metals, fabricated metal products, except machinery and equipment is the one which, on average, is of a considerably smaller size than the others (61.8 employees). In comparison, the largest firms are those of manufacture of electrical machinery, apparatus, medical, precision and optical instruments, watches and clock having, on average, 126.4 employees.

Table 4.2.2: Distribution of firms by workforce and sales

	Number of employees										
Activity	<49		50-99		100-149		>149		Total	Average	**Sales ***
	N	%	N	%	N	%	N	%			
Medium-high technology											
Manufacture of electrical machinery and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks	1	20	1	20	0	0	3	60	5	126.40	16.488
Manufacture of machinery and equipment n.e.c.	0	0	2	33	3	50	1	16	6	112.83	18.496
Manufacture of motor vehicles, trailers and semi-trailers	1	50	0	0	0	0	1	50	2	92.00	12.327
Manufacture of chemicals and chemical products (24)	0	0	1	20	2	40	2	40	5	123.00	18.960
Medium-low technology											
Manufacture of rubber and plastics products	3	33	2	22	2	22	2	22	9	96.44	14.690
Manufacture of other non-metallic mineral products (26)	1	33	0	0	1	33	1	33	3	105.00	17.600
Manufacture of basic metals; Manufacture of fabricated metal products, except machinery and equipment	5	50	3	30	2	20	0	0	10	61.80	10.729
Low technology											
Manufacture of food products and beverages	1	25	1	25	1	25	1	25	4	115.00	14.925
Manufacture of textiles	3	50	0	0	1	16	2	33	6	94.00	12.430
Manufacture of paper and paper products	0	0	3	75	0	0	1	25	4	83.50	10.416
Manufacture of furniture; manufacturing n.e.c.	1	20	1	20	1	20	2	40	5	121.60	15.696
Total	**16**	**27**	**14**	**23**	**13**	**22**	**16**	**27**	**59**	**100.81**	

Note (1): * - thousands of €

In terms of the workforce, there is an imbalance between small firms (less than 50 employees) and medium-sized firms (between 51 and 250 employees). In fact, we could say our study is more focused on medium-sized firms than on small ones (although the fact that we eliminated firms with less than 20 employees from our study sample may have affected this distribution). The average number of employees is close to 100, that turns out to be the central point of the sample.

In terms of sales, the profile is about the same as the one that is revealed by number of employees and sector; the majority of firms are to be found in a central position. Nevertheless, there is one company which exceeds the conditions of a small or medium-sized company and three firms which come very close to the limit.

4.2.3.2. Variables

Descriptive statistics on all variables is provided in Table 4.2.3.

Table 4.2.3: Descriptive statistics (type, name, mean, valid cases, standard deviation)

	Variables	Mean	N	Standard deviation
Dependent variables				
RDintensity – R&D expenses over sales		2.01	50	1.727
MakeBuy – make or buy			59	
	(100% make) 1	33.9%		
	(make and buy) 2	64.4%		
	(100% buy) 3	1.7%		
Explanatory variables				
H1	*group* – technology intensity groups		59	
	(low technology) 1	32.2%		
	(medium-low technology) 2	37.3%		
	(medium-high technology) 3	30.5%		
H2	*qualification* – R&D qualified personnel	2.14	53	1.982
H2	*barriers* – technology complexity related barrier		59	
	(Yes) 1	23.7%		
	(No) 0	76.3%		
H2	*incentives* – tax incentives		52	
	(Yes) 1	48.1%		
	(No) 0	51.9%		
H3	*extcollaboration* – external collaboration		51	
	(Yes) 1	37.3%		
	(No) 0	62.7%		
H4	*internal sources* – internal sources of information for ideas	58.51	48	13.651
H5	*owndepartment* – R&D department		59	
	(Yes) 1	33.9%		
	(No) 0	66.1%		
H6	*patents* – patents applied for or obtained		59	
	(1 and more) 1	42.4%		
	(Zero) 0	57.6%		
H7	*outsourcebarrier* – exploitation of internal R&D		22	
	(Yes) 1	36.4%		
	(No) 0	63.6%		
H7	*dep&collaboration* – firms with an own R&D department and no external collaboration		19	
	(Yes) 1	52.6%		
	(No) 0	47.4%		

Dependent variables

Firms' technological intensity (*RDintensity*). We use a continuous variable that measures the resources that firms spent on R&D as a percentage over sales. This dependent variable is used in the hypotheses 1 and 2. Table 4.2.4 shows the distribution of this variable across the industry sectors represented in our sample.

