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Erik E. Lehmann
Albert N. Link
Alexander Starnecker *Editors*

Technology Transfer in a Global Economy

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Technology Transfer in a Global Economy

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Chapter 1
Introduction: Technology Transfer in the Global Economy

David B. Audretsch, Erik E. Lehmann, Albert N. Link, and Alexander Starnecker

Abstract Technology transfer—the process of sharing and disseminating knowledge, skills, scientific discoveries, production methods, and other innovations among universities, government agencies, private firms, and other institutions—is one of the major challenges of societies operating in the global economy. This volume offers state-of-the-art insights on the dynamics of technology transfer, emerging from the annual meeting of the Technology Transfer Society in 2011 in Augsburg, Germany. It showcases theoretical and empirical analyses from participants across the technology transfer spectrum, representing academic, educational, policymaking, and commercial perspectives. The volume features case studies of industries and institutions in Europe, the United States, and Australasia, explored through a variety of methodological approaches, and providing unique contributions to our understanding of how and why technology transfer is shaped and affected by different institutional settings, with implications for policy and business decision making.

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1 Introduction

Technology transfer is one of the major challenges for society and firms in a global economy. Also, technology transfer may be seen as only advantageous for the involved parties; the exceptional benefits are also associated with their costs. Thus, technology transfer offers a promising field of research with several faces and fields of application. This volume offers recent research and state-of-the-art articles to cover the broad field of technology transfer in the global economy. The articles presented and collected in this volume were presented at the annual meeting of the Technology Transfer Society in 2011 in Augsburg, Germany. The guiding topic of this conference was "Technology Transfer in the Global Economy."

This volume differs from other related volumes and books in several ways. First, it combines and presents theoretical and empirical insights from different participants along the technology transfer process, i.e., universities, research institutions, global players, and policy-advising institutions. Thus, this volume tries to bring together both the academic perspective on technology transfer and the experience made by practitioners and policymakers. Second, this volume provides an overview over multiple countries. While most of the academic research is focused on a small number of countries, like the USA, the UK, Sweden, or Italy, this volume provides insights from several countries beyond the Anglo-Saxon and European lenses of research. Such an approach helps to detect how and why technology transfer is shaped and affected by different institutional settings. Third, this volume collects studies based on different methodological approaches. Understanding technology transfer in the global economy needs theoretical thoughts about the underlying principles of causes and effects. It needs rich empirical studies to confirm theoretical consideration but also to highlight variations and thinking in new directions and paths. Finally, case studies help to improve our understanding of the big picture of technology transfer and also help managers and policymakers in their decision-making process. Therefore, we hope to provide a comprehensive volume summarizing different aspects and perspectives on technology transfer which might be fruitful and stimulating not only for academic research but also for managers and policymakers.

The volume is divided in five parts, following the technology process as described in the literature. The volume starts with the role of universities within the technology transfer process in the first part. Then, part two highlights theoretical and empirical work analyzing the innovation process in firms. Part three focuses on the regional perspectives influencing technology transfer. Part four is dedicated to different innovation business models. The volume ends with part five providing tools and best practices in the technology transfer process.

The first part highlights the *role of universities within the knowledge transfer process*. In their study *Forget R&D—pay my coach: young innovative companies and their relations with universities, Joaquín M. Azagra-Caro, Francisco Mas-Verdú, and Victor Martinez-Gomez* analyze how young and innovative firms (YIF) can interact with universities and build up fruitful relationships. They explore university-industry interaction involving YIF in the Valencian Community (Spain), using YIF founders' personal attributes and motivations as explanatory variables. Their study shows that in general the probability of contracting with universities is not affected by firm size. Most importantly, firm founders' personal characteristics and motivations seem to be the driving forces for contracting with universities, more important than the R&D intensity of the respective firm. They also provide evidence that YIF founders, which are primarily interested in exploiting market opportunities and necessity entrepreneurs, are the least likely to interact with universities.

Important vehicles for technology transfer from universities to society are joint projects with firms. Such projects are often funded by industry, and thus, their quantity and quality is expressed and measured by the amount of industry funds raised by universities. *Hanna Hottenrott* analyzes *The Role of Research Orientation for Attracting Competitive Research Funding* in Germany. While traditionally research activities were funded by the institutions' core budget, extramural research funding has become increasingly important for universities in Germany. Her results are based on a sample of professors in science and engineering and suggest that basic and applied research is complementarity for attracting research funding from the industry. Professors conducting basic research in addition to research on the applicability of their results appear to be most successful in raising industry funds. For raising grants from public sources, it turns out that specialization is more important. Specialized research units on either basic or applied research obtain significantly more public grants which points to a substitutive relationship between basic and applied research for grants from public sources.

The literature on technology transfer offices (TTOs) focuses on the main variables explaining the performance of these organizations. The implicit strategic model considered by the literature is that the TTOs have to control all the activities, resources, and competences of the value chain of the technology transfer process. The aim of the TTO is to maximize the revenues of the commercialization of academic results, and its role is to manage a linear and unidirectional process. *Mireille Matt and Véronique Schaeffer* propose that this model is not applicable for every university. In their paper *The Cooperative Strategy of Technology Transfer Offices: A Longitudinal Study*, they show that France differs in some cases. In particular, TTOs have to develop cooperative strategies with other local TTOs to pool resources and share costs and to structure the regional innovation system. Their alternative model is illustrated by a longitudinal study of a French University being active in technology transfer activities for several years.

L. Ranmuthumalie De Silva, Elvira Uyarra, and Ray Oakey investigate academic entrepreneurship in a resource-constrained environment. Their paper *Academic Entrepreneurship in a Resource Constrained Environment: Diversification and Synergistic Effects* adopts sequential mixed methods in three stages, namely, an initial context-specific data gathering stage, an on-line survey, and in-depth interviews. They reveal entrepreneurial activity as a means of becoming resource rich in a resource-constrained environment. They argue that in order to extract value from their environment, academic entrepreneurs adopt diversification strategies, which generate synergies between multiple academic entrepreneurial activities. They conclude that diversifying into a greater number of different activities generates more synergistic effects than diversifying into a limited number of similar activities and highlight the importance of a university having a team of different academic entrepreneurs, who complement each other.

In their study *Introducing the University of Applied Science in the Technology Transfer Process, Erik E. Lehmann* and *Alexander Starnecker* analyze the division of labor in the German higher education sector and its effect on technology transfer. Public universities are mainly focused on basic academic research, whereas Universities of Applied Science are more concerned about applied research and teaching. While the role of public universities and their role within the technology transfer processes are intensively studied, the impact of UAS remains rather under researched. Despite structural disadvantages, their study discovers that the technology transfer process of Universities of Applied Science is as successful as of public universities. Additionally, they find regional characteristics connected with the differences in patenting application performance of Universities of Applied Science. Therefore, this type of universities could be a role model, in particular for countries and regions where small- and medium-sized firms dominate the industrial landscape.

Thomas O'Neal and *Vernet Lasrado* discuss *The Role of University of Central Florida in Regional Economic Development*. They show how the University of Central Florida (UCF) has enabled an innovation-centric entrepreneurial culture by developing a rich innovation and entrepreneurial ecosystem in the Central Florida region. As a key enabler of this entrepreneurial culture, they highlight the UCF Business Incubation Program (UCFBIP). They argue that since its inception, the UCFBIP has been a catalyst for many entrepreneurial initiatives that served to empower the local entrepreneurs. The UCFBIP also plays a key role in facilitating the economic development cycle in the Central Florida region. Their study clearly highlights how universities, like the UCF, have become a driver and a partner to help diversify the economy of a region that is heavily depended on tourism, hospitality, and agriculture, sectors known for lower than average wages.

The second part of this book is dedicated to *innovation in firms*. *Philipp Buss* analyzes *the impact of technological acquisitions on innovation quality*. In recent years, M&A has been a prominent strategy in the context of interfirm technology transfer. Prior literature has evaluated the latter by using different types of post-merger innovation measurements. In this connection, the study provides a framework to analyze the effects of corporate acquisitions on innovation quality. The approach presumes that an acquirer's post-merger innovation outcome is a function of learning capabilities with respect to recent technologies. Buss investigates a sample of German domestic and cross-border takeovers, in order to analyze the ex ante determinants of post-merger innovation quality. The results show that especially middle-aged and specialized acquirers achieve improved innovation quality subsequent to takeovers.

Is it worth all the trouble? An assessment of the economic value of firm patent applications with shared intellectual property rights in the biotechnology industry is the title of the study conducted by *Heide Fier* and *Andreas Pyka*. They argue that shared intellectual property rights are connected with complex legal issues, and therefore, firms that apply for patents have a strong incentive to avoid co-ownership on their patents. In contrast to this, the share of EPO firm patent applications with a joint ownership has increased in the biotechnology industry during the last two decades as it has been observed in other industries. They question whether joint patent applications are associated with a higher economic potential compared to the patents with no joint ownership so that firms are willing to cope with the legal issues that are associated with shared intellectual property rights on patents. Measuring the economic value of a patent by the number of subsequent citations it has received, they empirically address this question by the application of a nonparametric matching approach on patent level. They find a positive causal relationship between the decision of a firm to jointly apply for a patent and the future economic value that is associated with the regarded patent.

Flexibility in response to competitive pressure from globalized markets and increasingly individualized costumer desires has become vital for firms, argues *Christian Peukert.* A common strategy to address this challenge is to employ a dynamic concept of organization and reach beyond the boundaries of the firm. Accordingly, technology transfer from providers of knowledge intensive business services attracts more and more attention. His paper *External Technology Supply and Client-Side Innovation* focuses on external supply of information technology and client-side innovation. He contributes to the literature by resolving an empirical puzzle questioning the beneficial effects of IT outsourcing. His stylized theoretical model combines a knowledge production function framework and transaction cost economics and hypothesizes that the right balance between internal and external knowledge is critical for innovation. The empirical application is German firm-level data covering a wide range of industries from 2003 to 2006. The results widely support the theoretical arguments and suggest a positive linear relationship between the level of outsourcing and process innovation and a hump shape for product innovation.

Niclas Rüffer, Detlef Keese, and Michael Woywode analyze *the enrolment in an R&D subsidy program for SMEs—evidence from South-West Germany*. The literature on R&D subsidy programs has mainly focused on final R&D outcomes and has largely ignored the processes that operate within subsidy programs that include the implementation of programs and allocation of funds which have a profound impact on the final economic outcome. The authors discuss the targeting process of R&D subsidy programs and analyze empirically the *enrolment* in a particular R&D promotion program. Companies applying for this program often seem not to have complete knowledge on their projects and project partners once they apply for funds. Their study shows that about one out of five companies does not conduct the project it was granted money for. They conclude that companies that were planning to cooperate with "high-quality" R&D institutions in the scope of the project and those from core cities are more likely not to conduct their projects. In contrast, companies that have cooperated with R&D institutions in the past and thus are more experienced are more likely to conduct their projects than those without cooperation experience.

The third part reveals *regional differences* in the technology transfer process. *Claudio Cozza, Raquel Ortega-Argilés, Mariacristina Piva, and Rui Baptista* highlight *productivity gaps among European regions*. They are interested in finding answers how R&D-productivity links are affected by the environment. In particular, they analyze whether companies located with their registered offices in more R&D favorable environments are better able to translate their R&D knowledge into productivity gains. Their paper tries to answer these questions analyzing—in the European context—if R&D performing companies cluster themselves in "higher-order R&D regions," as the economic geography theories postulate, inducing a polarization in terms of labor productivity in comparison with firms located in "lower-order R&D regions." The proposed microeconometric estimates are based on a unique longitudinal database of publicly traded companies in the manufacturing and service sectors. The results of their study show that European "higher-order R&D regions" not only invest more in R&D but also achieve more in terms of productivity gains from their own research activities. In the case of "lower-order R&D regions," physical capital stock is still playing a dominant role, they conclude.

The effect of regional characteristics on the relationship between university resources and knowledge-based startup's performance is analyzed by *Thomas O'Neal, Cameron Ford, Vernet Lasrado, and Stephen Sivo*. Past research provides evidence that regional resource endowments promote the viability of firms within those regions. University resources endowments are often portrayed as especially important to the development and success of firms, especially knowledge-based firms that benefit from faculty expertise, specialized facilities, and intellectual property. The contribution of university resources endowments to firm performance and viability is contingent on the presence of complementary regional resource endowments, and thus, firms, drawing resources from universities, are more likely to realize performance benefits once a regional economy is rich in complementary resources. They propose that for knowledge-based start-up firms, in addition to the direct positive effects of regional and university resources endowments on firm performance, regional resource endowments availability will moderate the impact of university resources endowments on firm performance. The authors examine these relationships within the population of university-based incubators in the USA and a sample of knowledge-based firms associated with those incubators.

Part four contains on studies analyzing *innovation business models*. The first study in this section is from *Alexander Brem and Deependra Moitra*, *Learning from Failure—Case Insights into a UK-India Technology Transfer Project*. They argue that the success of firms in emerging economies like India and China is generally attributed and reduced to their low-cost R&D and manufacturing capabilities, scalable resource pool, and rapidly growing domestic demand. Recently, however, emerging economy firms have been employing new innovation strategies to morph into higher orbits and drive profitable business growth. Many emerging economy firms are deploying their earnings to invest in R&D and to acquire advanced technologies from developed countries' firms to boost their innovative capability and to drive their global business competitiveness. Drawing on recent literature on international technology transfer, their paper presents a case study of an Indian MNC to provide theoretical and practical insights into the dynamics and process of technology transfer. They conclude that lacking strategic orientation is identified as a main missing factor in recent literature.

The Emerging Properties of Business Models: A Systemic Approach by *Andrea Cocchi* explores the emerging properties of business models design processes in complex contexts such as a traditional manufacturing cluster. Distinguish between a static and dynamic perspective on business models, profiting from a critical analysis of the recent literature. Then he defines the service orientation landscape for manufacturing sectors, approaching different strands of analysis. On this canvass, he presents case scenario based on an ongoing project for the design and delivery of new business model concept for the machine tool sector, based on renting and leasing. The analysis of this case will allow to draft some conclusions about the emerging properties of business models design processes in context different form the one traditionally used to this kind of activities: a cluster of Italian SMEs. The interesting aspects accruing form this analysis lies on the different roles played by public and semipublic institutions in participating to this pilot project. Moreover, the business models' systemic impact and strategic dimensions are explored, showing how this tool can be considered as a systemic instrument for the governance of the innovative processes.

Mehmet Teoman Pamukçu and Alper Sönmez analyze the *Technology Transfer in the Global Automotive Value Chain: Lessons from the Turkish Automotive Industry.* The automotive industry is proclaimed as one of the main contributors to value added employment and exports of the Turkish economy. This industry has undergone major changes since the mid-1990s. Most automotive manufacturers in Turkey are either joint ventures or wholly owned affiliates of multinational companies. Literature on global value chains points to the possibility of technology transfer occurring through backward linkages from automotive manufacturers to their suppliers. In this context, the authors analyze the existence and the importance of different types of knowledge and technology transfer mechanisms in the Turkish automotive industry. They draw on characteristics of local suppliers as successors for the technology transfer process and its impact on firm performance. Based on survey data administered to production and R&D managers of 158 automotive suppliers operating in Turkey in 2010, their findings confirm the existence of transfers from customers to their local suppliers. In particular, they show that codesign and codevelopment activities or design of materials are the key variables and successors within the technology transfer process which shape the performance of supplier firms.

The Australian mining sector is analyzed by *Tim Turpin, Hao Tan, Phil Toner, and Sam Garrett-Jones in their paper Investigating the Lateral Migration of Technology in a Resource Based Economy: Conceptual and Methodological Issues from a Study of the Australian Mining Sector*. This paper provides a conceptual and methodological approach to investigate lateral migration of technology from the mining and energy sector in Australia. "Lateral migration" refers to the application of technologies in a different sector and context they were originally developed. Previous research proposed that lateral migration is most likely to occur when there is a significant market demand from local producers, local opportunity to test, and commission new technologies, a cluster of firms that can support each other and cross-fertilize ideas and a strong base of R&D. In order to investigate these propositions, a robust methodology is needed to identify the pathways along which such technology migration occurs and the ways it is facilitated or inhibited. After an econometric analysis measuring the extent of lateral migration of mining and energy technologies, they use a case study approach to investigate the processes that inhibit or facilitate lateral migration.

Several *tools and best practice models* complete this volume in part five. *Florin Paun* and *Dimitri Uzundis* provide insights and an overview of *The Impact of Collaborative Tools and Practices in Technology Transfer Process*. The aim of this section is to highlight the collaborative tools and practices between R&D laboratories and industrial partners, developed, implemented, and used by various technology transfer and R&D commercialization offices. Various asymmetries related to information, financial risk, culture (behaviors and expectations), and time scaling are identified between the actors involved in technology transfer processes. These asymmetries provide a potential source for value creation in a collaborative work environment but could also become barriers, if ignored, in technology transfer process inducing important consequences on the innovation paths.

Innovative collaborative tools activating between R&D laboratories and their industrial partners like codevelopment contracts, co-innovation processes, IP co-ownership, risk sharing, R&D commercialization favorable conditions, market pull and technology push hybridized approaches, TTOs networking, or knowledge-based clusters are identified as a reduction or compensation mechanisms. Handling these asymmetries is the challenge for a successful technology management.

The technology transfer process between a public laboratory and a company has been the subject of many publications and has been widely discussed in economic theory. The paper *The Demand Readiness Level Scale as New Proposed Tool to Hybridize Market Pull with Technology Push Approaches in Technology Transfer Practices* by Florin Paul highlights several newly identified asymmetries occurring between the different agents taking part in the process. The theoretical corpus of this article draws upon empirical sources, being based on the recent experience of one of the most dynamic technology transfer offices (TTOs) in France: the case of ONERA (the National Office for Aerospace Studies and Research) and the SMEs. In such a cooperative innovation process, certain collaborative tools or practices emerge, aimed at reducing information asymmetries or acting as compensation mechanisms for other types of asymmetries between the partners at a microeconomic level. *Paun* introduces and discusses the Demand Readiness Level scale (DRL) as a tool to better manage the technology transfer relationship.

Martina Schauder and *Solveig Wehking* draw on the Fraunhofer Institute as a key player in the technology transfer process: *Fraunhofer's Discover Markets—fostering technology transfer by integrating the layperson's perspective.* Fraunhofer is Europe's largest applied research organization, employing more than 18,000 people worldwide, in particular engineers, mathematicians, and natural scientists with more than 80 locations in Germany, including 60 Fraunhofer Institutes. The most famous innovation in the past years was the MP3 format—an innovation made by researchers of the Fraunhofer Institute but commercialized by other firms. *Discover Markets* is a project, funded by the German Federal Ministry of Education and Research (BMBF) and set to run from August 2010 to July 2013, which seeks to redefine the boundaries of research and development and to foster technology transfer by including a wider range of people in the process. The authors present *Discover Market's* methods and current findings from approximately midway through the project. Technology transfer is defined here as the exchange of ideas, findings, and methods of production and management among research institutions, industry, and the public with the purpose of making scientific and technological advances accessible and appealing to a wider range of potential users such as consumers and licensees.