Table 4.2.4: Distribution of R&D expenditure, by economic activity

OECD Technological intensity groups	Economic activity	Percentage of R&D expenses over sales
C	Manufacture of furniture; manufacturing n.e.c.	0,8
C	Manufacture of food products and beverages	0,9
C	Manufacture of paper and paper products	1,0
C	Manufacture of textiles	1,0
B	Manufacture of basic metals; Manufacture of fabricated metal products, except machinery and equipment	1,0
B	Manufacture of other non-metallic mineral products	1,5
B	Manufacture of rubber and plastics products	2,7
A	Manufacture of chemicals and chemical products	2,7
A	Manufacture of machinery and equipment n.e.c.	3,4
A	Manufacture of electrical machinery and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks	3,7
A	Manufacture of motor vehicles, trailers and semi-trailers	4,3

Note (1): A – medium-high technology; B: medium-low technology; C: low technology – OECD's classification for manufacturing sectors

Sourcing decision of technology (*makebuy*). In the rest of the hypotheses (3 to 7) we use a dependent qualitative variable that measures the distribution of R&D expenditures between internal technology development and technology outsourcing. It can take three values: 1 (make – 100% internal R&D), 2 (make and buy), 3 (buy – 100% external R&D).

Table 4.2.5 shows the distribution of this variable across the industry sectors represented in our sample.

Table 4.2.5: Location of R&D across economic activity sectors

Economic activity sector	Internal percentage of R&D
Manufacture of chemicals and chemical products	66,3
Manufacture of furniture; manufacturing n.e.c.	66,7
Manufacture of other non-metallic mineral products	78,5
Manufacture of rubber and plastics products	79,8
Manufacture of machinery and equipment n.e.c.	80,8
Manufacture of paper and paper products	90,0
Manufacture of food products and beverages	92,5
Manufacture of motor vehicles, trailers and semi-trailers	92,5
Manufacture of basic metals; Manufacture of fabricated metal products, except machinery and equipment	95,0
Manufacture of textiles	96,0
Manufacture of electrical machinery and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks	98,6

Explanatory variables

Intensity of technology groups. We use the variable *group* to classify the intensity of the technology groups (H1). We use a qualitative indicator which can take the values of 1 (low technology), 2 (medium-low technology) and 3 (medium-high technology).

The classification of firms into the technology groups follows an OECD classification of industrial sectors by technological intensity (how much firms in different industrial sectors invest in technology-measured by the % of R&D over sales).

Technological complexity. To measure technological complexity (H2), we use the following set of variables:

- *Qualification*. It is a continuous variable which quantifies the number of qualified people (having an education degree at University level) working in the R&D department. Rather than account only for full-time R&D staff, we use estimates of the man-years working in R&D. These data is especially valuable for the case of SMEs as employees there are more likely to divide their time at work among various departments.
- *Barriers*. We asked firms to identify which were the three most important barriers to entry for a potential competitor in the sector in which the firm operates. Firms could choose between: firm size (bar1), the prestige and trademark of incumbents (bar2), clients' fidelity to incumbents (bar3), knowledge of the consumption preferences of clients (bar4), access to the distribution channels (bar5), high cost of installations (bar6), the technological complexity of the production process (bar7)

and the necessity of specific knowledge and highly qualified personnel (bar8), access to the sources of raw materials (bar9) and others (bar10).

To proxy for technological complexity, we construct the variable *barriers* by giving value 1 to the firms that identify both bar7 and bar 8 as important and 0 otherwise.