Part I
Role of Universities Within the Knowledge Transfer Process

Chapter 2
Forget R&D – Pay My Coach: Young Innovative Companies and Their Relations with Universities

Joaquín M. Azagra-Caro, Francisco Mas-Verdú, and Victor Martinez-Gomez

Abstract Young innovative companies (YICs) are attracting attention in their role of industry regenerators. However, we have little understanding about their relations with universities as sources of information. This chapter explores university-industry interaction involving YIC in the Valencian Community, using YIC founders' personal attributes and motivations as explanatory variables. The Valencian Community has a relatively high degree of university-industry interaction but surprisingly little technological innovation.

A survey of YICs in the region shows that, in their case, firm size does not affect the probability of contracting with universities and that R&D intensity is not significant if we consider firm founders' personal characteristics and motivations. YIC founders exploiting market opportunities recognized in previous business activities and necessity entrepreneurs are the least likely to interact with universities. We highlight the role of external advisory services to realise the benefits of universities.

1 Introduction

In this chapter, we discuss the determinants of university-industry interaction on the basis that they encompass the personal characteristics of the firm's creator as well as the usual firm characteristics, e.g. degree of openness and research and development

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(R&D) investment. Among these personal characteristics, we focus on educational attainment and motivations for setting up a firm. We explore this latter by combining elements of the strategy, psychology and entrepreneurship literature and provide a study which, in our view, extends the work on university-industry interactions.

We focus on young innovative companies (YICs) because they are important for transforming the industrial structure and contribute to economic growth and innovation within a territory. The academic community and policy makers are devoting increased attention to YICs (BEPA 2008; Schneider and Veugelers 2010), and several EU member states have implemented programmes to promote the establishment, consolidation and development of YICs (Veugelers 2009; Schneider and Veugelers 2010). However, many of these support measures are aimed at facilitating access to R&D funding sources and do not include other types of indirect actions such as advice and consultancy services.

Since we believe that these other types of firms and actions that facilitate technology transfer deserve further analysis, we focus on the determinants of YICs' interactions with universities. We find that, despite their different endowments, YICs' frequency of working with universities is similar to that of the typical innovative firm, although YICs are often very small and very R&D intensive. The existing evidence on YICs and other similar firms is limited and not conclusive about these aspects.

In a global economy, technology transfer from universities acts as a source of firms' innovation and competitive advantage. However, the innovative process is clearly influenced by the spatial dimension, according to the regional competitiveness approach, since highly innovative firms settle in highly competitive regions (Audretsch et al. 2010). Besides, some authors highlight the relevance of the regional entrepreneurship capital to explain the innovation behaviour of firms (Audretsch and Keilbach 2004). Specifically, the 'coevolution' of regional knowledge production and university technology transfer (Hülsbeck and Lehmann 2010) is supported by the empirical evidence on young and high-tech entrepreneurial firms in Germany (Audretsch et al. 2010).

Our study contributes to the literature in several ways. First, it provides a measure and explanation of the level of YICs' interaction with universities, including a comparison with other innovative firms. Second, we analyse a particular regional context that is characterized by a relatively low-technological level but a high level of university-industry interaction, a rather surprising and underexplored combination that deserves special attention according to the relation between regional settings and university technology transfer mentioned above. Third, the inclusion of founders' personal characteristics as explanatory variables in the estimation offers some insights into the lack of significance of R&D intensity in this respect.

The chapter is organized as follows: Section 2 discusses our choice to study YICs compared to other firms and the influence of firm characteristics and founders' personal traits on interaction with universities. Section 3 describes the regional context, and Sect. 4 presents the data, method and variables used in the analysis. Section 5 presents the main results, and Sect. 6 discusses some limitations of our study, offers some conclusions and suggests some managerial and policy implications.

2 How Much and Why Do YICs Interact with Universities?

There is evidence of the positive effects of links with knowledge centres for firm innovation (Radas and Bozic 2009; Wagner and Bukó 2005). However, there are some aspects that need further research, such as the degree of interaction between particular types of firms, such as YICs and universities. We look at firm characteristics as the determinants of university-firm interaction and the influence of founders' personal traits on knowledge sharing (an important and understudied aspect according to Lin 2007).

2.1 University-Industry Links: YICs Versus Other Firms

The focus in this chapter is on YICs. EU state aid regulations define a YIC as a small firm, aged 6 years or less and certified by external experts on the basis of a business plan, as capable of developing new—or substantially improved—technological products or processes, but which runs the risk of technological or commercial failure.

Other terms are used in the literature to refer to other closely related types of firms. Some authors have studied what they call New Technology-Based Firms (NTBFs), which are young companies in high-tech sectors (see, e.g. Colombo and Grilli 2005). Our study covers a wider range of firms because it covers all productive sectors irrespective of their technological level. In our view, belonging to a high-tech sector should not be seen as synonymous with being an innovative company; many firms that operate in R&D intensive sectors are only adopters of already available innovations. YICs include young companies that also are active innovators. This definition is sufficiently flexible to allow for different degrees of innovation.

Several articles on collaboration among innovative firms refer to start-ups. However, we prefer the term YICs because it encompasses the dimension of innovation that does not necessarily apply to start-ups. For example, the start-up variable constructed by Cohen et al. (2002) defines a start-up as a young firm, with fewer than 500 employees in a baseline period, and typically as active in one industry.

A distinctive characteristic of a YIC is its length of establishment. Some studies that consider the influence of firm age on its contacts with universities show that younger firms are more likely to exploit universities, but the evidence is not conclusive. Audretsch et al. (2005) note that new firms often rely on external knowledge produced by other firms or by universities since they are less able than larger and more established enterprises to generate their own formal R&D. Similarly, Pérez and Martínez (2003) provide evidence that networking with universities and R&D centres was more intensive and more important during the early years of university spin-off foundation. Motohashi (2005), for a sample of Japanese NTBFs, finds that young/new firms are more likely to interact with universities than firms of a similar size that are longer established.

On the other hand, Cohen et al. (2002) in a study of US manufacturing industries report importance of university-firm interaction only for start-ups in the pharmaceutical sector, but not other sectors, and Laursen and Salter (2004) provide similar results for universities as a source of knowledge for UK manufacturing firms. Laursen and Salter include a variable to measure whether or not the firm is a start-up, but the results show that start-ups are not more likely to engage in contacts with universities.

YICs have been compared to the average firm, but in this chapter, we compare them with other innovative firms.

2.2 YICs' Characteristics and Their Influence on Interaction with Universities

To our knowledge, there are no studies that investigate the firm characteristics that determine interaction between YICs and university, and the evidence for start-ups is limited. Among the few papers that study R&D cooperation among start-ups, only Okamuro et al. (2011) investigate the determinants of cooperative R&D between start-ups and other organizations including universities. The more general literature, which includes some work on innovative firms and start-ups, highlights three firm characteristics: openness, R&D intensity and size.

Openness, according to Fontana et al. (2006), refers to the set of activities that firms undertake to acquire knowledge from, voluntarily disclose knowledge to and/or exchange knowledge with the external world. In other words, it refers to the firm's ability to network. It is clear that more open firms are more likely to enter into university-firm collaboration. This is confirmed by Laursen and Salter (2004).

There is evidence that more intensive firm R&D activity has a positive influence on R&D cooperation with universities (Fontana et al. 2006; Laursen and Salter 2004; Tödtling et al. 2009). These studies show that the propensity to cooperate with a university for innovation seems to depend positively on the firm's R&D intensity. However, Nakamura et al. (2003) report a nonsignificant relation for cooperation with universities. In a study of start-ups, Okamuro et al. (2011) report R&D intensity to be a nonsignificant variable and exclude it from their model; they find instead that R&D expenditure is significant.

The evidence relating to firm size indicates that it has a positive influence on the propensity to engage in cooperation and networking in the innovation process (Tödtling et al. 2009) and to interact with public institutions (Cohen et al. 2002; Laursen and Salter 2004; Levy et al. 2009) and this result applies to innovative firms in particular (Motohashi 2005). However, in the specific case of start-ups, the empirical evidence seems not to follow this general pattern: Okamuro et al. (2011) find that size is a nonsignificant variable.

Based on this empirical evidence, we hypothesize that:

Hypothesis 1 *The characteristics of YICs that contract with universities are similar to those of other firms that use universities as external sources of knowledge. The more open the search strategy, the higher the R&D intensity, and the larger the size of the YIC, the higher will be the probability that the firm will contract with universities.*

2.3 Education and Motivations of YIC Founders as Drivers of Interactions with Universities

Several authors have investigated the influence of the characteristics of university researchers (Ponomariov 2008; Grimpe and Fier 2010), and Lin (2007) argues that more research is needed into the influence of personal traits on industry-university linkages. In this study, we focus on firm founders' education and motivations for setting up a firm. Colombo and Grilli (2005) examine the role of human capital in firm growth, and Tödtling et al. (2009) identify employment of former university researchers as a key factor in the level of knowledge interactions with universities. Doloreux et al. (2008) show that knowledge-intensive business services (KIBS) in the R&D subsector in Quebec have a larger share of employees with at least a bachelors degree than KIBS in other subsectors, and Radas (2006) shows that recruiting highly educated workers can be crucial for establishing more intense collaboration. She finds that if employees are au fait with the work of the university scientists, they can bridge between the firm and the university.

While the above findings refer to firms' employees, Okamuro et al. (2011) show that in the case of start-up firms, the firms' creators have a crucial influence on their firms' strategies, including R&D cooperation. Colombo et al. (2010) include a set of characteristics of NTBF founders (including years of university education of founder) to control for the positive impact on firm growth of the human capital of the founding team.

In other words, highly educated firm creators may attract R&D partners and foster different forms of R&D cooperation. We therefore hypothesize that:

Hypothesis 2 *Better educated YIC creators are more likely to enter into contracts with universities.*

Next, we discuss how the reasons for establishing a firm affect the interaction with universities (on the motivations for interacting with a university, see, e.g. Arza 2010). In the work on entrepreneurship, which spans the fields of economics, psychology and sociology, there are several approaches aimed at identifying what motivates the entrepreneurial decision. We are interested in personal motivations, and we draw on this literature to link firm founders' motivations with university-firm interaction.

We consider motivations related to the so-called push and pull factors and those related to the entrepreneur's previous experience. Shapero (1984) indicates that an 'entrepreneurial event' occurs when a potential firm creator establishes a firm based on a series of drivers which may be negative (or push factors) or positive (pull factors). An example of the former is the desire to make money. Chiesa and Piccaluga (2000) and Shane (2004) report this to be the motivation respectively for university spin-offs and a group of MIT entrepreneurs. The strongest push factor is probably the need for employment, described as 'necessity entrepreneurship' (Reynolds et al. 2005), which occurs when establishing a new firm is not necessarily the preferred option (Acs et al. 2007). Firm founders driven by push factors tend to adopt reactive strategies. They may not recognize market opportunities or seek out external sources of knowledge. We hypothesize that:

Hypothesis 3 *YIC creators motivated by push factors such as creating employment for themselves or earning more money are less likely to contract with universities.*

At the other end of the spectrum are pull motivations, which are characterized by voluntary participation in entrepreneurial activities. Various studies show that there is a positive relationship between internal commitment to establishing a new firm and entrepreneurial activity (Amabile et al. 1994; Prabhu et al. 2008; Rauch and Frese 2007) and that it is linked (De Koning and Muzyka 1996; Herron and Sapienza 1992; Manimala 1996) to a greater capacity to identify and explore opportunities. Here, we focus on so-called 'opportunity entrepreneurship' (Kirzner 1973), where the entrepreneur detects a market opportunity which leads to the establishment of a new firm.

It is tempting to see pull factors as exactly opposite to push factors in terms of their effect on cooperation with universities. However, although pull factors are related to YIC creators more open to market opportunities, including cooperation, we cannot predict a preference for university-firm cooperation on this basis alone. The institutional context also plays a role and has different effects on different types of pull factors.

In relation to the firm founder's professional experience, this set of motivations is related to socio-demographic features and predicts a certain entrepreneur profile (see Collins and Moore 1964, for a seminal study in this field, and Colette et al. 2003, for a more recent analysis). This approach identifies previous work experience as important.

We assume that the previous or main employment of the firm's founder may create a firm culture that determines collaborative interaction. Tödtling et al. (2009) indicate that more sophisticated innovations are likely to be based on scientific knowledge generated in universities and research organizations. Geiger (2010) identifies the 'informational challenge' (understood as the inability of firms to understand that external sources might help to resolve problems) as limiting university-industry collaboration. Besides Decter et al. (2007), Hertzfeld et al. (2006) and Siegel et al. (2003) report the existence of 'cultural' differences between business and university, which act as barriers to technology transfer. Rappert et al. (1999) report that university spin-offs tend to interact more with universities than nonuniversity start-ups, showing that previous experience in academia may reduce these cultural barriers and foster linkages. We hypothesize that:

Hypothesis 4 *YIC creators motivated by the pull factor of building on previous experience as university professors or researchers are more likely to contract with universities.*

If the firm founder has a business background, the cultural gap with academia may hinder interactions with universities. We hypothesize that:

Hypothesis 5 *YIC founders motivated by the pull factor of previous business experience will be less likely to enter into contracts with universities than YIC creators motivated by the pull factor of building on previous experience as university professors or researchers.*

Hypothesis 5 is the only one of our propositions that does not predict a purely positive or negative impact on interaction with academia; it predicts only a reduced likelihood of firm founders with a business background interacting with universities, compared to those with an academic background. The final sign will be determined by the opposing influences on university-firm relations: A proactive entrepreneur may seek out knowledge linkages, but the cultural gap may deter interaction with universities. The data demonstrate the relative strengths of these two influences.

3 Research Context

The Valencian Community is a European region with low absorptive capacity (Azagra-Caro et al. 2006). Some of its main technological and industrial features are of interest for this study, including:

- Low-tech economic structure and high proportion of microfirms in services and traditional manufacturing
- Weak innovation, innovation mostly incremental in the form of machinery and equipment acquisition, and low level of expenditure on R&D
- Lack of qualified personnel even in firms in the knowledge-intensive sectors
- Policy emphasis on increased technology transfer, to the level in high-tech regions or countries, but aligned to the Valencian industry (Fernández de Lucio et al. 2010), through the establishment of a strong network of technology institutes (TIs) in the early 1980s

The TIs act as a bridge between firms and public research institutions and were founded mostly as industry-based firm associations. They were set up as private, non-profit associations with independent management (Mas-Verdú 2007).

There have been some pioneering actions related to the establishment of technology transfer offices, spin-off incubators, etc. located in universities, which have fostered academia-industry links. A report for the Valencian R&D Council (ACCID 2005) shows that 3 % of Valencian firms' sales are based on product innovations that could not have been developed without the input of academic research. Other studies provide similar results for the USA and Germany (see, e.g. Beise and Stahl 1999). The ACCID report shows also that industry funding of Valencian university R&D (6–8 %) was similar to the Spanish average and higher than the EU and OECD averages. The latest figures show this still to be the case and that Valencian firms tend to contract out low-tech, short-term-oriented R&D to Valencian universities.

There are some good academia-industry links because universities have adapted to the regional level of absorptive capacity.

Most university faculty are in favour of university-industry interaction (Azagra-Caro et al. 2006), but firms do not show the same willingness to interact with universities. Also, some Valencian universities have linkages outside the region (Azagra-Caro 2007a) which provides access to higher technology and larger firms (Azagra-Caro 2007b). Also, and contrary to the findings for leading innovative regions, there is an 'alocalization' effect in terms of knowledge flows (Azagra-Caro et al. 2009) and university-industry links (Todt et al. 2007). Therefore, the Valencian Community—five public universities—is an interesting case for the study of university-industry links.

4 Data and Methodology

The data are from a survey carried out by the Valencian Institute for Small- and Medium-Sized Enterprise (IMPIVA), a Valencian Regional Government organization created to promote innovation in small- and medium-sized enterprises. In 2009, IMPIVA began to compile a detailed directory of YICs in the region. Our cooperation in this endeavour provided allowed access to these firms and the opportunity to collect the necessary firm-level data to test our hypotheses. We designed a brief survey which was pretested and modified based on the feedback from experts and some randomly selected firms. The questionnaire was submitted to a target sample.

A crucial phase of the data collection process consisted of delimiting the population and sample. Identifying the population of firms was not straightforward because of the lack of an official list of such companies in the Valencian Community. After some consultation with academic (Belso-Martínez et al. 2011) and IMPIVA experts, we agreed on a number of sources of information to construct the target population. These included lists of academic spin-offs (provided by universities), business incubator centres, industry associations and applications from firms for public funding. We identified 210 YICs created during the period 2005–2008.[1] Note that the combination of different sources of information minimizes the risk of potential bias and distortions in our results. The process also ensures that almost all YICs established in the region at the time were identified.

Following this initial process, individual entrepreneurs were contacted, the profile of the company confirmed and the questionnaires administered. Of the total 210 distributed, we received 173 completed surveys. This high response rate (82.3 %) was down to the IMPIVA monitoring process.

Despite some idiosyncrasies, our data set includes a large and heterogeneous sample of YICs, spanning several mature industries. As well as those firms we initially identified as YICs, we included other innovative firms in the survey; the

[1] The YICs analyses were 4 years or younger. As already indicated, EU state aid regulation defines a YIC as a firm established for less than 6 years. The literature on start-ups uses a range of 5 (Cohen et al. 2002) to 1.5 years (Okamuro et al. 2011). Thus, there is no clear cut-off age for a 'young' firm.

Table 2.1 Having contracted with an institution for getting technology and strategic information (n = 520, don't knows = 1 %)

Institution	No (%)	Yes (%)
Consultants	55	43
Universities	48	51
Technological institutes	42	56
Other institutions	80	19
Average	56	42

response to the question about their year of creation allowed us to decide whether they fitted the definition of a YIC. Only YICs went on to complete the questionnaire, but using this method, we were able to obtain information on the characteristics of other innovative firms, which we use as a benchmark. Wherever possible, we present descriptive and econometric results for the full sample and distinguish between YICs and other innovative firms.

4.1 Dependent Variable

One question in the survey asked, 'In relation to the gathering of technology and strategic information, have you signed any contract with some of the following institutions?' Responses were tick boxes corresponding to the categories listed in Table 2.1, including universities. On average, a large proportion of the full sample of innovative firms interacts to acquire technology and strategic information (42 %). Among the organizations consulted, universities scored high and well above the average at 51 %. This is consistent with Spain (and the Valencian Community in particular) having a very high share of business funding of higher education expenditure on R&D.

Contracts with TIs are the only category that ranks higher than universities. This is peculiar to the Valencian Community with its strong network of TIs created in the early 1980s. Contracts with other institutions, such as public administration, chambers of commerce and business innovation centres, are less frequent.

Therefore, our dependent variable is:

- University contracts, where the binary variable is 1 if the respondent ticked the box for universities and 0 otherwise.

Table 2.2 shows that the average value is 0.52.[2] It also provides a first breakdown by whether the firm is a YIC. The difference between YICs (0.51) and other innovative firms (0.53) is not significant.

Given the dichotomous nature of the dependent variable, we use a probit model for our estimations.

[2] It corresponds to 1 % point above the figure in the previous table because here 'don't knows' are excluded from the total.