- *Incentives*. Various public institutions (for instance, the Government of Catalonia and the Spanish Ministry of Science and Technology) offer tax incentives to support R&D activities in SMEs. We asked firms how much they knew about these measures and the use of them. With their responses, we construct a binary variable taking the value of 1 if firms interviewed used tax incentives in the past 3 years, and the value of 0 if they didn't.

Technological complication. To measure technological complication (H3), we use a variable (*extcollaboration*) that measures whether firms consider necessary to establish external R&D collaborations to maintain or increase their competitiveness. It is a binary variable which takes the value 1 for firms that answered "yes" and 0 otherwise.

Context dependence. To measure context-dependence (H4), we use a variable that measures the importance of internal sources of information for the development of technology.

We asked firms to value from 0 (irrelevant) to 10 (important) the importance of the various sources of ideas that they used to innovate. The possible sources of ideas were classified into internal and external sources. We then construct the variable (*internal sources*) that we use in the regression analysis and which measures the importance of the internal sources of ideas over the total sources of ideas for innovation.

Absorptive capacity. The absorptive capacity (H5) is measured in our case with a variable that captures the existence or not of a formalized R&D department in the firm. It is a binary variable which takes the value of 1 if the firm does have an own formalized R&D department and 0 otherwise.

Appropiability. To measure appropriability (H6), we use the variable *patents* - It is a binary indicator which takes the value of 0 if firms did not ask for patents in the past 3 years, and 1 if they did.

Not-Invented-Here syndrome. To account for the Non-Invented-Here syndrome (H7), we use two indicators.

The first indicator is related to the importance for firms of the potential barriers to outsourcing technology. Specifically, we asked firms to value the importance of the following potential barriers to outsourcing technology: absorption difficulty, dimension/size too small, organizational differences between firms and partners, expensive and complicated administrative procedures, commercial exploitation difficulties, the necessity of previous internal R&D in order to complement it, lack of mechanisms to analyze and monitor the environment, lack of motivation because of previous unsatisfactory experiences, the need to fully use, in a continuous manner, an internal established R&D structure becomes a barrier to outsourcing technology, legislation and external factors.

We use the answers that firms gave to "the need to fully use, in a continuous manner, an internal established R&D structure becomes a barrier to outsourcing technology" (*outsourcebarrier*) as a measure of the NIH syndrome.

As an additional indicator of the NIH syndrome, we use the variable *depe&collaboration,* which indicates when the firm has an own R&D department and does not view collaboration as necessary to be competitive. To construct this proxy, we combine two variables in our survey measuring whether firms have a formalized R&D department and the necessity of collaborations in order to be competitive, respectively. We construct a binary variable that takes the value of 1 if firms have an own formalized R&D department and do not consider necessary collaboration in order to be competitive, and takes the value 0 otherwise.

4.2.3.3. Methodology

The methodology that we choose for this study is dictated by the limitations of the data set that we use, which is rather small (59 firms only) and contains many zeros. Hence, albeit we produce an analysis that is statistically well grounded, the limits on the scope of empirical tests that we can perform on our data set suggest that the results that we provide should be taken more as indicative rather than definitive.

We first conduct a descriptive analysis. Since most of the variables were politonic, we use frequency tables (see Table 4.2.5). For the case of the continuous and discrete variables, we use the usual measures (mean, median quartiles, standard deviation). We analyse the bivariate relationship (using contingency tables) of all the variables in our analysis, and specially, the relationship between the dependent and the explanatory variables. We check the significance of these relationships using Chi-square of Pearson and the Spearman correlation coefficient.

In our case the dependent variable is a count; that is, it can only take on values limited to the non-negative integers. This suggests that a Poisson process is the underlying mechanism being modelled. In a Poisson process, the expected value for the dependent variable on any firm is λ (i.e., $E(y|X) = \lambda$). Then the probability of y (…) occurring for a given firm is given by:

$$\Pr ob(y|\lambda) = (e^{-\lambda}\lambda^{y})/y!$$

In our case the Poisson process is not stationary, that is, the underlying risk λ varies with predictor variables.

$$\log (E(y|X)) = \beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p$$

where $X_{1, \ldots, } X_p$ were explanatory variables, and $\beta_{0, } \beta_{1, \ldots, } \beta_p$ denoted unknown parameters.

Furthermore, because the small size and, above all, the presence of zeros, the process is overdispersed, that is the variance of the dependent variable is higher than the nominal one (i.e., λ).

$$Var(y|X) = \phi\lambda$$

where $E(y|X) = \lambda$, and $\phi > 0$ is denoted the dispersion parameter.

Hence, it is appropriate to use Poisson regressions to estimate the causal models. We run simple Poisson regressions and then multivariate Poisson regressions to control for the influence of the other variables.

4.2.4. Results and discussion

Hypothesis 1: Table 4.2.6 shows that the OECD classification **is verified** in our SME sample, the expenses in R&D over sales are growing with the technological intensity group.

Table 4.2.6: Percentage of R&D expenses over sales, by technology intensity (Hypothesis 1)

Survey Technological intensity groups	OECD Technological intensity group	Industrial sector	Percentage of R&D expenses over sales
3	C	Various kind of manufacture	0,8
3	C	Food, drink and tobacco	0,9
3	C	Paper, publishing and graphic arts	1,0
3	C	Textile and clothing	1,0
2	B	Metallurgy and manufacture of metal products	1,0
2	B	Non-metal mineral products	1,5
2	B	Transformation of rubber and plastic materials	2,7
1	A	Chemical	2,7
1	A	Construction of machinery and mechanical equipment	3,4
1	A	Electrical, electronic and optical material	3,7
1	A	Manufacture of transport materials	4,3

Note (1): 1 – medium-high technology; 2: medium-low technology; 3: low technology – Survey classification used by the authors for manufacturing sectors

Note (2): A – medium-high technology; B: medium-low technology; C: low technology – OECD's classification for manufacturing sectors

Since the OECD classification was established over a sample including big corporations and small firms, our verification suggest the prevalence of industry effects over firm size.

This result should be taken with care account given that it is not a statistical test and that the size of firms may exhibit collinearity with the industry code. Nevertheless, the result is intuitive of the importance of R&D in SMEs.

An additional consideration is the industry code in our dataset. We work with 4-digit industry groups; because of this, there is substantial variance in relevant characteristics among firms in the same group. To overcome this problem, the following tests were run at firm, rather than industry, level.

Hypothesis 2: We find a positive relationship between the intensity of technology and the complexity of knowledge that firms develop/accumulate during their activities.

RR coefficients indicate the following: with every additional qualified person working in the R&D department, the probability of having more R&D expenses is 19.36% higher. If the firm doesn't vote for barriers 7 and 8 (about barriers to entering the sector) (7. technological "complexity" of the production process and 8. need of specific knowledge and highly qualified personnel), the probability of having more R&D expenses is 43.49% lower. If a firm has not used R&D related tax incentives in the past 3 years, the probability of having more R&D expenses is 47.37% lower.

Table 4.2.7: Poisson regressions

Variable	Description	Poisson regression (RR)	t-value
A. Dependent variable: percentage of R&D over sales (Hypothesis 2)			
qualification	Number of qualified people employed in the R&D department	1.193656	3.048030
barriers	A barrier to entry in the industry is the technological complexity, specific knowledge and qualified personnel	0.565197	-3.291314
incentives	Use of tax deduction incentives in the past 3 years	0.526325	-3.252533
B. Dependent variable: make or buy (Hypothesis 3, 4, 5, 6, 7)			
extcollaboration	External collaboration	0.8314669	-3.195085
internal sources	Percentage of internal sources of ideas over total ideas	0.9940295	-1.806342
owndepartment	Own, formalised R&D department	0.8898269	-1.971444
patents	Patents applied for or obtained	0.9442182	-1.014637
outsourcebarrier	Continuous exploitation of internal R&D	1.137600	1.905667
dep&collaboration	Formalised R&D department and no need of collaboration	1.123814	1.971444

We show the results of the best models we tried. We checked the goodness of fit and the specifications of the model. Additional results can be requested on the authors.