Table 2.2 Descriptive statistics—independent variables and firm characteristics

	Full sample					YICs					Other innovative firms					Mean differences test
	Mean	St.dev.	Min.	Max.	Cases	Mean	St.dev.	Min.	Max.	Cases	Mean	St.dev.	Min.	Max.	Cases	
University contracts	0.52	0.50	0	1	514	0.53	0.50	0	1	185	0.51	0.50	0	1	329	N.s.
Openness	1.20	0.90	0	3	514	1.07	0.89	0	3	185	1.28	0.89	0	3	329	*
R&D intensity	0.96	0.90	0	2	509	1.18	0.91	0	2	184	0.83	0.87	0	2	325	**
YIC	0.36	0.48	0	1	521	—	—	—	—	—	—	—	—	—	—	—
Firm size	0.60	0.74	0	2	516	0.16	0.40	0	2	186	0.84	0.78	0	2	330	**

N.s. not significant
**Significant at 1%. *Significant at 5%

4.2 Independent Variables

The literature review shows that there are advantages from considering different types of explanatory variables. Here, we consider firm characteristics, firm founder's personal characteristics (including education) and firm founder's motivations.

Table 2.2 presents the descriptive statistics for firm characteristics, which include those related to Hypothesis 1:

- Openness—related to the question, 'In relation to the gathering of technology and strategic information, have you signed any contract with some of the following institutions?' The response choices (ranging from 0 to 3) include consultants, TIs and other organizations. The average score of 1.20 indicates a degree of openness: Most firms have interacted with at least one of these types of institutions.
- R&D intensity—this is proxied in the survey. Respondents were asked to classify their company according to one of the following labels: technology-based company (high R&D intensity), very innovative company (medium R&D intensity) and innovative company (low R&D intensity). This typology is familiar to Valencian innovative firms because it is used for applications for local public R&D grants. The classifications were validated by technicians from the regional innovation agency. Our variable takes the values 2, 1 and 0, respectively. The average firm in the sample is medium R&D intensive.[3]
- YIC—a dummy variable that is equal to 1 if the firm was created after 2005: 36 % of the firms in the sample were YICs.
- Firm size—number of employees, in the categories: 0 (less than 10 employees), 1 (10–49 employees) and 2 (50 employees or more). This corresponds to Eurostat's distinction between micro, small and medium/large firms. The average firm is between categories 0 and 1, i.e. even within innovative firms, microfirms predominate in the Valencian case.

When we differentiate between YICs and other innovative firms, we see that the former use more closed search strategies, are more R&D intensive and are smaller in size than the latter. Hence, YICs are interesting because despite their different endowments, their frequency of contracts with universities is similar to the typical innovative firm.

Table 2.3 shows that the correlation between variables is small.

[3] This classification is based on self-assessment, unlike studies that give precise numbers for R&D intensity. However, many studies using Community Innovation Survey (CIS) data or similar are based on self-assessments. Our results may be more reliable since offering a choice of category can be less prone to inaccuracies than asking for unaccounted numbers. Also, as a robustness check, we used two alternative variables: the budget of granted innovative projects and the budget of granted R&D projects, applied for by firms through competitive tenders. We chose this method because according to the literature (Hyytinen and Toivanen 2005; Takalo and Tanayama 2010), being awarded financial support (subsidy) for innovative activity can be seen as reflecting the high quality of the innovative efforts made by the company. The results (available on request) did not change, in particular, the lack of significance of R&D that we will see afterwards.

Table 2.3 Correlation matrix—firm characteristics—full sample

	Openness	R&D intensity	YIC	Firm size
Openness	1.00			
R&D intensity	–0.03	1.00		
YIC	–0.10	0.19	1.00	
Firm size	0.23	–0.14	–0.44	1.00

The second group of variables refers to the personal characteristics of the firm founder:

- Age of entrepreneur—an ordinal scale of four categories: 0 (less than 30 years), 1 (30–39 years), 2 (40–49 years) and 3 (more than 49 years).
- Sex—1 if female.
- Education—an ordinal scale of three categories: 0 (no university degree), 1 (graduate university degree) and 2 (postgraduate university degree).

While age and sex are control variables, education refers to Hypothesis 2.

The questions were addressed only to YICs. Table 2.4 shows that the average YIC founder is aged between 30 and 39 years and has a university first degree; 10% are women.

The third group of variables, motivations (applying only to YICs), comes from a question in the survey asking firm creators their reasons for setting up their companies. We grouped the variables as follows:

- Self-employment push—1 if the respondent chose 'I chose to create my own workplace' and 0 otherwise.
- Monetary push—1 if the respondent chose 'Expectations to gain money through an own business' and 0 otherwise.

(Both the above refer to Hypothesis 3)

- Academic pull—sum of two categories: 'To benefit from my specialist knowledge acquired from my activity as a university professor or researcher' plus 'application of doctoral thesis or university R&D project'. This refers to Hypothesis 4.
- Business pull—sum of five categories: 'To benefit from my specialized knowledge acquired from my R&D activity in my former company/work at technology centres/consultancy work/integration of several sources' plus 'opportunity arisen in the professional environment'. This refers to Hypothesis 5.

Table 2.4 shows that business pull is the more frequent motivation. The means are not comparable among motivations because of the different range of variation for each variable, but a breakdown of business pull would still show that many of its

Table 2.4 Descriptive statistics—personal characteristics and motivations

	Mean	Standard deviation	Min.	Max.	Cases
Age	1.41	0.81	0	3	189
Sex	0.10	0.30	0	1	189
Education	1.16	0.65	0	2	189
Self-employment push	0.19	0.39	0	1	189
Monetary push	0.18	0.39	0	1	189
Academic pull	0.26	0.57	0	2	189
Business pull	0.79	0.95	0	4	189

single components are ranked first in the hierarchy of motivations. Academic pull motivations are ranked second if we sum the two components: 'university professor or researcher' and 'application of doctoral thesis or university R&D project'. Separately, each ranks below the two push motivations.[4]

Table 2.5 shows that the correlations between the variables in the YIC sample are small.

We control for industry fixed effects. The survey distinguishes 27 economic activities, including manufacturing and services. Since some activities involved only a very few firms, we grouped the activities into seven sectors: three corresponding to Pavitt's (1984) taxonomy of industrial activities plus four service sectors (ICT, R&D, engineering, architecture, environmental services and a fourth category of other services).[5] We created dummies for each of the seven types listed in Table 2.6.

According to Table 2.6, there is large variation in the percentage of firms that contract with universities, by economic sector. The highest shares correspond, as expected, to R&D services, followed by science-based and production-intensive manufacturing and ICT services. Supplier-dominated firms; 'engineering, architecture and environmental services'; and 'other services' rank lowest. As for the aggregate, differences between YICs and other innovative firms are not significant, except for the case of supplier-dominated firms, where YICs are less likely than other innovative firms to contract with universities.

[4] For the estimations, we tried different breakdowns of the academic and business pull variables; the results did not change. We prefer to present the current aggregates because this results in models with more degrees of freedom. The descriptive and econometric results and the breakdowns are available from the authors on request.

[5] Fifteen percent of respondents chose 'other' rather than any of the 27 initial categories; they were required to make a qualitative response. This information and the response to another question about the firm's economic activity allowed us to reclassify this 15 % into the initial categories or to drop unclear cases. One of the authors with many years practical experience at IMPIVA and direct contact with Valencian companies helped in this reclassification exercise.

Table 2.5 Correlation matrix—YIC sample

	Openness	R&D intensity	Firm size	Age	Sex	Education	Self-employment push	Monetary push	Academic pull	Business pull
Openness	1.00									
R&D intensity	0.00	1.00								
Firm size	0.04	–0.03	1.00							
Age	0.02	0.10	0.10	1.00						
Sex	–0.05	–0.02	–0.09	–0.05	1.00					
Education	–0.03	0.12	–0.07	0.01	0.08	1.00				
Self-employment push	–0.14	–0.07	–0.09	0.26	0.18	–0.16	1.00			
Monetary push	–0.06	0.00	0.02	–0.15	–0.11	0.07	0.03	1.00		
Academic pull	–0.08	0.24	–0.10	0.06	0.10	0.38	0.02	0.05	1.00	
Business pull	0.21	–0.14	–0.06	–0.09	–0.09	–0.02	0.05	0.19	0.02	1.00

Table 2.6 Average value of having contracted with universities (yes/no), by economic sector

Economic sector	Full sample	YICs	Other innovative firms	Mean differences test
Supplier-dominated manufactures	0.40	0.00	0.44	*
Production-intensive manufactures	0.54	0.58	0.53	N.s.
Science-based manufactures	0.57	0.67	0.49	N.s.
ICT services	0.57	0.57	0.57	N.s.
Research and development services	0.70	0.65	0.79	N.s.
Engineering, architecture and environmental services	0.47	0.52	0.43	N.s.
Other services	0.41	0.31	0.48	N.s.
Average	0.52	0.53	0.51	N.s.

N.s. not significant
*Significant at 5%

5 Econometric Results

5.1 The Distinctive Insignificant Effect of YIC Firm Size on Contracting with a University

Table 2.7, column 1, shows that innovative firms with more open search strategies and are more R&D intensive have more employees and are more likely to enter into contracts with universities. Notice that in our case (similar to the case of start-ups in Laursen and Salter 2004), being a YIC is not significant.

In column 2, we reproduce the model for the YIC sample (obviously, we drop the YIC variable from the model because it always takes the value 1). The coefficients of openness and R&D are still positive and significant (with R&D slightly less significant); firm size is not significant. The evidence only partially supports Hypothesis 1. For YICs, if we do not control for YIC founder's education and personal motivations, openness and R&D are as important for contracting with universities as for the average innovative firms, but size has no effect.

The results for non-YIC innovative firms are shown in column 3. They confirm the average behaviour, a significant, positive effect of openness, R&D intensity and size on contracts with universities.

It is questionable, perhaps, whether the observed lack of significance of size is an idiosyncrasy of the geographic origin of the sample. However, the fact that the aggregate and the non-YIC innovative firm samples follow the results for the UK sample in Laursen and Salter (2004)—including the significance of size—seems to indicate that this is not the case: It is the fact of being a young company rather than geography that is having an effect. Also, Okamuro et al. (2011) find that the effect of size on interaction with universities is not significant for Japanese start-ups.

Table 2.7 Probit model of having contracted with universities (yes/no)—YICs versus other innovative firms

	1	2	3
	Full sample	YICs	Other innovative firms
Number of observations	498	178	320
Log likelihood function	−294	−104	−182
Prob[χ^2 > value]	0	0	0
Pseudo R^2	0.68	0.70	0.68
	Coeff. (t-ratio)	Coeff. (t-ratio)	Coeff. (t-ratio)
Constant	−1.05 (−5.55)**	−0.68 (−1.82)	−1.13 (−5.24)**
Openness	0.52 (7.08)**	0.38 (3.15)**	0.61 (6.41)**
R&D intensity	0.25 (3.48)**	0.27 (2.17)*	0.23 (2.51)*
YIC	0.22 (1.51)		
Firm size	0.34 (3.54)**	0.18 (0.69)	0.32 (3.05)**
Industry sector dummies	Included (6)	Included (6)	Included (6)
BIC	656	261	422

*$p < 0.05$; **$p < 0.01$

5.2 How Do Entrepreneur's Education and Motivations Reduce the Significance of R&D in Relation to Contracting with a University

The first estimation includes YIC founders' personal and motivational characteristics (Table 2.8, column 1). Firm size is not significant, which is consistent with Table 2.7, column 2. However, that R&D intensity is also not significant is surprising. The higher value of the Bayesian information criteria (BIC) indicates that in spite of the higher pseudo R^2, the fit is worse than in Table 2.7, column 2, due to the inclusion of too many variables. In order to achieve a more parsimonious model, with more degrees of freedom, we perform a selection strategy. Starting from the model in column 1, we drop the insignificant variable with the lowest t-ratio and estimate a new model. We replicate the procedure successively until we achieve a model with only significant variables.

The results are shown in Table 2.8, column 2.[6] The lowest value of BIC indicates also that this is the best model (compared to the models in Table 2.8, column 1 and Table 2.7, column 2). Openness is significant and R&D intensity is excluded from the model. Hence, when we control for the personal characteristics and motivations of the YIC founder, the effect of R&D intensity for the YIC is not relevant. Size is also insignificant and can be excluded from the model.

[6] As a robustness check, we carried out another selection strategy: We introduced the independent variables separately into the regressions and retained only those with a significant effect in the joint model. The results were the same as Table 2.8, column 2.

Table 2.8 Probit model of having contracted with universities (yes/no)—the effect of education and motivations in YICs

	1	2
Number of observations	178	185
Log likelihood function	–90	–98
Prob[χ^2 > value]	0	0
Pseudo R^2	0.74	0.72
	Coeff. (t-ratio)	Coeff. (t-ratio)
Constant	–0.87 (–1.69)	–1.07 (–3.59)**
Openness	0.48 (3.51)**	0.49 (3.92)**
R&D intensity	0.1 (0.75)	
Firm size	0.28 (1.01)	
Age	–0.14 (–0.97)	
Sex	0 (0.01)	
Education	0.38 (1.97)*	0.42 (2.37)*
Self-employment push	–0.79 (–2.38)*	–0.75 (–2.54)*
Monetary push	0.11 (0.37)	
Academic pull	0.62 (2.54)*	0.67 (2.9)**
Business pull	–0.28 (–2.17)*	–0.27 (–2.42)*
Industry sector dummies	Included (6)	Selected (3)
BIC	268	243

*$p < 0.05$; **$p < 0.01$

Two personal characteristics are dropped because of their lack of significance, leaving only a positive coefficient of education. This evidence supports Hypothesis 2. The better educated the firm founder, the more likely that his/her company will interact with a university.

Regarding motivations, self-employment tends to lead to less contact with universities, which supports Hypothesis 3, and earning money has no influence, which does not. Hence, there is only partial support for Hypothesis 3. If our data and methods are correct, the theory could be refined by establishing a ranking among push factors: YIC creators aiming at earning more money are not as reactive as necessity entrepreneurs in their collaborative efforts.

Benefiting from specialized knowledge acquired from academia promotes interaction with universities, confirming Hypothesis 4. Benefiting from specialized knowledge acquired from a former nonacademic environment or from opportunities arising in the professional environment is detrimental for contracting with universities. This implies, first, that the business pull is less likely than the academic pull to foster interaction (confirming Hypothesis 5) and, second, that the negative effect of differences in the business and university cultures outweighs the positive effect of the pull motivation.[7]

[7] In the estimations, only three industry sector dummies are significant (see Table 2.8, column 2): science-based manufactures, ICT services and R&D services. Although further development of this idea is beyond the scope of this study, it is in line with some evidence that the study of university-industry interaction should not be restricted to manufactures but expanded to services (see D'Este and Cameranii 2010).

6 Conclusions

This study explored the theoretical determinants of contracts between YICs and universities. It provides an empirical analysis of a sample of innovative companies in the Valencian Community to compare YICs with older innovative companies and allows the inclusion of the personal characteristics and motivations of the firm creator as explanatory variables, as well as firm characteristics. To our knowledge, the use of this combination of variables is novel. Furthermore, this is the first empirical analysis of YIC cooperation.

First, we can highlight that current thinking about university-industry interaction is valid for YICs in relation to its positive influence but that there are differences related to YIC size and R&D intensity. Size is not a determinant of YIC-university contracting, and when we control for the personal characteristics and motivations of firm founders, R&D intensity is not significant. Our study extends the theory by examining the role of firm founders' education and types of motivations. The evidence confirms the hypotheses that higher education and the pull motivation of founders from academia increase the frequency of university interaction, while the pull motivation of founders from the business sector and push motivations lead to fewer contracts with universities. However, the empirical validation applies to necessity entrepreneurship not to the desire to make more money, which suggests a further refinement to the theory.

There are two main limitations to our study. First, the dependent variable, the binary answer to the question, 'have you signed any contract with universities', does not give any idea of the frequency, length, size or results of contracts with universities. It provides no information on when a contract was signed, which does not allow us to make dynamic comparisons among firms. However, this type of dichotomous variable does provide valuable information on university-industry links, as shown by Nakamura et al. (2003), Motohashi (2005) and Okamuro et al. 2011. Also, even with the broad formulation of the question, our variable shows high percentages for each possible outcome (yes/no). This fact and the high industry variation (e.g. the science-intensive manufacturing and services score higher) are signs of the appropriateness of the variable.[8]

A second limitation is that the number of YICs in the sample is small (less than 200 observations). However, due to our survey design, we are confident that the sample is very representative of the full population of this type of companies in the region. Also, comparison with the larger population of innovative firms that are not

[8] It might be that studies based on more fine-grained information, e.g., variables with more points on a Likert scale, would be more useful. In our case, we included a question in the survey about satisfaction with services provided by universities to be ranked on a five-point Likert scale, ranging from 'not satisfied' to 'very satisfied'. We found that most firms that had interacted with universities were 'very satisfied', while most firms with no experience of university contracting expressed an opinion of 'neither very satisfied or very dissatisfied'. Ordered models predict both outcomes, meaning they perform no better than a simple dichotomous variable.

YIC suggests that our results are plausible. Finally, reduction of the econometric models to those with significant variables only shows that the estimations have sufficient degrees of freedom.

Nevertheless, we cannot claim that this study provides definitive evidence of what determines contracting between YICs and universities. Since this is new evidence, more research is needed using different data, in particular in other contexts where the technology transfer may be influenced by a different regional endowment. We believe that our analysis is useful; it has been argued that an increased level of university-industry cooperation would require changes to the motivations of faculty members (sometimes with no clear idea of the direction of change, Uyarra 2010). Our study highlights that change is needed in the motivations of firm creators, starting with YIC creators. Based on our findings, we can derive some implications for policy and corporate governance and provide tools for further methodological exploration.

Regarding the design of public policies, this research suggests that in a given region, a relatively high degree of university-industry relation may coexist with low levels of technological innovation, when the entrepreneur's motivation for creating a YIC is not positively related to contracts with universities. We show that if the firm's founder is or was a university professor researcher, motivated by commercializing research results, then it is likely that the firm will have high levels of interaction with universities. Other firm founder motivations are either negatively associated or not associated with firm-university interaction. For example, if the motivation for founding a firm is to make more money, this does not necessarily lead to more contracts with universities. Policy should try to understand whether this is desirable. In terms of policy instruments to foster the growth of university-firm links that lead to major (as opposed to minor) technological innovations, in our view, the emphasis should be on indirect actions (i.e. advice and consulting services) rather than on direct actions such as R&D subsidies and fiscal incentives, even though provision of the former is less straightforward (Lerner 2009).

In order to improve corporate governance, in the cases of YIC creators who are not able to overcome the cultural gap with universities, they might expand their management teams with the addition of people with similar motivations (employment, exploit business opportunities, earning more money) who have learnt how universities can fulfil their needs. Firm creators could try to overcome the cultural gap by improving their abilities and competences through external advisory services, such as coaching. This is in line with the study by Cosh and Hughes (2010), which discusses the differential roles played by intermediaries between firms and universities, in the USA and the UK. US firms report fewer direct contacts with universities, use coaching services and, also, are more likely to commit resources to supporting innovation related to university interactions.

In this study, the questionnaires were addressed to firm founders. However, many studies that take the firm as the unit of observation administer surveys which are responded to by an employee. Hence, the real unit of observation in these studies is the employee who responded to the survey and not the firm. This means that it is necessary to control for the employee's individual characteristics when assessing the impact of the characteristics of the firm on any possible outcome. In line with this reasoning, our finding that firm R&D intensity is not significant for interaction with university could perhaps be extrapolated to firms in general. Although it may not be applicable, it would open a stimulating line of research and future innovation surveys that include the personal characteristics and motivations of the respondent.

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References

ACCID (2005) Análisis de la contribución de la I+D universitaria al desarrollo económico de la Comunidad Valenciana. In: Alto Consejo Consultivo en Investigación y Desarrollo de la Presidencia de la Generalitat Valenciana, Informe anual sobre el estado de la investigación, el desarrollo y la tecnología en la Comunidad Valenciana. Valencia, Generalitat Valenciana

Acs Z, O'Gorman C, Szerb L, Terjesen S (2007) Could the Irish miracle be repeated in Hungary? Small Bus Econ 28:123–142

Amabile TM, Hill K, Hennessey B, Tighe EM (1994) The work preference inventory: assessing intrinsic and extrinsic motivational orientations. J Pers Soc Psychol 66:950–967

Arza V (2010) Channels, benefits and risks of public–private interactions for knowledge transfer: conceptual framework inspired by Latin America. Sci Public Policy 37(7):473–484

Audretsch D, Keilbach M (2004) Entrepreneurship capital and economic performance. Reg Stud 38(8):949–959

Audretsch D, Lehmann E, Warning S (2005) University spillovers and new firm location. Res Policy 34(7):1113–1122

Audretsch D, Hüslbeck M, Lehmann E (2010) Regional competitiveness, university spillovers, and entrepreneurial activity. Small Bus Econ. doi:10.1007/s11187-011-9332-9

Azagra-Caro JM (2007a) The regional dimension of university-industry interaction. In: Suriñach J, Moreno R, Vayá E (eds) Knowledge externalities, innovation clusters and regional development. Edward Elgar, Cheltenham/Northampton

Azagra-Caro JM (2007b) What type of faculty member interacts with what type of firm? Some reasons for the delocalisation of university-industry interaction. Technovation 27:704–715

Azagra-Caro JM, Archontakis F, Gutiérrez-Gracia A, Fernández-de-Lucio I (2006) Faculty support for the objectives of university-industry relations versus degree of R&D cooperation: the importance of regional absorptive capacity. Res Policy 35(1):37–55

Azagra-Caro JM, Fernández de Lucio I, Perruchas F, Mattsson P (2009) What do patent examiner inserted citations indicate for a region with low absorptive capacity? Scientometrics 80(2):443–457

Beise M, Stahl H (1999) Public research and industrial innovations in Germany. Res Policy 28(4):397–422

Belso-Martínez JA, Molina-Morales X, Mas-Verdú F (2011) Clustering and internal resources: moderation and mediation effects. J Knowl Manage 15(5):738–758

BEPA (2008) Innovation and growth in the EU: the role of SME policy. European Commission, Brussels

Chiesa V, Piccaluga A (2000) Exploitation and diffusion of public research: the chase of academic spin-offs companies in Italy. R&D Manage 30(4):329–339

Cohen W, Nelson R, Walsh J (2002) Links and impacts: the influence of public research on industrial R&D. Manage Sci 48(1):1–23
Colette H, Hill F, Leitch C (2003) Entrepreneurship education and training. Ashgate Publishing Company, England
Collins OF, Moore DG (1964) The enterprising man. Michigan State University, East Lansing
Colombo MG, Grilli L (2005) Founders' human capital and the growth of new technology-based firms: a competence-based view. Res Policy 34(6):795–816
Colombo MG, D'Adda D, Piva E (2010) The contribution of university research to the growth of academic start-ups: an empirical analysis. J Technol Trans 35:113–140
Cosh A, Hughes A (2010) Never mind the quality feel the width: university– industry links and government financial support for innovation in small high-technology businesses in the UK and the USA. J Technol Trans 35:66–91
D'Este P, Camerani R (2010) Knowledge from businesses to universities: an investigation on the two-way knowledge transfer in university-business partnerships. In: Triple Helix VIII international conference on university, industry and government linkages, Madrid, December
De Koning A, Muzyka D (1996) The convergence of good ideas: when and how do entrepreneurial managers recognize innovative business ideas? In: Churchill N, Bygrave W, Butler J, Birley S, Davidsson P, Gartner W, McDougall P (eds) Frontiers of entrepreneurship research. Babson College, Wellesley
Decter M, Bennett D, Leseure M (2007) University to business technology transfer—UK and USA comparisons. Technovation 27:145–155
Doloreux D, Amara N, Landry R (2008) Mapping regional and sectoral characteristics of knowledge-intensive business services: evidence from the province of Quebec (Canada). Growth Change 39(3):464–496
Fernández de Lucio I, Mas-Verdu F, Tortosa E (2010) Regional innovation policies: the persistence of the linear model in Spain. Serv Ind J 30(5):749–762
Fontana R, Geuna A, Matt M (2006) Factors affecting university–industry R&D projects: the importance of searching, screening and signaling. Res Policy 35(2):309–323
Geiger R (2010) University supply and corporate demand for academic research. J Technol Trans. doi:10.1007/s10961-010-9192-5
Grimpe C, Fier H (2010) Informal university technology transfer: a comparison between the United States and Germany. J Technol Trans 35:637–650
Herron L, Sapienza H (1992) The entrepreneur and the initiation of new venture launch activities. Entrepreneurship Theory Pract 17:49–55
Hertzfeld H, Link A, Vonortas N (2006) Intellectual property protection mechanisms in research partnerships. Res Policy 35(6):825–838
Hülsbeck M, Lehmann E (2010) The role of regional knowledge production in university technology transfer: isolating coevolutionary effects. UO working paper series 01–10. http://ssrn.com/abstract=1588930. Accessed 18 Sept 2011
Hyytinen A, Toivanen O (2005) Do financial constraints hold back innovation and growth? Evidence on the role of public policy. Res Policy 34(9):1385–1403
Kirzner IM (1973) Competition and entrepreneurship. University of Chicago Press, Chicago
Laursen K, Salter A (2004) Searching high and low: what types of firms use universities as a source of innovation? Res Policy 33:1201–1215
Lerner J (2009) Boulevard of broken dreams. Princeton University Press, Princeton
Levy R, Roux P, Wolff S (2009) An analysis of science–industry collaborative patterns in a large European University. J Technol Trans 34:1–23
Lin HF (2007) Knowledge sharing and firm innovation capability: an empirical study. Int J Manpower 28(3/4):315–332
Manimala M (1996) Beyond innovators and imitators: a taxonomy of entrepreneurs. Creativity Innov Manage 5:179–185
Mas-Verdú F (2007) Services and innovation systems. European models of technology centres. Serv Bus Int J 1:7–23

Motohashi K (2005) University–industry collaborations in Japan: the role of new technology-based firms in transforming the National Innovation System. Res Policy 34(5):583–594

Nakamura M, Mohnen P, Hoareau C (2003) What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. Manage Decis Econ 24(2–3):133–145

Okamuro H, Kato M, Honjo Y (2011) Determinants of R&D cooperation in Japanese start-ups. Res Policy 40(5):728–738

Pavitt K (1984) Sectoral patterns of technical change: towards a taxonomy and a theory. Res Policy 13(6):343–373

Pérez M, Martínez A (2003) The development of university spin-offs: early dynamics of technology transfer and networking. Technovation 23:823–831

Ponomariov BL (2008) Effects of university characteristics on scientists' interactions with the private sector: an exploratory assessment. J Technol Trans 33(5):485–503

Prabhu V, Sutton C, Sauser W (2008) Creativity and certain personality traits: understanding the mediating effect of intrinsic motivation. Creativity Res J 20:53–66

Radas S (2006) Collaboration between industry and science: motivation factors, collaboration intensity and collaboration outcome. Croatian Economic Survey 8(1):11–31

Radas S, Bozic L (2009) The antecedents of SME innovativeness in an emerging transition economy. Technovation 29:438–450

Rappert B, Webster A, Charles D (1999) Making sense of diversity and reluctance: academic–industrial relations and intellectual property. Res Policy 28:873–890

Rauch A, Frese M (2007) Let's put the person back into entrepreneurship research: a meta-analysis on the relationship between business owners' personality traits, business creation, and success. Eur J Work Organ Psychol 16:353–385

Reynolds PD, Bosma N, Autio E, Hunt S, de Bono N, Servais I, Lopez-Garcia P, Chin N (2005) Global entrepreneurship monitor data collection design and implementation 1998–2003. Small Bus Econ 24(3):205–231

Schneider C, Veugelers R (2010) On young innovative companies: why they matter and how (not) to policy support them. Ind Corp Change 19(4):969–1007

Shane S (2004) Academic entrepreneurship: university spinoffs and wealth creation. Edward Elgar, Cheltenham/Northampton

Shapero A (1984) The entrepreneurial event. In: Kent CA (ed) The environment for entrepreneurship. Lexington Books/D.C. Heath and Company, Lexington

Siegel D, Waldman D, Link A (2003) Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. Res Policy 32(1):27–48

Takalo T, Tanayama T (2010) Adverse selection and financing of innovation: is there a need for R&D subsidies? J Technol Trans 35(1):16–41

Todt O, Gutiérrez Gracia A, Fernández de Lucio I, Castro Martínez E (2007) The regional dimension of innovation and the globalization of science: the case of biotechnology in a peripheral region of the European Union. R&D Manage 37(1):65–74

Tödtling F, Lehner P, Kaufmann A (2009) Do different types of innovation rely on specific kinds of knowledge interactions? Technovation 29:59–71

Uyarra E (2010) Conceptualizing the regional roles of universities, implications and contradictions. Eur Plan Stud 18(8):1227–1246

Veugelers R (2009) A lifeline for Europe's young radical innovators. Bruegel Policy Brief 2009(1), Brussels

Wagner S, Bukó C (2005) An empirical investigation of knowledge-sharing in networks. J Supply Chain Manage Fall 2005:17–31

Chapter 3
The Role of Research Orientation for Attracting Competitive Research Funding*

Hanna Hottenrott

Abstract This article studies the role of research orientation for attracting research grants at higher education institutions in Germany. Traditionally research activities were funded by the institutions' core budget. More recently, extramural research funding has become increasingly important. Besides the public sector, industry provides a growing share of such funds. The results based on a sample of professors in science and engineering suggest that basic and applied research is complementarity for attracting research funding from industry. Thus, professors who conduct basic research in addition to research on the applicability of their results appear to be most successful in raising industry funds. For raising grants from public sources, it turns out that specialization is more important. Specialized research units on either basic or applied research obtain significantly more public grants which points to a substitutive relationship between basic and applied research for grants from public sources.

1 Introduction

Based on the idea that university systems with competitive funding mechanisms provide output incentives and are consequently more efficient and productive than traditional funding environments, university research throughout Europe is

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increasingly funded by a mix of "fixed" institutional budget and project-based funds (Auranen and Nieminen 2010). Industrial grants provide an increasing share of such extramural funds (OECD 2007, 2009). Besides the growing role of funding from the private business sector, public research funding is also becoming increasingly competitive. The rules and precepts according to which such funds are granted may naturally differ between schemes and sponsors. This chapter aims to contribute to the understanding of how university research matches industry demands for scientific knowledge by analyzing the role of research orientation for the attraction of competitive research funding and how it is different for public sector grants.

While previous literature found academic research to be highly valuable for industrial innovation (Mansfield 1991, 1995; Cohen et al. 2002; Cassiman et al. 2008), the direction of research that is most beneficial and therefore more likely to be sponsored has not been studied as extensively. Do firms benefit from sourcing basic science that is not feasible or unprofitable to build up themselves? Or do they seek access to rather applied research that provides knowledge that is closer to applicable technology and thus closer to marketable innovations?

Previous studies did shed some light on the question which fields of science were particularly interesting for certain industries and on the importance of geographical proximity and faculty quality for getting funded by industry (Mansfield 1995; Mansfield and Lee 1996). At the university level, Ljungberg (2008) finds that mainly larger and highly specialized universities in Sweden attract most industry funding relative to their size. The larger but less specialized universities and most of the smaller regional colleges and universities receive less. Thus, he sees specialization in research as an important characteristic for explaining differences in the ability to attract private-sector funding. Anders Broström (2012), on the other hand, finds in a study on firms collaborating with major Swedish universities that these firms collaborate with university researchers in order to access academic networks and to strengthen skills of their employees, i.e. to increase absorptive capacity for knowledge spillovers in general, not only from science. This may suggest that firms are less interested in highly specialized research units but in those that provide a variety of skills.

The reason for the lack of evidence in the literature at the laboratory level so far could be rooted in the seemingly obviousness of the question who gets such funding. As argued by Trajtenberg et al. (1997), industry research and development (R&D) is directed at commercial success, while university research focuses on solving fundamental scientific questions. Thus, it seems obvious to assume that firms fund university research labs to gain access to such basic research that complements their own application-oriented R&D.

However, firms cannot absorb scientific knowledge without effort. Investments in absorptive capacities may be crucial. The extent of such investments may depend on whether firms source solely basic research or whether they are able to contract researchers with applied research skills. Consequently, it could be argued that as applied science is easier to identify and exploit for industry and involves lower monitoring costs (Thursby and Thursby 2004), instead of sourcing pure basic research results, firms could target university research that has passed a certain threshold of applicability and is consequently less costly to adopt. Moreover, sourcing applied research reduces the "distance" from basic science to applicable technology that may be especially large for early-stage technologies (Thursby et al. 2007).

As both arguments are straightforward, one could reason that firms prefer those researchers as collaboration partners whose labs are capable of doing both basic as well as applied research especially if the joint research evolves through different stages of maturity. If the latter argument applies empirically, we would expect to find a complementary relationship between basic and applied research orientation.

Another question that arises is whether research orientation plays a different role for the successful acquisition of public grants as compared to industry funds. The rationale behind public research funding has traditionally been based on the positive externalities from basic science. Public funding for applied research, on the other hand, has usually been linked to public-private research partnerships and has been justified by the resulting economic benefits from such collaboration (Czarnitzki 2009). Given the limits of public funds, award criteria generally revolve around academic excellence to ensure highest possible returns to society (Viner et al. 2004; Sorenson and Fleming 2004). Excellence, however, may require a high degree of specialization in order to achieve an accumulative advantage at the level of the individual researcher or the research team.

This chapter adds to previous research by studying the role of research orientation, i.e., basic versus applied research, for attracting competitive research funding from the private as well as from the public sector. The sample of 669 research units at 46 higher education institutions in Germany covers a broad range of disciplines in science and engineering. The results suggest that basic and applied research is complementary for raising funds from industry. Professors whose labs conduct both types of research attract most funding from industry in contrast to those who are focused on either basic or applied research, both in monetary terms as well as in percent of their total research budget. For raising grants from public sources, on the other hand, specialization seems more important. Specialized research units on either basic or applied research obtain significantly more public grants pointing to a substitutive relationship between basic and applied research for such grants.

This chapter proceeds as follows. Section 2 describes the data and sets out the empirical framework. Section 3 presents the econometric analysis and the results. Section 4 concludes and points out roads for further research.

2 Data and Empirical Framework

The unit of analysis is the research lab for which data has been collected from different sources. First, a survey among research units at German higher education institutions in the fields of science or engineering was conducted by the Centre for European Economic Research (ZEW, Mannheim) in the year 2000. In the survey, university professors indicated the percentage of their units' research that is directed at basic research (*BASIC_SHARE*) or applied research (*APPLIED_SHARE*). Moreover, the amount of private-sector research grants received during the year 1999 both in monetary terms (*INDFUND*) as well as share of their overall budget

(*INDSHARE*) and the corresponding information on public grants (*GOVFUND*, *GOVSHARE*) is obtained immediately from the survey.[1]

To control for other important determinants of research funding, the survey data is supplemented with additional information from different data sources. Most importantly, the previous scientific performance of the research units' heads may also impact the attraction of grants (e.g., Murray 2002; Viner et al. 2004). Past scientific publications (*PUBS*) as well as citations to these publications (*CIT_PUBS*) have been collected from the ISI Web of Science® database. In addition, information on patent applications (*PATS*) on which the respective professor was listed as inventor and forward citations to these patents (*CIT_PATS*) were drawn from the database of the German Patent and Trade Mark Office (DPMA).[2] We limit the time frame ("activity window") for both publications and patents to the period from 1994 to 1999. As the effectiveness with which a research unit attracts third-party funding may depend on the head's experience or seniority, information on the year in which the professor received his Ph.D. had been gathered from the German National Library, and his academic experience was calculated (*EXPER*). To test for any nonlinear life-cycle effect (Levin and Stephan 1991), the squared value ($EXPER^2$) is included. For differences in the size of the different institutions is controlled for by including the (logged) total number of students (*UNI_SIZE*). Larger universities may, for instance, be more visible to funding agencies and to industry and thus attract relatively more third-party funding. A squared term is included to control for nonlinearity. A dummy is included accounting for whether the professor had collaborated with his institution's Technology Transfer Office (*TTO*). We account for differences between research fields by utilizing seven field dummies (see Table 3.5 for key variables by research field). Three institution-type dummies are added to capture differences in funding patterns between general universities, technical universities, and polytechnic colleges. Finally, we include a gender dummy (*FEMALE*) for the head of the department. The final sample contains 669 professor-research unit observations from 46 different institutions of which are 56% universities, 23% technical universities, and 21% polytechnics. Table 3.1 shows descriptive statistics for the main variables of interest.[3]

Research units in the sample obtained about 96.5 thousand Euros from industry on average. This makes up for 8.6% of their total budgets in 1999. Grants from public sources amounted to about 120 thousand Euros on average or about 22% of their total budgets. Research units spend on average 42% of their time on basic research. The share is higher at universities (57%) and considerably lower at polytechnics (4%).

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[1] The sum of INDFUND and GOVFUND is 'total third-party funding'. Adding this to the 'core' institutional funding (COREFUND) yields the units' overall funding: TOTALFUND = INDFUND + GOVFUND + COREFUND.

[2] Patent forward citations have been shown to be a suitable measure for the quality, importance, or significance of a patented invention and have been used in various studies (see, e.g. Henderson et al. 1998; Hall et al. 2001).

[3] Cross-correlations between the main variables are presented in Table 3.4.

Table 3.1 Descriptive statistics (699 obs)

Variable	Description	Mean	Std. Dev	Min	Max
Grant-based funding					
$INDFUND_t$	T €	96.43	219.90	0	2,129.53
$INDSHARE_t$	% of total budget	8.61	13.48	0	100
$GOVFUND_t$	T €	118.31	244.44	0	1,844.53
$GOVSHARE_t$	% of total budget	21.71	20.22	0	100
Research orientation					
BASIC_SHARE	%/100	0.42	0.34	0	1
APPLIED_SHARE	%/100	0.58	0.34	0	1
Controls					
$PUBS_{t\text{-}6\ to\ t}$	Publication count	11.08	20.51	0	243
$PUBCITS_{t\text{-}6\ to\ t}$	Citation count	228.16	571.22	0	5,907
$PATS_{t\text{-}6\ to\ t}$	Patent count	1.41	3.48	0	32
$PATCITS_{t\text{-}6\ to\ t}$	Citation count	20.25	126.61	0	2,634
UNI_SIZE	Student count	17,789.40	11,817.00	1,451	59,599
EXPER	Years since Ph.D.	21.64	8.68	1	43
TTO	Dummy	0.73	0.44	0	1
FEMALE	Dummy	0.03	0.18	0	1

Note: Institution-type dummies and field dummies not presented. Note also that the time period for the controls for past scientific includes t as articles published in t have usually been written in the years up to t, thus reflecting research outcomes of the period t-1 or earlier. The same applies to patents applied for in t.