Hypothesis 3: We find a positive relationship between the complication of knowledge and external acquisition of technology - if firms do not find external collaboration necessary to be competitive, the probability that the firm externalises part of it its R&D is 16.86% lower.

Thus, the effect of the complexity of knowledge requiring the cooperation of firms with competitors or with other institutions to be competitive prevails in our sample over the effect of the complexity of knowledge making its transfer less efficient and thus lowering the external acquisition of technology. In other words, firms collaborate with others and develop complex knowledge with this interaction for themselves. This is a significant finding because the existence of complex knowledge may also make the firms less amenable to collaborating with others, because of difficulty in transferring this knowledge.

However, the fact that firms manage to find willing collaborators in production of knowledge suggests that firms are able to transfer enough knowledge to make it "economically worthwhile" for their partners, or they overestimate the value of knowledge in other firms, or underestimate the effort required to internalise it. Since the last two conditions are not sustainable in the long run, we should have observed a lack of collaborations in the knowledge area, contrary to actual observation. Therefore this finding suggests that SMEs can transfer worthwhile knowledge in collaborations.

Hypothesis 4: We verify that there is a **positive** relationship between the context-dependence of knowledge and the in-house development of technology. With every additional percentage point of the use of internal sources of ideas in the development of new products, the probability that the firm externalises part of it its R&D is 0.60% lower. The sign of this relationship reflects the impediments to the existence of a market for a technology when that technology would require many adaptations to the particularities of each firm. In other words, when knowledge developed is extremely firm-specific, the desire to use the market for its development is low. Yet, the significance of the relationship that we find is very low.

Hypothesis 5: We find a significant **negative** relationship between the existence of an own formalized R&D department and the acquisition of technology. This provides evidence *against* the absorption capacity effect in our sample. However, this effect is weak and we only find marginally statistically significant. This result could also be an artifact of our sample - if we take into account that only 20 firms in the sample had a formal R&D department, whereas 39 declared not to have it. If the firm has a formal R&D department, the probability that the firm externalises part of its R&D is 11.02% *lower*. (see Table 4.2.7).

The "informality" of R&D decisions is itself characteristic of SMEs. During our interviews, we asked firms about the influence of various agents in the new products development process. On a scale of 1 (low) to 3 (high), general managers (score of 2.49) were ranked first, R&D department was ranked second (2.16 points). The rest, in the order of importance, were clients, marketing, production, suppliers, human resources, commercial and financial department. This suggests the wide variety, albeit varying in importance, of sources via which these firms involved/were influenced by different agents in developing new products.

Hypothesis 6: We find no evidence of appropriability effects in our sample as the relationship between our measures of appropriability conditions (patents) and the internal development of R&D is **not significant** (see Table 4.2.7).

Due to data limitations, we could not test the significance of patents at industry, rather than at firm level. These would have been desirable since, as explained in section 2, the propensity of firms to patent varies greatly across industries.

In our empirical analysis we find that approximately 60% of the survey did not ask nor obtained patents in the last 3 years. This data confirms our perception coming from the interviews that patents are not the most efficient mechanism of protecting technology, we even found a group of firms which did patent in the past and they are not doing it anymore because of their low utility.

Hypothesis 7: We do find a significant relationship between the sourcing decision and the need to exploit the installed capacity of the internal R&D department. In other words, a

firm uses externalization of R&D as an option only when it believes that it doesn't interfere with using its internal R&D department in a negative way. For firms without an internal R&D department, external collaboration is more easily welcomed when seen as a necessary condition to be competitive. Both these suggest that the internal R&D department can act as a deterrent to external collaboration, supporting the "not-invented-here" hypothesis.

The results show that if the firm gives a low score (3 or less out of 5) to the influence of an existing R&D department (need to use its capacity) as a barrier to the externalisation of R&D, the probability that the firm externalises part of its R&D is 13.76% higher. Another way to look at it is via probability of externalization without an internal R&D department. If the firm doesn't have an own R&D department and find external collaboration necessary to be competitive, the probability that the firm externalize part of its R&D is 12.38% higher (see Table 4.2.7).