At technical universities, the average share time spent on applied research is 62%. The relative focus on applied research naturally differs between fields of research. Electrical engineering, mechanical engineering and other engineering report high shares of 79%, 77%, and 74%, respectively. Research units in chemistry and physics spend about 61% and 69% of their time of basic research, while and mathematicians and computer scientists and biologists have basic research shares of 56% and 50%, respectively. Professors in the sample published on average 11 items in the period 1994–1999 and occurred 1.4 times as inventor on a patent application. The numbers vary by research field and type of institution (see Table 3.5). The size of the institutions differs in student numbers ranging from 1,451 to nearly 60 thousand students. The share of scientists of a unit's total staff is 73% on average. The share is slightly lower at polytechnics (68%) and technical universities (71%). The professors have an average experience of about 22 years in academe. Seventy three percentage of them had some form of contact to a TTO, and only 3% of them are female.

3 Econometric Analysis and Results

The research unit's amount of industry funding (*INDFUND,* and the share of this funding as % of the total budget *INDSHARE*) and the amount and share of public grants (*GOVFUND*, *GOVSHARE*) serve as dependent variables. However, not all professors in the sample attracted third-party funds. Tobit models are being estimated to account for this censoring bias. The models to be estimated can be written as

$$Y^{*} = X'\beta + \varepsilon, \tag{3.1}$$

where the unobserved latent variable Y^{*} is equal to *INDSHARE* and *GOVSHARE* in the first set of models and to the logarithm of *INDFUND* and *GOVFUND* (+1), respectively, in the second set of specifications. The observed dependent variable is equal to

$$Y = \begin{cases} Y^{*} \text{ if } X'\beta + \varepsilon > 0 \\ 0 \text{ otherwise} \end{cases} . \tag{3.2}$$

X represents the matrix of regressors, β the parameters to be estimated and ε the random error term.[5] The main hypothesis concerns the effects of a unit's research orientation on third-party funding. To test for complementarity between the two, an interaction term *BASIC*APPLIED* is added to the model. As *BASIC_SHARE* and *APPLIED_SHARE* add up to 1, it is necessary to multiply the individual shares with the number of scientific staff (mean = 13, median = 9, and the maximum number is 130).[4] After the core specification, we add the research track record of units' heads (*PUBS* and *PATS*) and the gender dummy (*FEMALE*). Due to the skewed distributions of patents and publications, the logs of these variables are included. For those with zero patents or publications, i.e., if the log is not defined, a dummy variable is included to capture the "quasi-missing" values (*NO_PUB_DUM*, *NO_PAT_DUM*).

Table 3.2 presents the regression results. They show that basic research is associated with a lower share of funding from industry, whereas applied research has a significantly positive effect in all three specifications. The latter confirms findings by Gulbrandsen and Smeby (2005) who study differences in research orientation between university professors with industry funding and professors with other types of funding or no external research funding. They find support in their Norwegian data for the hypothesis that professors with industrial funding indeed describe their research more often as applied than professors without funding from the private sector.

The inclusion of the interaction term reveals that research units which do both basic as well as applied research have a larger share of industry grants compared to

[4] This transformation results in a shift in interpretation of the variable from 'share of effort devoted to basic or applied research' to 'staff working on basic or applied research'. Thus, it ought to be kept in mind for the interpretation of the results that these variables (*BASIC* and *APPLIED)* also measure lab size.

[5] The standard Tobit model requires the assumption of homoscedasticity; otherwise, the estimates are inconsistent (cf. Greene 2000). Tests on heteroscedasticity (Wald tests and LR tests) using a heteroscedastic specification of the Tobit model in which the homoscedastic standard error σ was replaced with $\sigma i = \sigma \exp(Z'\alpha)$ in the likelihood function find indeed evidence of heteroscedasticity. Consequently, regional dummies, one for each of the 16 German states, and field and institution-type dummies were used to model group-wise multiplicative heteroscedasticity. The presented estimation results are thus obtained from heteroscedastic-consistent estimations.

Table 3.2 Tobit regressions on source of funding as share of total budget (669 obs.)

Variable	Tobit models on *INDSHARE*			Tobit models on *GOVSHARE*		
BASIC	−0.153*	−0.323**	−0.320**	0.252**	0.538***	0.454***
	(0.085)	(0.132)	(0.137)	(0.120)	(0.169)	(0.173)
APPLIED	0.321***	0.229**	0.196***	0.344***	0.516***	0.519***
	(0.082)	(0.090)	(0.085)	(0.125)	(0.160)	(0.172)
*BASIC*APPLIED*		0.013**	0.013**		−0.019***	−0.017***
		(0.006)	(0.006)		(0.006)	(0.006)
EXPER	0.275	0.296	0.287	0.854*	0.783	0.835
	(0.333)	(0.340)	(0.305)	(0.512)	(0.512)	(0.521)
EXPER^2	−0.010	−0.010	−0.009	−0.018	−0.017	−0.017
	(0.007)	(0.008)	(0.007)	(0.012)	(0.012)	(0.012)
TTO	3.927***	4.136***	3.404**	3.032	2.689	2.461
	(1.516)	(1.542)	(1.498)	(2.022)	(2.032)	(2.055)
ln(*UNI_SIZE*)	93.573***	91.531***	88.936***	16.759	24.552	22.597
	(31.572)	(31.084)	(31.477)	(35.785)	(37.710)	(37.579)
ln(*UNI_SIZE*^{2})	−4.903***	−4.771***	−4.612***	−0.686	−1.139	−1.007
	(1.653)	(1.627)	(1.649)	(1.879)	(1.975)	(1.970)
ln(*PUBS*)			−0.729			1.928**
			(0.712)			(0.924)
ln(*PATS*)			0.914			1.862
			(1.120)			(1.676)
NO_PUB_DUM			−1.538			−0.281
			(1.884)			(2.863)
NO_PAT_DUM			−3.450**			2.997
			(1.721)			(2.307)
FEMALE			0.076			2.209
			(2.189)			(4.838)

(continued)

Table 3.2 (continued)

Variable	Tobit models on *INDSHARE*			Tobit models on *GOVSHARE*		
Joint significance of institution dummies χ^2 (2)	29.66***	26.89***	21.60***	25.97***	26.41***	24.96***
Joint significance of field dummies χ^2 (6)	42.16***	41.27***	31.68***	32.09***	33.15***	30.35***
Joint significance of *Länder* dummies χ^2 (15)	88.38***	84.37***	99.21***	51.94***	48.85**	51.83***
Log-likelihood	−1,855.67	−1,853.78	−1,851.48	−2,410.06	−2,406.32	−2,402.02
# of censored obs	260			147		

Notes: All models include a constant, institution-type and field dummies. The heteroscedasticity term includes six field dummies, 15 *Länder* dummies, and two institution-type dummies. *** (**, *) indicate a significance level of 1% (5%, 10%).

more specialized units. On the contrary, the models on *GOVSHARE* show a negative sign for the interaction term which indicates a substitutive relationship between basic and applied research for the attraction of public grants. As expected, contact to a TTO increases industry funding, but has no effect on public grants. The share of industry grants is higher at larger institutions up to a size of about 14,000 students but is decreasing with the number of students at larger institutions. Moreover, having no past "patenting experience" reduces the share of industry grants. The coefficient of the variable capturing past publications has the expected positive sign for public grants pointing to the importance of scientific achievements for raising such funds. Past patent applications are not significant for the share or amount of public grants.

In a section step, models on the total amount of grants (*GOVFUND*) instead of the share of total budget are estimated in order to be able to calculate more meaningful marginal effects. The key insights are confirmed (Table 3.3). Here, the estimated coefficients describe the marginal effects of the regressors on Y^*, such that

$$\frac{\partial E\left[Y_i^* | x_i^{'}\right]}{\partial x_{ik}} = \beta_k. \tag{3.3}$$

(see, e.g., Greene 2000: 908–910). Since the dependent variable in this model is specified as logarithm, a unit change in our main variables of interest, i.e., *BASIC* and *APPLIED*, can be interpreted as a percentage change in funding. If one additional person works on applied research, industry funding (in terms of the latent index Y^*) increases by 8.1% and public grants by 10.8% (Table 3.3, specification 3.3). If an additional basic researcher is hired, government grants (column 6) increase by about 10%, all else constant.

As a robustness check, all models have been estimated accounting for quality-weighted measures of past research performance. The results confirm previous findings. The total number of citations to past publications (in the pre-sample period 1994–1999) is positive and significant in the *GOVFUND* equation but insignificant for *INDFUND*. The same applies for citations per publication. It is noteworthy that the marginal effects are larger for the quality-weighted measures for scientific output. Thus, the quality of scientific output seems not only to be important but also to be more important for public grants than for industry grants.

4 Conclusions

Given the increasing share of competitive grants—from public as well as private-sector sources—supplementing universities core funding, the objective of this chapter was to provide an analysis of the role of direction of faculty research in terms of basic versus applied research for attracting such grants. Although we see that applied research indeed increases the share of industry funding of the research units' total

Table 3.3 Tobit regressions on source of funding (669 obs)

Variable	Tobit models on ln (*INDFUND* +1)			Tobit models on ln (*GOVFUND* +1)		
BASIC	0.007	–0.025	–0.027	0.063***	0.105***	0.098***
	(0.015)	(0.027)	(0.027)	(0.013)	(0.016)	(0.015)
APPLIED	0.101***	0.086***	0.081***	0.083***	0.107***	0.108***
	(0.018)	(0.020)	(0.020)	(0.009)	(0.013)	(0.013)
*BASIC*APPLIED*		0.002*	0.002**		–0.003***	–0.002***
		(0.001)	(0.001)		(0.001)	(0.001)
EXPER	0.036	0.042	0.041	0.080*	0.063	0.074
	(0.070)	(0.072)	(0.071)	(0.046)	(0.044)	(0.045)
EXPER^2	–0.001	–0.001	–0.001	–0.002	–0.001	–0.001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
TTO	1.134***	1.174***	1.016***	0.545***	0.468***	0.457***
	(0.312)	(0.317)	(0.323)	(0.175)	(0.169)	(0.170)
ln(UNI_SIZE)	7.347	6.639	5.575	1.714	2.816	2.170
	(5.289)	(5.256)	(5.246)	(3.454)	(3.597)	(3.672)
ln(UNI_SIZE^2*)*	–0.367	–0.325	–0.264	–0.067	–0.129	–0.094
	(0.279)	(0.278)	(0.278)	(0.180)	(0.187)	(0.191)
ln(PUBS)			–0.058			0.248*
			(0.131)			(0.133)
ln(PATS)			0.126			0.096
			(0.202)			(0.075)

NO_PUB_DUM			–0.310			–0.302
			(0.379)			(0.256)
NO_PAT_DUM			–0.692**			0.327
			(0.311)			(0.211)
FEMALE			0.141			0.164
			(0.672)			(0.512)
Joint significance of institution dummies χ^2 (2)	17.17***	17.19***	15.52***	36.18***	75.89***	79.39***
Joint significance of field dummies χ^2 (6)	59.18***	53.72***	43.59***	75.50***	38.06***	36.13***
Joint significance of *Länder* dummies χ^2 (15)	52.41***	50.34**	48.61**	71.77***	77.21***	74.19***
Log-likelihood	–1,184.01	–1,182.23	–1,179.05	–1,162.25	–1,152.80	–1,147.28
# of censored obs	260			147		

Notes: All models include a constant, institution-type and field dummies. The heteroscedasticity term includes six field dummies, 15 *Länder* dummies, and two institution-type dummies. *** (**, *) indicate a significance level of 1% (5%, 10%).

budgets as well as the amount, the complementarity between basic and applied research for success in raising industry grants suggests that researchers who provide basic scientific input as well as competencies on the applicability of such are most attractive targets for funding from the business sector. Thus, firms appear to seek access to basic science that is not feasible or not profitable to build up in-house but also rely on the scientists' ability to translate it into applicable technology. This points to a trade-off faced by the sponsoring firm between the advantage of sourcing basic science from universities and the costs of building absorptive capacities to effectively use this knowledge. Collaborating with university research labs that are able to conduct both basic as well as applied research may reduce these costs and, hence, alleviate the trade-off.

With respect to public grants, the results suggest that public funding-authorities prize specialization. Research units with either a strong focus on either basic or on applied research raise significantly more grants than others. This is in line with previous findings. Application-oriented research, for instance, has been shown to benefit from supranational funding programs such as the EU-wide "Framework Programme for Research and Development". In Germany, direct project funding by the federal government has been to an increasing extent directed at promoting industry-science consortia that aim explicitly at promoting applied research. Grant programs by the German Research Foundation (DFG), on the other hand, may support rather basic research agendas as they attract applicants with particular high scientific excellence if measured in publications and citations (Grimpe 2010). Moreover, the result that private-sector and public grants are subject to different criteria with respect to research orientation suggests that industry grants offer an additional source of competitive funding for research units that may not be willing or not be able to raise other types of grants. What is more, worries about a "funding split" in the sense that industry only provides grants for applied research and government only promotes basic research may be exaggerated - at least in the short run.

However, the results ought to be interpreted with the study's limitations in mind. Given the available data, it was not possible to account for the dynamics between ex ante research orientation that shapes the attractiveness for receiving industry funding and the incentives to adopt a certain orientation to become more attractive for funding in the future. Panel data on a set of professors and their research unit would be desirable for such an exercise. Further analysis would, moreover, not only benefit from distinguishing between types of public grants but also from studying the providers of industry grants in greater detail. As results for the USA by Cohen et al. (2002) suggest, it is very likely that the observed effects differ substantially between industries, firms of different sizes and different stages of maturity. Further research should also take into account the impact of "outside factors" such as government-subsidized cost sharing in public-private partnerships and their effects of industry-funded university research that may also cross-impact the researchers' attention to other public funding schemes.

5 Appendix

Table 3.4 Cross-correlations matrix between main variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 INDSHARE	1															
2 INDFUND	0.532*	1														
3 GOVSHARE	–0.082	0.034	1													
4 GOVFUND	0.083	0.439*	0.572*	1												
5 BASIC	–0.303*	–0.163*	0.303*	0.018	1											
6 APPLIED	0.303*	0.163*	–0.303*	–0.018	–1.000*	1										
7 PUB	–0.119*	–0.056	0.182*	0.067	0.369*	–0.369*	1									
8 PAT	0.103*	0.158*	0.045	0.146*	–0.058	0.058	0.034	1								
9 PUBCITS	–0.123*	–0.063	0.196*	0.062	0.349*	–0.349*	0.802*	0.011	1							
10 PATCITS	0.098	0.289*	–0.022	0.084	–0.023	0.023	0.003	0.502*	0.004	1						
11 UNI_SIZE	–0.046	0.035	0.274*	0.192*	0.428*	–0.428*	0.187*	–0.043	0.178*	0.004	1					
12 TOT_STAFF	0.037	0.487*	0.151*	0.499*	0.022	–0.022	0.102*	0.099	0.068	0.136*	0.127*	1				
13 SCI_STAFF	–0.186*	–0.200*	0.192*	–0.012	0.247*	–0.247*	0.122*	–0.039	0.135*	–0.073	0.123*	–0.188*	1			
14 EXPER	0.009	0.004	0.150*	0.054	0.197*	–0.197*	0.080	–0.020	0.015	–0.073	0.186*	0.054	–0.002	1		
15 TTO	0.147*	0.119*	0.002	0.131*	–0.297*	0.297*	–0.107*	0.125*	–0.065	0.074	–0.152*	0.115*	–0.155*	0.020	1	
16 GENDER	–0.030	–0.055	–0.014	–0.060	–0.031	0.031	–0.029	–0.015	–0.027	–0.011	–0.004	–0.069	–0.001	–0.055	0.036	1

*Significant at 1% level

Table 3.5 Grants, research orientation, and research performance by research fields and institution type (means)

Field	# of obs.	GOVSHARE	GOVFUND	INDSHARE	INDFUND	PUB	PUBCITS	PAT	PATCITS
Physics	101	32.03	149.72	4.29	45.68	22.90	627.76	1.13	17.61
Maths and computer science	107	16.46	60.51	5.95	39.09	3.97	44.48	0.21	0.84
Chemistry	95	22.10	82.22	6.06	68.05	27.52	513.24	1.80	23.24
Biology	57	24.43	77.03	7.59	29.10	3.05	324.81	0.93	7.73
Electrical engineering	101	14.76	108.83	11.53	130.76	11.58	53.88	2.27	33.74
Mechanical engineering	108	21.68	174.52	14.00	205.35	3.93	27.06	1.84	40.39
Other engineering	100	22.00	155.84	10.05	123.51	6.73	88.38	1.57	12.59
Universities	371	26.25	129.02	7.51	80.06	16.37	348.46	1.55	16.56
Technical universities	156	25.09	190.47	10.62	167.84	6.49	128.96	1.27	35.83
Polytechnics	142	6.11	11.53	9.29	61.74	2.28	22.82	1.20	12.77

References

Auranen O, Nieminen M (2010) University research funding and publication performance – an international comparison. Res Policy 39:822–834

Anders Broström (2012) "Firms' rationales for interaction with research universities and the principles for public co-funding. The Journal of Technology Transfer 37(3):313–329, June

Cassiman B, Veugelers R, Zuniga MP (2008) In search of performance effects of (in)direct industry science links. Ind Corp Change 17(4):611–646

Cohen W, Nelson R, Walsh J (2002) Links and impacts: the influence of public research on industrial R&D. Manage Sci 48:1–23

Czarnitzki D (2009) The virtue of industry-science collaborations. EIB Papers 14(1):121–143

Greene WH (2000) Econometric analysis, 4th edn. Prentice-Hall, New Jersey

Grimpe C (2010) Scientific excellence and extramural research grants: beggars can't be choosers? ZEW discussion paper no. 10–031, Mannheim

Gulbrandsen M, Smeby JC (2005) Industry funding and university professors' research performance. Res Policy 34:932–950

Hall BH, Jaffe A, Trajtenberg M (2001) The NBER patent citations data file: lessons, insights, and methodological tools. NBER working paper no. 8498

Henderson R, Jaffe A, Trajtenberg M (1998) Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988. Rev Econ Stat 80(1):119–127

Levin S, Stephan P (1991) Research productivity over the life cycle: evidence for academic scientists. Am Econ Rev 81(1):114–132

Ljungberg D (2008) What industry funding and academic patents tell us about university-industry interaction: the case of Sweden. In: DRUID-DIME academy winter 2008 conference proceedings, Aalborg (Denmark)

Mansfield E (1991) Academic research and industrial innovation. Res Policy 20:1–12

Mansfield E (1995) Academic research underlying industrial innovations: sources. Characteristics Financ Rev Econ Stat 77:55–65

Mansfield E, Lee J-Y (1996) The modern university: contributor to industrial innovation and recipient of industrial R&D support. Res Policy 25:1047–1058

Murray F (2002) Innovation as co-evolution of scientific and technological networks: exploring tissue engineering. Res Policy 31:1389–1403

OECD (2007) Science, technology and innovation indicators in a changing world responding to policy needs. OECD, Paris

OECD (2009) Business-funded R&D in the higher education and government sectors, in: OECD science, technology and industry scoreboard 2009. OECD, Paris

Sorenson O, Fleming L (2004) Science and the diffusion of knowledge. Res Policy 33:1615–1633

Thursby J, Thursby M (2004) Are faculty critical? Their role in university-industry licensing. Contemp Econ Policy 22(2):162–178

Thursby J, Thursby M, Gupta-Mukherjee S (2007) Are there real effects of licensing on academic research? A life cycle view. J Econ Behav Organ 63:577–598

Trajtenberg M, Henderson R, Jaffe A (1997) University versus corporate patents: a window on the basicness of invention. Econ Innov New Technol 5(1):19–50

Viner N, Powell P, Green R (2004) Institutionalized biases in the award of research grants: a preliminary analysis revisiting the principle of accumulative advantage. Res Policy 33:443–454v

Chapter 4
The Cooperative Strategy of Technology Transfer Offices: A Longitudinal Study

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Abstract The literature on technology transfer offices (TTOs) focuses on the main variables explaining the performance of these organizations. The implicit strategic model considered by the literature is that the TTOs have to control all the activities, resources, competences of the value chain of the technology transfer process. The aim of the TTO is to maximize the revenues of the commercialization of academic results and its role is to manage a linear and unidirectional process. However, this model is not applicable for every university. In France, TTOs developed cooperative strategies with other local TTOs on the one hand, to pool resources and share costs and on the other hand, to structure the regional innovation system. TTOs do not anymore control internally all the activities and accept to share some of them with partners. Instead of having as unique objective to maximize the gains of technology transfer activities, TTOs set up alliances with the aim to diffuse more largely and at a higher speed the research results. The technology transfer process is considered as interactive and multidirectional. This alternative model is illustrated by a longitudinal study of a French University active since a long time in technology transfer activities.