4.2.5. Conclusions

Our results have implications for our understanding of the patterns of technological innovations in small and medium sized-firms. We first empirically verify the soundness of OECD classification of industries on the basis of R&D intensity. This is an important empirical contribution because this classification may be the basis for several policy prescriptions among OECD countries – for instance, to provide tax and location incentives to industries that are assumed to be at the forefront of new knowledge creation. In addition, we find some evidence of increasing R&D intensity leading to increasing knowledge complexity. To some extent therefore, increasing knowledge complexity could be driven by managerial action. We elaborate on this next, incorporating the results of other hypotheses also.

The primary contribution of this subchapter is the verification of a clear relationship between technology intensity and its "complexity" (of all the attributes of type and knowledge); on the other hand, we have shown that, when it comes to the sourcing of technology, other factors, such as the influence of the internal R&D department (rather than only "complexity" of the technology) may also influence the R&D decisions of firms. This suggests the possibility of technology and knowledge development trajectory of a firm

being endogenous to managerial vision and decision-making, rather than determinate aspects of technology and knowledge *per se*. In other words, managerial vision and values about how technology and knowledge develops, and the strategies that they adopt in pursuit of such vision, play an important role in the development of a firm's knowledge and technology base. In other words, managerial actions play a significant role in path dependencies in developing a firm's technology and knowledge base.

The fact that firms with internal R&D department could suffer from a "not-invented-here" phenomenon is also significant. Knowledge production and advancement may require unfettered collaboration and transactions to increase a firm's stock of knowledge. However, it is possible that existence of an internal R&D department may add to the transactions cost of collaborating and producing complicated knowledge at the margin, since there is no *a priori* reason to give preference to an internal R&D department in knowledge creation on its own.

The fact that we were unable to support absorptive capacity and appropriability arguments in this study may be an interesting artifact of our sample. The smaller firms in the Catalan region may be more conservative than their larger counterparts – the sample is dominated by firms that do a major proportion of R&D inhouse. These privately-held and sometimes family-owned firms may have different objectives than publicly-held professionally managed corporations (Tagiuri and Davis, 1992; Sharma, Chrisman, and Chua, 1997; Westhead, Cowling, and Howorth, 2001; Cooley and Edwards, 1983). In the absence of deep pockets to preserve appropriability, the former may prize control and preservation of knowledge inhouse than favor rapid growth via extensive rapid linkages at the risk of losing control. A broader sample of firms in terms of governance structures, and incorporating differences in these structures to predict appropriability and absorptive capacity may be a fruitful area of research. While governance has been linked to innovation in the past, the sample has been range-restricted to either very large firms (with disperse or concentrated holdings) *or* SMEs.

Our study has some limitations, which should be considered when evaluating our results. First, our sample size is rather small, with only 59 total firms, in several industries. This limits the scope of empirical tests we can perform on our model. A more comprehensive model may be able to test the simultaneous effect of several constructs that we are only

able to test in partial, bi-variate models. Therefore, our results should be taken more as indicative, rather than definitive. Larger sample studies would be needed to test more comprehensive models, although we acknowledge the difficulty of collecting good data on small and private SMEs, especially in more conservative contexts.

In conclusion, this study adds to the growing literature on knowledge creation, especially by SMEs, and highlights important aspects of their decisions on whether and how to use internal R&D departments. It especially highlights the role of managerial actions in creation of new knowledge – underlining the point made by Nonaka (1991) et al that the trajectory of knowledge creation may be endogenously determined by managerial actions rather than being an intrinsic trait of stock of knowledge at any point of time.

Endnotes

1. We thank Marc Sáez (University of Girona) for the help with data analysis.

2. Additional statistical results can be obtained from the authors upon request.

5 Summary

Each of the chapters of this dissertation provided explanations and empirical evidences to knowledge generation, exploitation and commercialization in business environments. Three were the main topics tackled: organizational innovation, university entrepreneurship and R&D outsourcing.

After the introduction, Chapter 2 provided an overview on how the concept, definition and treatment of organizational innovation, complementary to product and/or process innovation, changed among the scientific community. As a result, those willing to monitor them, as a first step to doing so, included the concept in existing innovation surveys.

The first subchapter (Section 2.1) is an intent to describe and define organizational innovation together with its measurement on large scale surveys until now. Data used for showing empirical evidences was collected through a complex questionnaire aiming to collect valuable data on detailed organizational concepts, not organizational innovation as a whole. The goal of this study is not to offer a "new" or "better" methodology, rather it considers and shows those aspects important to take into account when willing to efficiently measure organizational innovations. In any circumstances, they should be considered as complementary sources of information of existing large scale surveys.

The second part of this chapter (Section 2.2) deals with one organizational concept, namely teamwork in production, in order to overcome the "much speculation, little data" phenomena. The adoption of such techniques of new forms of work organization among German manufacturing firms is described, characteristics of these teams (number of people normally working in a team, tasks to perform, etc), as well as a modelling of determinants of adoption are considered.

The design and application of an organizational innovation monitoring system is a challenging matter and both researchers' and official survey conductors' opinion should be taken into account. The design phase, followed by the data collection process is tested and validate through the information collected. Chapter 2 caught the essence of the design phase and one example of organizational concept treated in detail. There are grounded

reasons for the study of both. It would be interesting to find out more about the determinants, effects and linkages (among them and with others) of the different techno-organizational concepts.

One of the contributions of this chapter consists in the empirical evidences brought as a result of a complex research project conducted repeatedly and during a long period of time. Still, the main contribution of this chapter is methodological. On the one hand side, it shows what should be the issues to take into account for the design of an organizational innovation monitoring systems. On the other hand side and in terms of one concrete innovation, it is an example of valuable data and its exploitation, result of the applied methodology.

Chapter 3 concerned university entrepreneurship. The University of Girona was followed up an analyzed in-depth since the entrepreneurial transformation of the universities became an institutional and political priority. The sources, the process and the results of university research commercialization strategy represent the main content of this chapter.

First, section 3.1 describes the entrepreneurial transformation of universities in their search for marketing strategies and efficient research commercialization methods as an important part of their third mission. European public research institutions served as starting point when willing to find the most appropriate research commercialization strategy, including spin-off modality among most traditional ones such as contract research and patent licensing. Although up to some-point elite universities can easily serve as role models and best practices, their research management model should be adapted and not imported in other settings.

Therefore, the single university case presented in section 3.2 serves as an example for that. Scanning best practices made possible the design of a research commercialization unit specialized in spin-off creation and support, thought to be optimum in a concrete moment in time. The evolutionary perspective adapted in this subchapter makes the reader see how this specific unit changed over time in terms of strategy, objectives, activities and resources. Although being a regional and non-elite public research institution, it is still part of a wider

European setting. Consequently, matching this university's spinning-off strategies with other European public research institutions is a must.

While the previous chapter's main contribution is methodological, Chapter 3 is valuable in terms of content, findings and challenging future research area generated. More concretely, the last research shows that even incomparable in volume but easily matching in structure and functioning regional non-elite universities do their best taking into account their limited resources but each time more diversified tasks. Once commercialization "philosophy" got clear the results did not trig to appear. Still, they are part of an important initial euphoria of university spin-off creation. The main issue concerns the entrepreneurial transformation of research institutions. Under the institutional and political pressure some universities put a grate emphasis on the former – entrepreneurial transformation- and neglected the importance of the latter – research institution-. Once research having commercial potential is exploited, spin-off creation will not follow a growth path. Resuming, it is a call for a continuous effort in investing in both content and structure.

Latest official statistics on the topic on entrepreneurship (GEM, 2005) highlight Catalonia as the second most important region in Europe (after Ireland) by the total early stage entrepreneurial ventures –start-up and baby businesses-created. The case described, the model's strengthens and weaknesses, could serve other universities willing to develop an appropriate research commercialization infrastructure. Including the spin-off modality among the "classics" is a complex and dynamic procedure.