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1 Introduction

During the last decade, technology transfer offices (TTOs) were developed all over Europe for several reasons. Governments wanted to foster science-industry relations in order to speed up the exploitation of research results reached within public research institutions. The need to find alternative sources of funding induced PROs (Public Research Organizations) to better formalize their technology transfer activities. At the end of the 1990s, many OECD countries modified their IPR legislation giving public research organizations and universities the property rights instead of researchers. The necessity to better protect and control research results reinforced the need to establish TTOs. However, the organization, the performance, and the functioning of TTOs vary between universities.

The literature on the performances of TTOs is extensive (Sect. 2). The objective of this literature is to highlight the factors favoring the performance of TTOs in terms of licensing, patenting, R&D contracting, and start-up creation. The performance is mainly explained by the aim of a TTO to protect the intellectual property of the university and to appropriate the gain of the technology transfer activities, i.e., to maximize revenue. The implicit strategic model is that the TTO controls the entire value chain of the technology transfer process. The TTO has a central position in a linear technology transfer process: it takes valuable research results generated by the university scientists and transfers them toward industry. It corresponds to a unidirectional vision of the TT process and a "knowledge factory" vision of the university.

The aim of this chapter is to consider an alternative technology transfer model in which the objective of the TTO is to increase the diffusion and the speed of technology transfer. Our contribution is to suggest a model (Sect. 3) in which the TTOs develop cooperative strategies, on the one hand, to pool resources to answer economies of scale issues and, on the other hand, to structure the regional system of innovation. The technology transfer process involves a multiplicity of decentralized actors and is multidirectional. The TTO is one actor of the regional innovation system, and its role is to create an appropriate context to coordinate and to interconnect the activities of a variety of actors in order to foster the process. This alternative model corresponds to a "knowledge hub" vision of the university and is not well studied in the literature.

We present a longitudinal case study (see Sect. 4 for methodological issues and Sect. 5 for the case) of the University of Strasbourg. This case study covers the evolution of the TTO of the University of Strasbourg over 23 years based on interviews at several periods of time, with a variety of actors (TTO directors, vice-rectors, researchers) and completed by additional information sources. This case shows how the university first developed a TTO based on the "knowledge factory" model and evolved to a "knowledge hub" one. A French public program induced the development of the cooperative strategy of the TTO. The case provides examples of activities aiming at pooling resources and structuring the regional innovation system. In Sect. 6, we discuss the case along the following elements: the evolution from a knowledge factory to a knowledge hub position, the increased visibility and reputation of the university thanks to its coordinator role, and the importance of public intervention in the implementation of the cooperative strategy of the TTO. Section 7 concludes.

2 Review of the Literature

The literature on technology transfer offices (TTOs) and the commercialization of academic research results is vast and expanding. Several papers (Siegel et al. 2007; Rothaermel et al. 2007; Geuna and Muscio 2009; Phan and Siegel 2006; Markman et al. 2008a) review the literature and highlight the main dimensions explaining the performances of TTOs. A large number of contributions based on quantitative methodologies (Chapple et al. 2005; Siegel et al. 2008; Thursby et al. 2001; Lockett and Wright 2005) are completed by others using qualitative approaches (Jain and George 2007; Shane 2002; O'Shea et al. 2007; George 2005; Jackson and Audretsch 2004). We present the main results about the factors explaining the performances of TTOs. According to Phan and Siegel (2006), university administrators have to think about the technology transfer process in strategic terms. Building a strategy implies that the university should set up clear and transparent objectives, allocate resources according to the strategic choice, build up capabilities to develop the targeted activities, provide incentives, and take account of the external context. In this reviewed literature, the implicit strategic model is that the TTO controls all the activities, resources, and competences of the value chain of the technology transfer process. The aim of the TTO is to maximize the revenues generated by its activities. The TTO is an intermediary actor who facilitates the transfer of knowledge produced by academic researchers toward interested industrial partners. It manages a unidirectional process (from science toward industry).

2.1 Objectives and Measure of Performance

The literature on TTOs usually distinguishes between the performance in academic patenting and licensing on the one side and in spin-offs creation on the other side. Many academic papers stress the prevalence for university administrators to protect intellectual property and appropriate the gains of technology transfer, over creating an appropriate context in which these types of activities could take place (Thursby and Thursby 2007). Jensen and Thursby (2001), Thursby et al. (2001), and Jensen et al. (2003) survey 62 major US university TTOs about the importance of various licensing outcomes. The TTOs first value revenues generated, inventions commercialized, licenses executed, sponsored research, and patents. The faculty members rate first sponsored research. In the same line of ideas, Markman et al. (2005a) find that licensing for cash is the most prevalent technology transfer strategy and that TTOs overemphasize royalty income and underemphasize entrepreneurship activities. These ideas are somehow convergent with the revenue maximization model presented by Litan et al. (2007). According to these authors, this prevailing model was created in the 1980s when universities established TTOs to centralize all university inventions and commercialization activities. TTOs were created to implement the intellectual property strategy of the university: the faculty members should notify all their discoveries to the TTO in charge of protecting and licensing the invention.

The TTO becomes the gatekeeper of the portfolio of IP, the unique access to the inventions developed by researchers. It occupies a monopoly situation which allows selecting a small number of projects characterized by high short-term rates of return. These projects are sold via licenses to companies at a monopoly price. Siegel et al. (2003a) report the following result: "The managers/entrepreneurs in our study commonly perceived that universities are too aggressive in exercising intellectual property rights. This results in a hard line on negotiations, excess concern on the part of university administrators that they will not realize sufficient revenue, and unrealistic expectations" (Siegel et al. 2003a, p. 121).

2.2 Financial Resources

Financial resources devoted to the TTO by the university increase the number of licenses and patents (Siegel et al. 2004) and the speed of start-up creation (Markman et al. 2005a). A larger proportion of industry funding level influences positively the creation of start-ups (O'Shea et al. 2005; Powers and McDougall 2005). Federal science and engineering funding with an orientation toward life science and chemistry also impacts positively start-up formation (O'Shea et al. 2005). Universities engaged in technology transfer activities should have a balanced portfolio of funding: basic funding from government for long-term research, research funded by industry with a shorter-term perspective, and competition-based financing (Polt 2001). This is important not only for financial risk diversification reasons, but it is also compatible with the necessity, on the one hand, to pursue basic and applied (long- and short-term) research simultaneously and, on the other hand, to manage a portfolio of complementary activities.

2.3 Scientific and Technological Resources

Several papers (Polt 2001; Debackere and Veugelers 2005; Muscio 2010; Siegel et al. 2007) underline the necessity for universities to have a strong research base, to reach scientific excellence, and to keep their competences in generating new knowledge, ideas, and original findings. They should be able to exploit the complementarities existing between teaching basic and more applied research. Polt (2001) highlights that the most successful universities are those able to combine basic and applied research within specific research teams and to carry out strategic auditing to adjust the research agenda to the economic and social needs. O'Shea et al. (2005) suggest that universities with high-quality science and engineering departments positively impact the number of spin-off companies created. The presence of a medical school has no significant impact on technology transfer activities (Siegel et al. 2003b), has a negative impact according to Thursby and Kemp (2002), and influences positively the licenses income in the UK (Chapple et al. 2005).

A critical mass of faculty generating world-class research and the presence of star scientists positively influence technology transfer activities such as invention disclosure (Jensen et al. 2003), spin-offs (Di Gregorio and Shane 2003; Powers and McDougall 2005; Lockett and Wright 2005), and patents (Siegel et al. 2007). The number of postdoctoral students and of researchers in scientific and engineering disciplines is positively correlated to the number of spin-offs created and licenses sold (O'Shea et al. 2005).

2.4 *Organizational Structure*

From an organizational point of view, some papers (Debackere and Veugelers 2005; Bercovitz et al. 2001) underline that universities with high technology transfer outcomes have often established a decentralized, dedicated, and specialized TTO. According to Debackere and Veugelers (2005, p. 329), "creating a specialized and decentralized technology transfer office within the university is instrumental to secure a sufficient level of autonomy for developing relations with industry, allowing for specialization in supporting services, reducing transaction costs in scientific knowledge market." When TTOs enjoy greater autonomy, they reach higher commercialization outcomes such as revenue and start-up creation (Markman et al. 2005b, 2009). Bercovitz et al. (2001) analyze the role of organizational structures on the performances of TTOs. They show that organization does matter and influences the ability to coordinate activities and to manage information flows between internal and external actors, the incentive alignment, and the performance of the TTO. Siegel et al. (2003b) find a learning effect in terms of licensing revenue: the older the TTO, the higher the revenue generated. In the UK, Chapple et al. (2005) argue that older TTOs are less efficient than comparable younger ones. Universities with tradition and history of spinning out companies are more efficient (O'Shea et al. 2005). Moreover, TTOs that actively support the researchers in their transfer projects and communicate with them are more successful than the ones behaving like an administrative office. At the researchers' level, being in a laboratory and working with colleagues involved in commercialization stimulate the scientist to value his/her research results. The presence of entrepreneurial curricula within universities is also a positive element.

2.5 *The Development of Capabilities*

The relation between the number of staff in the TTO and the number of licenses is not clear. In the USA, Siegel et al. (2003b) show that the larger the TTO, the higher the number of licenses. Chapple et al. (2005) exhibit the reverse result for the UK situation. Thursby and Kemp (2002) highlight that the number and the quality of the staff impact positively technology transfer activities. O'Shea et al. (2005) underline that universities with more full-time equivalent people dedicated to technology transfer efforts increase their probability of creating start-ups.

The development of specific capabilities has been particularly studied in the context of start-up creation. Lockett and Wright (2005) stress that business development capabilities influence positively the spinning out of companies. The technical, industrial, and spinning out experience of licensing officers is positive (O'Shea et al. 2007; Powers and McDougall 2005). However, Siegel et al. (2007) claim that there exists a general problem of attracting and remunerating personnel with appropriate skills to support the creation of spin-offs.

In their early contributions, Siegel et al. (2003a, b) underline that US TTOs are characterized by a lack of competences, especially in business and marketing. Technology transfer managers should have a background in industry to reduce the cognitive distance between researchers and company managers (Muscio 2010): TTOs managed by professional staff with industry background exhibit higher technology transfer performances in Italy. UK TTOs need to upgrade business skills and capabilities (Chapple et al. 2005).

Siegel et al. (2003b) show that external expenses on lawyers reduce the number of licensing agreements, but increase licensing revenue. The use of external lawyers is seen by some companies as a deliberate intention of universities to be tough in exercising their intellectual property rights. In the same line of ideas, Lockett and Wright (2005) find that external expenditure on intellectual property advice influences positively spin-off creation.

Siegel et al. (2004) highlight that the social network of TTO managers is an important element to consider in explaining the performance of TTOs. Social networks rely on shared norms and the currency of exchange is information. In that respect, Owen-Smith and Powell (2003) show that the connection between TTOs and science-based firms having the expertise to provide information about the value of the patent is positively correlated to technology transfer activities. But being too close or over connected might act negatively. Franklin et al. (2001) underline that the more successful universities (in terms of start-ups) have developed social networks. Experienced universities in spinning out companies find it advantageous to hire surrogate entrepreneurs with previous commercial experience, motivated by capital gain and having their own networks. Strong network ties between TTOs, venture capitalists, business angels, IP specialists, and entrepreneurs explain the success of the spinning out process (Wright et al. 2006). O'Shea et al. (2007) show that the network between MIT, the government, and the industry increased research funding at MIT and allowed for the sharing of knowledge and thus helped stimulate high-tech entrepreneurship.

2.6 Incentives

In most OECD countries, new IPR legislation has given public research organizations and universities the property rights instead of researchers. However, in case of successful commercialization through licensing, the share of royalties between the scientists and the institution has to be decided by the research organization, taking into account the different costs related to the enforcement and exploitation of patents. If universities want to induce researchers to disclose their research results and get involved in commercialization activities, they should ensure a significant share of royalties to their researchers or of equity shares when spin-off companies are at stake. Siegel et al. (2003a, b, 2004) underline the insufficient rewards for faculty involved in technology transfer activities. Tenure and promotion decisions continue to be made almost strictly on the basis of publications and grants but not on technology transfer activities. This situation generates a lack of incentives for the researchers to disclose inventions with a potential commercial value. The disclosure problem is reinforced by the lack of understanding of the value of the discovery by the scientists and the lack of confidence between the scientists and the TTO (Link et al. 2007; Markman et al. 2008b). A group of papers (Link and Siegel 2005; Markman et al. 2009; Lach and Schankerman 2004) show that a higher royalty share to the researchers and to the scientific department is associated to higher licensing income. On the contrary, maintaining low inventors' shares of royalty increases new firms formation activity (Di Gregorio and Shane 2003; Markman et al. 2005a). There is also a lack of financial incentives for TTO staff, who often consider that their careers are not attractive. As a main consequence, we observe a high turnover of employees (Siegel et al. 2003a, b). Markman et al. (2009) show that higher bonuses or salaries to TTO managers raise licensing income and technology transfer outcome.

2.7 Institutional Context

Increased licensing by universities is due to increased business reliance on external R&D (Thursby and Thursby 2002; Thursby and Kemp 2002). Di Gregorio and Shane (2003) show that venture capital availability in the environment of the university has no influence on start-up formation. The reverse result is presented by Powers and McDougall (2005). Siegel et al. (2003b) argue that R&D activity of local firms has a positive impact on the number of licenses sold. In regions with a low level of R&D and economic activity, universities are less efficient in technology transfer performances (Chapple et al. 2005). High-tech clusters and science parks seem to have positive effects on start-up creation. Link and Scott (2005) find that start-up formation increases in older science parks, active in biotechnology, located close to universities, and in a rich research environment. The proximity of high-tech clusters, science parks, incubators, entrepreneurs, and clients facilitates access to critical knowledge, expertise, resources, and networks. The legal context is also an element to be taken into account. The Bayh-Dole Act in the USA and similar bills in other countries surely contributed to the increasing commercialization of research results.

3 The Cooperative Strategy of TTOs

The review of the literature highlights a large set of variables explaining the performances of TTOs: resources, capabilities, incentives, and institutional context. The implicit strategic model is that the TTO controls the entire value chain of the technology transfer process. It supervises and monitors all the activities adding value to the process and all the related information flows, risks, resources, and capabilities. In the case of a licensing process, for instance, the TTO manages all the following different steps: the identification of a potentially valuable discovery, the selection of the technology to be protected, the search for additional funding to get the technology more mature, the protection of the invention, the search for a client interested by the technology, the negotiation process of licensing, and the involvement of the faculty member to further develop the technology to be transferred.

In this model, the TTO has a very central position in the technology transfer process and manages all the activities to close the gap between the external partners and the researchers: it is a gatekeeper of the university inventions, aiming at protecting them in order to generate a maximal amount of revenues. It is coherent with a linear and unidirectional view of the innovation process in which the TTO takes the research result from a laboratory and transfers it to an industry. The university is considered as a knowledge factory (Youtie and Shapira 2008), and the TTO is in charge of the commercialization of the knowledge produced.

The literature also suggests that this model, in which the TTO controls all the support activities of the technology transfer process, is not applicable to every university. For example, in Europe, many TTOs have inefficient size and lack human resources with marketing and entrepreneurial skills, and the pooling of resources of some specialized functions might help create a critical mass (Siegel et al. 2007). In a value chain perspective (Phan and Siegel 2006), the technology transfer process can be split into activities. All of them need not remain within the TTOs and can be shared with external partners. One of the models suggested by Litan et al. (2007) is the regional alliances of TTOs: several universities of a same region form a consortium to develop their commercialization strategy. For the authors, cost reduction constitutes the main reason for cooperating. Cost minimizing concerns and achieving economies of scale are central in the traditional economic analysis of cooperation, as proposed by scholars in industrial organization (Katz and Ordover 1990; De Bondt 1997; Salant and Schaffer 1998).

In a value chain perspective, the TTO could reorganize its activities in order to reduce the “transaction costs” associated with a better diffusion of technologies. These costs are related to all the expenses linked to the different technology transfer activities: identification of technologies, selection of technologies to patent, searching for money to get a mature technology, looking for potential clients, administrative expenses, opportunity costs, etc. TTOs of a same region could minimize the cost by pooling some activities (for instance, communication and marketing of available technologies) or some patents in some disciplines to create a coherent set of intellectual property rights, etc.

Table 4.1 Two models of technology transfer

	Knowledge factory vision	Knowledge hub vision
Objectives of the TTO	Maximizing revenues of the TT activities	Maximizing diffusion of technologies and the speed of TT
Vision about the TT process	Linear	Interactive
	Unidirectional	Multidirectional
Strategic model	Internalization of all activities (controlling the entire value chain)	Cooperation between local TTOs (sharing activities of the value chain) to:
		Reduce costs
		Structure the regional innovation system

Moreover, instead of having as unique objective to protect the intellectual property right of the university and to appropriate the gains of technology transfer, the university can also set up alliances with the aim to create a suitable context in which technology transfer activities could take place. This vision is compatible with the “volume model” developed by Litan et al. (2007): universities should disseminate the achieved research results more largely and at higher speed. As innovation is a distributed and decentralized process, wider diffusion is associated with better communication between the different actors involved in the process, better coordination, and better sharing of knowledge. It is also coherent with the vision of the university as a knowledge hub (Youtie and Shapira 2008, p. 1189): “(…) a third model of the university has emerged in recent decades—one in which the university functions as a “knowledge hub” that seeks to animate indigenous development, new capabilities, and innovation, especially within its region (…). In this model, universities become even more deeply embedded in innovation systems, seeking to actively foster interactions and spillovers to link research with application and commercialization, and taking on roles of catalyzing and animating economic and social development.”