Chapter 4 dealt with R&D outsourcing, insisting on the importance and use of different strategies SMEs might adopt in order to complement their knowledge base.

Subchapter 4.1 identifies the main barriers perceived by companies when willing to engage in cooperative agreements, in general, and with universities, in particular. The results show that the difficulties of absorbing and profiting from the acquired knowledge, troublesome and costly management of cooperation, and the need for previous internal R&D activities are among the most frequent obstacles for cooperation in general. Those collaborating with universities name primarily their unresponsiveness to industry needs, academia being unable to provide industry solutions due to lack of applicability, and a general lack of trust.

It is collaboration intensity, rather than technology intensity determining differences in barrier identifying patterns.

Section 4.2 tries to find answer to the question how is knowledge accumulated in SMEs? The hypothesis capture the sense and significance of the relationships between, on the one hand side, firms' decision on the intensity of R&D and make-or-buy decisions, and, on the other hand side the nature of knowledge, absorptive capacity, appropriability characteristics and the not-invented-here syndrome. Empirical evidences come from Catalan manufacturing gazelle SMEs. Once innovation and R&D management is studied in-depth in these firms, policy makers use their example for enhancing involvement of regular SMEs in complex and challenging innovative practices. The existence of an internally formalized R&D department has an important effect on firms' decision to make or buy.

It is the same R&D department, the level of R&D investment and the absorptive capacity of the firm that seem to be determinants or minimum conditions for engaging in cooperative agreements or buying technology/knowledge from partners, universities. All linkages between the different actors need bridges in order to facilitate and fasten these strategic relationships. Those willing to cross the bridges should take into account both the direction (one-way, two way) and the barriers (up, down) of these facilitators of communication and transfer.

The contribution of this chapter is clearly policy oriented due to two main reasons and conclusions extracted from it. First, the topic of innovation patterns in SMEs and its tracking in official statistics. Second, practical barriers identified by businesses in their cooperative agreements. In both fields, policy makers have important gaps to fill in.

In the followings a brief reflection on the issues for the future research is made.

The enriching thing about research relies in its infinite explorations and gaps. Most often conducted analysis makes the researcher aware of new and underexplored research horizons. This is also the case of the present dissertation.

Willingness in continuing the study of organizational innovation is concreted by the desire to know more about the topic in general, its determinants and its impact on business results in particular. Differentiated degrees of diffusion raises the obvious question of why? Longitudinal studies and international comparative studies would clearly enrich the existent knowledge base on the topic. The regular base of conducting the European Manufacturing Survey, on a two year basis, as well as its wide country coverage, including 11 countries in the 2006 edition, the diversity of concepts analyzed are all factors motivating further research in the innovation management area. In the near future a comparative analysis on technological innovations' determinants and organizational innovations' determinants is foreseen. The linkages between both are stated clearly by most of the authors dealing with these topics. Still, there are no previous works trying to find out more on what factors influence their occurrence.

The single university case would gain value if framed in the context of other Catalan, Spanish or European universities. Still, the most promising field is trying to measure the contribution of this particular typology of firms on regional development, topic that most of the existing studies limit to job and wealth creation. A second step would be determining weather this contribution is important or up to which point this contribution is important and significant. Recent personal research priorities include the design of a set of indicators trying to capture both qualitative and quantitative contribution of technology based new ventures.

Interestingly, up to present, those institutions inverting in spin-off creation in the region, did not conduct any type of monitoring on the effect of their investment. Basic characteristics of the new ventures are known, but finally it is their contribution to the regional and/or local environment that matters most. Existing studies in the field come mostly from the US and show figures that are uneasy to compare and interpret in the framework of European or local reality.

To conclude, future activities seem to be more oriented to methodological aspects enriched with empirical evidences, rather than other topics. Exhaustive exploitation of the European Manufacturing Survey, changes in future questionnaires and measurement issues in the field of entrepreneurship are short term concerns, while long term research proposals consist in, for example, the study of culture as a determinant of innovation diffusions and

its past and present operationalization, or the challenging topic of teaching entrepreneurship.

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