In a “knowledge hub” vision, the strategy of a TTO evolving in a complex regional system differs from the “knowledge factory” model in several dimensions:

- Its objectives focus on wider diffusion of technologies at higher speed.
- It is based on an interactive and multidirectional vision of the TT process.
- It establishes cooperation with other local TTOs to share activities of the value chain for cost minimizing reasons and to structure the regional innovation system (foster the coordination of the variety of actors, ease their interaction, increase the transparency of information in the system, and avoid duplication of efforts).

The following table (Table 4.1) summarizes the characteristics of the “knowledge factory” model, coherent with the approaches developed in the literature review and the “knowledge hub” model, developed in this chapter as a new option highly understudied in the literature.

The idea we will develop in the remaining part of this chapter is that in a "knowledge hub" perspective, TTOs develop cooperative strategies responding, on the one hand, to cost reduction and sharing issues and, on the other hand, to the development of an appropriate context in which technology transfer activities could be facilitated by better knowledge sharing and coordination.

4 Methodology and Presentation of the Case Study

4.1 Methodology: A Longitudinal Study

To characterize the cooperative strategies of a TTO and their impact on the development of effective practices, we studied over several years the evolution of the TTO of one of the most active French universities in technology transfer activities. We confront our case study to the best practices identified in the literature to show that they do not represent a sufficient response to the limits of the technology transfer activities of the university. We show that the current identification of best practices neglects the role of the TTO in a regional system of innovation and thus ignores the role of TTOs in implementing cooperative strategies between the different actors of the technology transfer process at the regional level. This chapter proposes an extension of the current best practices through the identification of new practices that the TTO of the University of Strasbourg was able to develop, thanks to the cooperative strategy it devised.

We conducted a longitudinal study based on semi-structured interviews. The aim of the interviews was to characterize the role, the organization, the strategy, and the identified limits of the TTO of the University of Strasbourg. We interviewed three directors of the TTO in 1998, 2006, 2009, and 2011. To complete the vision of TTO managers and to gather the political point of view concerning the technology transfer mission of the university, we also interviewed the three vice-presidents in charge of industrial relations at the same periods and the director of the incubator.

We cross-checked this information by using other sources of information. We used university archives, financial documents, and the web sites of the university and the TTO. During a period going from 2002 to 2008, we also interviewed around 20 scientists involved in technology transfer activities about their perceptions of the role of the TTO and of the complementarity between technology transfer activities and academic research.

4.2 Presentation of the Case Study

Before presenting the French context and the main policies adopted since 2000 to support the development of the transfer of knowledge between academic science and the economic world, we present the university TTO.

4.2.1 The TTO of the University of Strasbourg

The University of Strasbourg constitutes an interesting case for studying the management of technology transfer activities for several reasons mentioned in the reviewed literature. First, the University of Strasbourg has an old tradition of fundamental research, and some of its researchers have received numerous national and international scientific prizes, including two Nobel Prizes (one in chemistry in 1987 and one in medical sciences in 2011). Second, the University of Strasbourg is one of the largest French universities in terms of research. The European Report on Science & Technology Indicators (2003) ranks the university first among French universities in terms of impact and 11th among European universities. In the 2010 Shanghai ranking, the University of Strasbourg occupies the 14th position in chemistry (1st in France) and ranks between the 51st and 75th place in mathematics (4th in France). Third, the University of Strasbourg has a diversified portfolio of funding. In 2010, the global budget of the University of Strasbourg (salaries included) was around 400 million€. Government and competitive funding cover the main part, and around 40 million€ (10% of the total budget) are own resources coming from services, contractual activities, life-long learning, student fees, and other resources.

The University of Strasbourg was born on January 1, 2009, from the merger of the three preexisting universities in Strasbourg: University Louis Pasteur (specialized mainly in science, health, and a few social sciences), University Marc Bloch (specialized in social sciences and humanities), and University Robert Schuman (specialized in law, management, and political science). As a result, the University of Strasbourg is a comprehensive and multidisciplinary university and one of the biggest universities in France with 42,000 students, 40 departments offering a large variety of curricula, more than 2,550 professors (associate and full), more than 1,500 researchers from PROs, 1,600 administrative staff, and 2,500 doctoral students.

Before the merger, University Marc Bloch and University Robert Schuman had no formal structure that dealt with technology transfer. The TTO of the University of Strasbourg is a heritage of the preexisting TTO of University Louis Pasteur (ULP). ULP was one of the first French universities to create a TTO called "ULP-Industrie" in 1987. The aim was to help researchers negotiate the financial and intellectual property dimensions of their contractual activities with industry. In 1998, the president of the university created the function of vice-president in charge of research valuation activities and of partnerships with companies. The aim of this political decision was to develop the technology transfer activities of the university. Besides the valuation of research results via industrial partnerships, the university decided to be an active actor in terms of firm creation and established an incubator (SEMIA) in 2000.

4.2.2 The French Context

In France, as in many OECD countries, a set of measures were implemented at the end of the 1990s in order to overcome barriers hampering cooperation and knowledge transfer between public research and industry. In 1999, the government executed the

Innovation and Research Bill. The main measures concern the definition of clear property rights policies in public research institutions, the researchers' mobility toward industry, the incentives of researchers to handle economic exploitation of the research results, and the creation of TTOs called SAIC (Services for Industrial and Commercial Activities) within French universities. The universities are public entities, and the rigidity of public administration is an important barrier to the development of commercial activities and research collaboration with industry. The SAIC is a new kind of structure in universities that can adopt more flexible financial rules and personnel recruitment procedures. It has its own budget and can directly hire non-civil-servant personnel, having the required competences, thus avoiding the complex and heavy procedure to hire civil servants.

Since 2005, the French government has implemented another set of policy instruments devoted to renovating the national innovation and research system. It created the ANR (National Agency for Research). Its main aim is to fund 4-year applied and fundamental research projects devoted to public research organizations and industry on a competitive basis. The objective is to create new knowledge and to favor interactions between public and private laboratories by funding partnerships.

In 2006, the French Parliament voted the "Research Planning Act." Several organizational structures were created to foster cooperation between public research organizations (Centers of excellence, regional pooling of resources of higher education institutions) and to ease public-private partnerships (Global Competitiveness Clusters and Carnot Institutes).

Since August 2007, the French universities are ruled by a new act that grants them more autonomy. This law provides universities with the conditions to build and implement their own strategies. The president has extended powers, under the control of the board of directors, which involves fewer members and a higher number of representatives from the socioeconomic world. One important aspect relies on relaxing the recruitment rules and on bonuses allocation. The president can recruit high-level administrative and academic staff on a contractual basis for an undetermined duration. Universities can create foundations to increase the part of their own resources in their budget and provide them with more financial autonomy to implement their own strategies, including strategies of development of technology transfer activities.

5 The Case of the University of Strasbourg

In this case study, we present the development of the TTO of the University of Strasbourg since its creation in 1987. We distinguish three main stages: the development in coherence with the international dominant best practices, the dismantling, and the reconstruction based on a larger vision in which the university becomes an essential actor of a regional system of innovation.[1]

[1] Before 2009, the TTO belonged to University Louis Pasteur and after to University of Strasbourg. To simplify the presentation of the case, we will use "University of Strasbourg" for the two periods.

5.1 The Development of the TTO and the Adoption of Best Practices: 1987 to 2005

From 1987 to 2005, the evolution of the TTO of the University of Strasbourg was mainly guided by a linear vision of the transfer of research outputs toward industry. Its main role was to close the gap between scientists and industrial actors and to guarantee the university interests concerning incomes provided by the management of intellectual property and contractual activities.

The Innovation and Research Bill (1999) induced the university to transform the valuation department into a SAIC in 2001. The SAIC was an internal service of the university, which had a specific budget but no financial autonomy. The university allocated to the service a fixed budget independent of the volume of activities generated by the SAIC. To be able to increase its activity, the SAIC had to find external sources of funding (such as funds provided by the Region but also national programs such as ANR).

Since the creation of the SAIC, the objectives of the TTO have evolved. They took account of the political, financial, and technical aspects of the valuation activities. The evolution was guided by the willingness to develop complementary competences to market the knowledge produced within the university. The aim of the SAIC was to display the following services:

- To help researchers to implement commercial activities
- To monitor the administrative and financial aspects of the projects
- To detect the results of research, with potential economic exploitation
- To help companies to find the suitable competences or knowledge within UdS
- To find potential partners

The creation of the SAIC led to a progressive expansion of the TTO. In 2004, two sections were created: a valuation section and a financial and administrative one. This organization enabled the SAIC to manage all the different aspects of contractual activities: recruitment of personnel working on contracts, legal aspects, monitoring of the contracts, and accounting issues. The financial section developed a cost accounting system to take into account the total cost in the financial negotiation of contracts, and fiscal competences were built up to improve the financial efficiency of the contractual activity. This evolution of activities was one of the positive effects of the development of the SAIC. Previously, there was a tendency to consider only the direct costs of research in the financial part of the contracts. The financial performance of contractual research was not a major concern for the TTO.

At the same time, a new director with previous experiences in the private sector and a background in law, marketing, and engineering was recruited to manage the development of the activities of the SAIC. The number of employees increased since 2001 to reach in 2005 a peak of 14: 1 director and his/her assistant, 6 persons working in the financial and administrative section (coming from central services of the university with a civil servant status), 5 working directly on valuation activities, and 1 on intellectual property rights. The competences of a person in charge of valuation activities were generally double: a specific scientific area plus a competence either in finance, marketing, law, or business development. Each of these staff members was in charge of a pool of laboratories in a specific scientific area and had to take care of all the different activities in the value chain of technology transfer. The recruitments of personnel coming from the private sector mainly depended on the external sources that the SAIC could raise.

The technology transfer activities of the university had undergone an important development since the creation of ULP-Industrie in 1987. But, according to the director of the SAIC, this development was due to the dynamism of the scientists and not to the proactive behavior of the TTO. He explained this situation by the lack of human resources to explore the labs and the potential industrial partners of the university. The reorganization of the TTO and the creation and development of the SAIC were time and resource consuming, and the limited resources of the service prevented the staff from fulfilling the objectives announced (cf. the above-mentioned list). Very often its role was restricted to the management and monitoring of intellectual property and of contracts that the scientists had obtained. The creation of new industrial relations by the SAIC was reduced. Another barrier to the proactiveness of the SAIC was the lack of knowledge about the different competences available within the laboratories and of the results to be transferred and to be patented.

5.2 *The Dismantling of the TTO: 2005*

The creation of a SAIC was an answer to the rigidity of the administrative functioning of the university, which is submitted to public management rules. The rigidities were more specifically related to the difficulty to hire non-civil-servant personnel and to avoid the long and rigid procedures linked to any type of expenditure (red tape, administrative process, procurement contracts, etc.). The aim of the creation of the SAIC was the implementation of a more autonomous and flexible structure. After a phase of development, the SAIC underwent major changes because the university central administration worried about its growing autonomy. Two main reasons explain these changes. The first was the fear of the central administrative staff to lose control over the expenditure of the SAIC while remaining responsible for the legal implementation of public administration rules. To remain in control, the administrative staff pleaded for the return of the financial section of the SAIC to the central level of the university.

The second reason relied on political considerations internal to the university. The latter had a strong culture of research and among its three missions—teaching, research, and economic exploitation of research—research was predominant at the level of the presidential team. The economic exploitation of research was seen as a way to increase the research performance through its positive financial impact on the university and not as an activity of its own. As a consequence, industrial activities had to be managed from a financial point of view as research, i.e., at the central level of the university, and the SAIC had to remain an administrative department and not a service with its own objectives and functioning rules.

In 2006, the financial section returned to the central financial service of the university, and from a financial point of view, the SAIC was again managed as any other part (laboratories, faculties) of the university. It was submitted to the same rules especially concerning the management of expenditure. The decision to separate again the financial and administrative sections from the SAIC and to keep a central control in this domain was an internal choice of the university and was not due to the inability of the SAIC to create flexible administrative and accounting rules.

The case of the University of Strasbourg shows that the organizational and administrative aspects were not just technical ones. They were the expression of a political willingness to sustain and develop valuation activities. The absence of a clear and shared vision of the mission of the TTO and of its complementarity with the other missions of the university induced internal conflicts that led to a step back. The TTO was developed with the implicit direct objective to maximize the income of the technology transfer activities. This vision of the technology transfer and the adaptation of the TTO to this objective, which was not the objective of the other activities in the university, induced conflicts about the role of the TTO and the definition of its frontiers and attributions. At the University of Strasbourg, research was considered as a predominant function and the development of the commercialization activity often depended on the internal political equilibrium.

5.3 The TTO as an Actor of a Regional System of Innovation: 2005 to 2011

At the regional level, there was clearly a situation where the supply may encounter difficulties to meet the demand requirements. The different regional actors involved in technology transfer activities decided to cooperate to overcome these problems. This cooperation was also expected to represent for each actor a means to rationalize the use of their limited resources and their internal shortages.[2] The university played an active role in this process.

5.3.1 The Pooling of Technology Transfer Offices

In 2005, ANR (National Agency for Research) launched a call for proposals concerning the pooling of technology transfer offices at a regional level in order to create

[2] Even if it is not the focus in this subsection, we would like to underline that the creation of the University of Strasbourg (merging process) in 2009 allowed the TTO to grow again, to reintegrate a financial section, and to build a more flexible management system. In 2011, the TTO employed again the same number of personnel than in 2005: 14 persons.

structures with a critical mass of resources and thus to overcome the general problem of limited resources devoted to this type of activities. The University of Strasbourg together with the other Alsatian universities, two engineering schools, the University Hospital of Strasbourg, CNRS (National Center for Scientific Research), and INSERM (National Institute for Medical Research) decided to answer this call and to create a cooperative agreement between their TTOs, called Conectus. Their application was elected and they got 4M€ from the ANR for 2005–2008.

The actors of Conectus devised six collaborative projects (Table 4.2). The aim of these projects was to pool costs but also to create a suitable regional technology transfer context.

The maturation fund was the first one created in France. Over 3 years, 40 projects were funded for a total amount of 4.5M€. Since 2007, the maturation fund led to the creation of 12 companies, 3 in a creation process, 3 licensing agreements. Twenty-five projects ended in 2011 and 55% of them led to a technology transfer.

The creation of Conectus and the six common projects favors the development of technology transfer activities and led to encouraging results for the University of Strasbourg. Since the end of 2007, the SAIC of ULP saw its global activity rise from 12M€ to 19M€ (20M€ end of 2008), an 84% increase of its public-private research collaborations (5.3M€), 75% more licenses, and 11 start-up projects.

5.3.2 The Coordination of Actors at the Regional Level

Conectus is not only a pooling of resources. It has also to be seen as an enabler of partnerships to foster innovation in the Alsace Region. The university used to evolve in a regional context where the different actors (public and private) were poorly coordinated along the innovation process. They had overlapping roles and initiatives (Fig. 4.1): several organizations had their own interface structures, collected public funds from the same sources, and explored external needs. According to a report from the DIACT in 2008 (Interministerial delegation for the development of territories), policy instruments such as Centers of excellence, regional pooling of resources of higher education institutions (PRES), Global Competitiveness Clusters, and Carnot Institutes had positive effects on the scientific and economic system. But they were built rather independently from one another in an environment already saturated by numerous technology transfer organizations, research clusters, public and private foundations, collective research centers, and regional development agencies. There is a clear lack of coordination with overlapping competences, activities, goals, and competition to access public funding. The complexity of the system makes it difficult for enterprises and for the involved actors themselves to have a global vision and to monitor the regional system.

The creation of Conectus was a first step in the coordination between the different TTOs and actors of the regional system of innovation. The different public actors could reach greater visibility and improve the coordination with the private sector. The longer-term vision of Conectus is that creating a unique network could simplify the regional context on the public side (Fig. 4.2).

Table 4.2 Collaborative projects of Conectus

Collaborative projects	Description
Unique entry point	External requirements from potential partners are managed by the "unique entry point" and redirected to the appropriate actors of the network. The aim is to increase the chances to give a positive answer to an industrial partner. Demands concern mainly services and technological exploration/canvassing and not contractual research
	Conectus hired one person for this task
Pooling of the technology transfer of medical research	The University of Strasbourg and INSERM pooled their commercialization activities in the medical sector[1]. INSERM is in charge of the intellectual property (except if the patent is related to [2]Alsace Biovalley or to the creation of a spin-off). All the inventions are co-patented in order to build a coherent set of patents in the field of medical research
	Conectus recruited one person to manage the contracts
Quality insurance	Conectus allocates financial resources for the implementation of a quality certification required by some industrial partners. This fund helps seven technical platforms and several labs implement a quality approach
Communication and marketing	Conectus is the unique trademark for the communication on competences, the participation in trade fairs, and the organization of events. Conectus develops a proactive approach toward industry
	One person was hired for the development of this axis
Cartography of competences	The aim is to identify and translate the competences of public laboratories in terms of potential applications. This mapping concerns also other regional structures involved in technology transfer
	The mapping of public competences in the Upper Rhine Region benefited from a European funding (InterregIV)
	One person has been employed in this project
Creation of maturation fund	This fund helps the evolution of some projects from a phase of proof of laboratory to a proof of concept during 12–18 months. The proof of concept is necessary to license a technology to a company or to create a start-up
	To create this fund, Conectus negotiated with the city of Strasbourg, the Alsace Region, other local authorities (department level), and Oséo (a public organization financing innovation projects and especially for SMEs)

[1]One peculiarity of the French system is the association of university research facilities with those of public research organization such as the National Center for Scientific Research (CNRS) and the National Institute for Health and Medical Research (INSERM). In Strasbourg, 46 over 87 of labs were associated either with the CNRS or with INSERM

[2]Alsace Biovalley is a Global Competitive Cluster specialized in health and life sciences

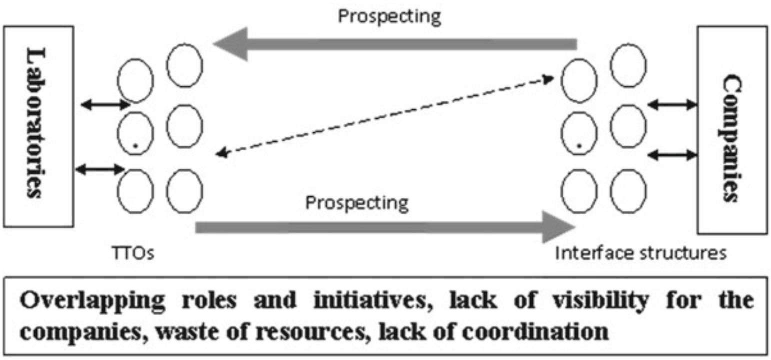

Fig. 4.1 Absence of coordination along the innovation process (Source: UdS)

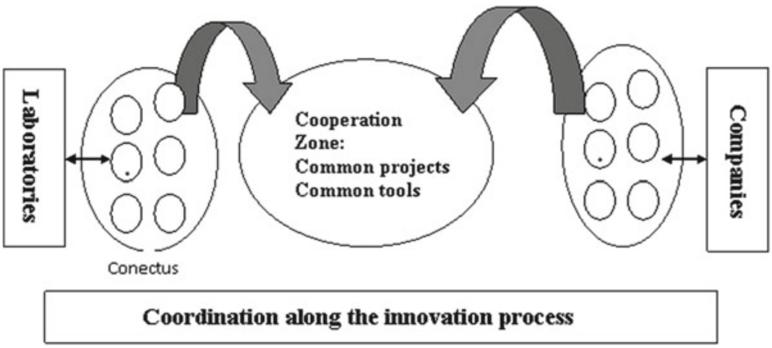

Fig. 4.2 Coordination along the innovation process (Source: UdS)

To better coordinate its actions with other interface organizations and to reach a collective functioning at the regional level, Conectus signed agreements with Alsace Biovalley (the Global Competitive Cluster in health and life science), Rhenaphotonics (a cluster in optics and photonics), Pôle Fibre Grand Est (the Global Competitive Cluster in fibers), SEMIA (the incubator of the Alsace Region), ARI (the Regional Agency for Innovation), and the Chamber of Commerce. For instance, they work all together to create an "innovation week" where all the local actors could be present instead of organizing each its own event. Conectus, SEMIA, and ARI plan to build a common building where all the actors involved in technology transfer activities would be located.

The development of the coordination between the different actors makes the system more transparent. This is probably one of the explanations of the 60% increase in Alsace of research contracts between Conectus members and enterprises from 2006 to 2009.

6 A Cooperative Strategy Based on a Knowledge Hub Vision

In our case study, we can identify two different visions of the role of a TTO. In a first vision, the development of the TTO corresponds to the adoption of practices commonly accepted in the literature as best practices. The TTO developed over time in order to enhance licensing, patenting, contractual research with industry, and spin-off creation. In a second vision, the TTO of the University of Strasbourg pooled its resources with other TTOs of the region and became a visible and an active contributor of the rationalization of the regional system.

In the first model, the implicit vision of technology transfer activities relies on a unidirectional transfer of research outputs toward industry (Acworth 2008). For Youtie and Shapira (2008), in this vision, universities are seen as "knowledge factories." The implicit role of the TTO is to market explicit knowledge produced by research activities. This model is predominant in the literature, and many of the best practices that guide the development of TTOs in many countries rely on this vision.

Colyvas et al. (2002) showed that technology transfer cannot be reduced to the transfer of explicit knowledge. Academic and industrial actors are involved in networks, and the transfer of explicit knowledge is a consequence of the informal relations they have developed over time. For Youtie and Shapira (2008), universities have to participate actively in the development of interactions to link research with the economic sphere. Universities are not just "knowledge factories." They have to evolve toward a "knowledge hub" model. To approach the latter and to go beyond the unidirectional transfer of research outputs to industry, it is necessary to create knowledge integration community mechanisms (Acworth 2008). Those rely on the existence of an organizational context that favors knowledge sharing between research, education, industry, and government. The aim is to create the conditions for interactions between these different groups, through the emergence of common platforms that do not exist naturally. The case of the University of Strasbourg shows how the cooperation between TTOs can be a first step in structuring the regional system of innovation and creating a context favorable to the development of technology transfer activities.

In a regional context, the network of TTOs includes innovation development agencies, local governments, funding agencies, other TTOs, clusters, innovative companies, other interface structures, etc. In the situation without cooperation among TTOs, each of them is embedded in its own network, exchanging information and trying to control part of the process. It looks like a system in which each agent exchanges information in multidirectional ways: the exchange of information is unorganized and inefficient. The supply side and the demand side of the technology transfer process are very badly connected. If the TTOs decide to cooperate to share some costs and pool resources, they become more visible in the regional network. They are able to provide better information about the set of technologies they develop, the services they offer, and the financial resources they need to further develop technologies. Their decision to rationalize part of their activities increases their reputation not only on the side of the political actors but also on the industrial side. This greater reputation allows them for instance to negotiate "maturation funds" with funding agencies and local governments in order to accelerate the technology transfer.

Their greater visibility and centrality in the regional innovation system increases their ability to coordinate actions with the other actors of the system. Very often, local companies have no information about the technologies and competences available in the academic sphere of the region, and the universities have no idea about the needs of industry. A possible added value of the better coordination with the regional actors is that each side of the technology transfer process codifies and exchanges information about the available competences and the potential needs.

Implementing a cooperative agreement is time and resource consuming. In cases where TTOs suffer from resource shortages, they might not cooperate whereas it could be socially better for them to do so. In this situation, it could be economically justified that the government provides incentives for TTOs to cooperate. Our case study underlines such a context. In 2005, the ANR launched a call for proposals concerning the pooling of technology transfer offices at regional level. Fourteen common structures were funded in 12 French regions. Siegel et al. (2007, p. 657) underline that the European Commission "is already actively supporting diverse forms of transnational partnering among TTOs and other public and private partners."

7 Conclusion

The contribution of this chapter is to show the cooperative strategies developed by a TTO, through the case of a large university active in technology transfer since a long time, which evolved from a "knowledge factory" model to a "knowledge hub" one. The case shows in a first period a TTO coherent with the predominant vision of the role of the university in the literature about TTOs. Universities are seen as "knowledge factories," which produce research outputs and set internal conditions to transfer technologies to the socioeconomic sphere. The external environment and the role the university could play are largely ignored in this first period. Technology transfer is mainly considered as a linear and unidirectional phenomenon. In the second period, the university is involved in networks and builds relations with external actors that help shape technology transfer activities. The development of cooperative strategies at the regional level should be added to the internal factors to grasp the "knowledge hub" vision of universities. The case study illustrates effective practices linked to the development of such a cooperative strategy.

We could expect that the cooperative model is not only relevant for smaller universities suffering from a lack of financial resources or stock of knowledge to transfer, as is suggested by Litan et al. (2007). This cooperation model could be generalized to all types of universities evolving in complex and uncoordinated environments. More case studies should be developed to document the "knowledge hub" model and the underlying boundary-spanning role of TTOs in order to derive related best practices. Other examples of resource pooling and platform creation exist around the world. For instance, in Canada, the government of Quebec decided to create, at the beginning of the year 2000, four valuation structures working each for a group of higher education institutions, which have their own TTOs dealing with contractual activities. These pooled valuation structures are mainly dealing with property right issues and start-up creations for their groups of universities.

One of them has decided to create an investment fund, open to all valuation structures, to help technologies mature. It could be interesting to analyze the effective practices of these structures and the way they coordinate their actions, if they do.

References

Acworth EB (2008) University–industry engagement: the formation of the knowledge integration community (KIC) model at the Cambridge-MIT Institute. Res Policy 37(8):1241–1254

Bercovitz J, Feldman M, Feller I, Burton R (2001) Organizational structure as a determinant of academic patent and licensing behavior: an exploratory study of Duke, Johns Hopkins, and Pennsylvania State Universities. J Technol Trans 26:21–35

Chapple W, Lockett A, Siegel D, Wright M (2005) Assessing the relative performance of U.K. university technology transfer offices: parametric and non-parametric evidence. Res Policy 34:369–384

Colyvas J, Crow M, Gelijns A, Mazzoleni R, Nelson RR, Rosenberg N, Sampat B (2002) How do university inventions get into practice? Manage Sci 48(1):61–72

De Bondt R (1997) Spillovers and innovative activities. Int J Ind Organ 15(1):1–28

Debackere K, Veugelers R (2005) The role of academic technology transfer organizations in improving industry science links. Res Policy 34:321–342

Di Gregorio D, Shane B (2003) Why do some universities generate more start-ups than others? Res Policy 32:209–227

Franklin S, Wright M, Lockett A (2001) Academic and surrogate entrepreneurs in university spin-out companies. J Technol Trans 26(1–2):127–141

George G (2005) Learning to be capable: patenting and licensing at the Wisconsin Alumni Research Foundation 1925–2002. Ind Corp Change 14(1):119–151

Geuna A, Muscio A (2009) The governance of university knowledge transfer: a critical review of the literature. Minerva 47:93–114

Jackson S, Audretsch DB (2004) The Indiana university advanced research and technology institute: a case study. J Technol Trans 29:119–124

Jain S, George G (2007) Technology transfer offices as institutional entrepreneurs: the case of Wisconsin Alumni Research Foundation and human embryonic stem cells. Ind Corp Change 16(4):535–567

Jensen R, Thursby MC (2001) Proofs and prototypes for sale: the licensing of university inventions. Am Econ Rev 91(1):240–259

Jensen R, Thursby JG, Thursby MC (2003) The disclosure and licensing of university inventions: the best we can do with the s**t we get to work with. Int J Ind Organ 21:1271–1300

Katz MJ, Ordover JA (1990) R&D cooperation and competition. Brookings papers on economic activity: microeconomics, pp 137–203 vol 1

Lach S, Schankerman M (2004) Royalty sharing and technology licensing in universities. J Eur Econ Assoc 2(2–3):252–264

Link AN, Scott JT (2005) Opening the Ivory's Tower Door: An Analysis of the Determinants of the Formation of US University Spin-off Companies. Res Policy 34:1106–1112.

Link AN, Siegel DS (2005) Generating science-based growth: an econometric analysis of the impact of organizational incentives on university-industry technology transfer. Eur J Finance 11(3):169–182

Link AN, Siegel DS, Bozeman B (2007) An empirical analysis of the propensity of academics to engage in informal university technology transfer. Ind Corp Change 16:641–655

Litan RE, Mitchell L, Reedy EJ (2007) Commercializing university innovations: alternative approaches. NBER working paper

Lockett A, Wright M (2005) Resources, capabilities, risk capital and the creation of university spin-out companies. Res Policy 34:1043–1057

Markman GD, Phan PH, Balkin DB, Gianiodis PT (2005a) Entrepreneurship and university-based technology transfer. J Bus Venturing 20(2):241–263

Markman GD, Gianiodis PT, Phan HP, Balkin DB (2005b) Innovation speed: transferring university technology to market. Res Policy 34:1058–1075

Markman GD, Siegel DS, Wright M (2008a) Research technology commercialization. J Manage Stud 45(8):1401–1423
Markman GD, Gianiodis PT, Phan PH (2008b) Full-time faculty or part-time entrepreneurs. IEEE Trans Eng Manage 55:29–36
Markman GD, Gianiodis PT, Phan PH (2009) Supply-side innovation and technology commercialization. J Manage Stud 46(4):625–649
Muscio A (2010) What drives the university use of technology transfer offices? Evidence from Italy. J Technol Trans 35:181–202
O'Shea RP, Allen TJ, Chevalier A, Roche F (2005) Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. Res Policy 34:994–1009
O'Shea RP, Allen TJ, Morse KP, O'Gorman C, Roche F (2007) Delineating the anatomy of an entrepreneurial university: the Massachusetts Institutes of Technology experience. R&D Manage 37:1–16
Owen-Smith J, Powell WW (2003) The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. Res Policy 32(9):1695–1711
Phan PH, Siegel DS (2006) The effectiveness of university technology transfer: lessons learned, managerial and policy implications, and the road forward. Found Trends Entrepreneurship 2(2):77–144
Polt W (2001) Benchmarking Industry-science relations: the role of framework conditions. Final report prepared for EC, DG enterprise
Powers JB, McDougall P (2005) University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship. J Bus Venturing 20(3):291–311
Rothaermel FT, Agung SD, Jiang L (2007) University entrepreneurship: a taxonomy of the literature. Ind Corp Change 16(4):691–791
Salant SW, Schaffer G (1998) Optimal asymmetric strategies in research joint venture. Int J Ind Organ 16:195–208
Shane S (2002) Selling university technology: patterns from MIT. Manage Sci 48(1):122–137
Siegel DS, Waldman DA, Atwater L, Link AN (2003a) Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration. J High Technol Manage Res 14:111–133
Siegel DS, Waldman D, Atwater L, Link A (2003b) Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. Res policy 32:27–48
Siegel DS, Waldman D, Link A (2004) Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J Eng Technol Manage 21:115–142
Siegel DS, Veugelers R, Wright M (2007) Technology transfer offices and commercialization of university intellectual property: performance and policy implications. Oxford Rev Econ Policy 23(4):640–660
Siegel DS, Wright M, Chapple W, Lockett A (2008) Assessing the relative performance of university technology transfer in the US and UK: a stochastic distance function approach. Econ Innov New Technol 17(7):719–731
Thursby JG, Kemp S (2002) Growth and productive efficiency of university intellectual property licensing. Res Policy 31:109–124
Thursby JG, Thursby MC (2002) Who is selling the ivory tower? Sources of growth in university licensing. Manage Sci 48(1):90–104
Thursby JG, Thursby MC (2007) Chapter 6 Knowledge Creation and Diffusion of Public Science with Intellectual Property Rights, in Keith E. Maskus (ed.) Intellectual Property, Growth and Trade (Frontiers of Economics and Globalization, Volume 2), Emerald Group Publishing Limited pp.199–232
Thursby JG, Jensen R, Thursby MC (2001) Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities. J Technol Trans 26:59–72
Wright M, Lockett A, Clarysse B, Binks M (2006) University spin-out companies and venture capital. Res Policy 35:481–501
Youtie J, Shapira P (2008) Building an innovation hub: a case study of the transformation of university roles in regional technological and economic development. Res Policy 37(8):1188–1204

Chapter 5
Academic Entrepreneurship in a Resource-Constrained Environment: Diversification and Synergistic Effects

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Abstract This chapter investigates academic entrepreneurship in a resource-constrained environment. Sequential mixed methods are adopted in three stages, namely, an initial context-specific data-gathering stage, an on-line survey, and in-depth interviews. It is revealed that entrepreneurial activity is a means of becoming resource-rich in a resource-constrained environment. In order to extract value from their environment, academic entrepreneurs adopt diversification strategies, which generate synergies between multiple academic entrepreneurial activities. Diversifying into a greater number of different activities is found to generate more synergistic effects than diversifying into a limited number of similar activities. Nevertheless, there remain synergies between those who adopt different diversification strategies, which highlight the importance of a university having a team of different academic entrepreneurs, who complement each other. Policy implications and future research avenues are considered in conclusion.

1 Introduction

Expectations regarding the contributions of academics to entrepreneurial engagement in addition to their primary role of teaching and research (Laukkanen 2003) have increased in recent years (Venkataraman et al. 1992). At a government policy level,

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the commercialisation of university-generated knowledge is often considered to be a way of achieving national competitiveness (McMullan and Vesper 1987; Henderson et al. 1998; Mowery et al. 2002) and innovation (Lam 2005). These expectations have increased pressure on universities to generate additional economic activity (Storey and Tether 1998; Shane and Stuart 2002) through bridging the gap between industry and academia (Mowery and Shane 2002).

However, research on academic entrepreneurship has to date been carried out mainly in developed countries. It is therefore questionable to what extent the findings of these studies can be applicable to low-income developing countries (Eun et al. 2006; Adesola 1991). Developing countries have been found to face relatively high levels of resource scarcity that involve the shortages of skills (Alexander and Andenas 2008; Griffith-Jones et al. 2003), finance (United Nations Human Settlements Programme 2005), infrastructure, technology (World Bank 2010), and institutions (Claude and Weston 2006). Therefore, this research attempts to address this gap in our knowledge by investigating the entrepreneurial engagements of academics in a resource-constrained environment, which will enhance the understanding of technology transfer in a global economy.

2 A Theoretical Context

2.1 Resources and Academic Entrepreneurship

While the term academic entrepreneurship has mostly been used in a focused manner to illustrate academic engagements in the formation of spin-off companies, some studies have used it to represent a much broader spectrum of knowledge-transfer activities (Jones-Evans and Klofsten 2000; D'Este and Perkmann 2011). Since the objective of this research is to investigate the nature of academic entrepreneurial engagement in a context that has received inadequate attention in prior research, it was required to investigate the whole subject of academic entrepreneurship. Hence, it was decided to use the broad view of the term. As the broad view has not defined the term theoretically (Mars and Rios-Aguilar 2010), in this study, by considering the definitions of entrepreneurship (Shane and Venkataraman 2000), academic entrepreneurship is defined as academics capitalising on perceived opportunities, by matching these with resources, in order to accumulate wealth, which could be monetary and/or social.

It has been argued that the entrepreneurial engagements of academics are shaped by their environment and its availability of exploitable resources (Ucbasaran et al. 2000), which influence an entrepreneur's ability to identify, and capitalise on, opportunities (Scott et al. 2000). The total environment of the academic entrepreneur consists of the university (Eun et al. 2006), which comprises the internal environment, and actors in the wider economic and social environment, especially government and industry (Etzkowitz and Leydesdorff 2000; Siegel et al. 2004).

Based on the resource-based view of firms, Eun et al. (2006) have argued that the stronger the universities are in terms of resources, the higher the tendency for academics to engage in entrepreneurial endeavour. Similarly, other literature suggests that there is a higher propensity for academics to engage in entrepreneurial endeavour when their external macroenvironment is resource rich (Etzkowitz and Leydesdorff 2000; Siegel et al. 2004). The studies of this type have led to a belief that the propensity for entrepreneurship is highly encouraged by a resource-rich environment. This argument is further supported by studies that have found resource limitations to be strong barriers to academic entrepreneurial engagement (Monck and Segal 1983). Indeed, when a full range of facilities are unavailable in universities, these resource deficiencies may critically inhibit entrepreneurship (Van Dierdonck and Debackere 1988).

However, some studies in the entrepreneurship literature have argued that, in extremely unpromising and resource-constrained environments, entrepreneurial skills may remain important in spotting opportunities and matching these with available resources. Thus, resource constraints can conversely stimulate entrepreneurial behaviour in such relatively impoverished environments (Kodithuwakku and Rosa 2002; Adesola 1991; Gilad and Levine 1986). This argument is further supported by studies which state that the availability of resources is not critically damaging and that entrepreneurs can creatively overcome resource barriers (Hart et al. 1995). These findings have led to the argument that resource barriers may not necessarily inhibit academic entrepreneurship and that being entrepreneurial may be a means of overcoming resource constraints. This has led to the first testable 'null' proposition of this chapter which asserts:

H1 *Being entrepreneurial is not a means of overcoming resource barriers in a resource-constrained environment.*

2.2 The 'Plural Activity' of Academic Entrepreneurs and Synergistic Effects

In order to shed further light on academic entrepreneurship in a resource-constrained environment, it was decided to investigate the entrepreneurial engagements of individual academics in detail, since they are the agents of academic entrepreneurship (D'Este and Patel 2007; Ambos et al. 2008). It has been found in some of the literature that entrepreneurs operating in such environments tend to engage in multiple income generation activities (Kodithuwakku and Rosa 2002). Therefore, it is possible to argue that academics operating in resource-constrained environments may also engage in several academic entrepreneurial activities. Since carrying out multiple income generation activities is defined as diversification in the entrepreneurship literature (Alsos et al. 2003), engaging in a number of entrepreneurial activities by academics may also represent diversification.

However, since diversification has not yet been a topic widely discussed in the academic entrepreneurship literature, it was decided to use corporate diversification literature, which has discussed quite a similar scenario where firms carrying out a number of business activities. The corporate diversification literature has identified two types of diversification strategies, namely, related diversification and unrelated diversification. Related diversification involves firms diversifying into activities that are related to their main activities (e.g. related markets, industries, or products). In contrast, unrelated diversification involves firms diversify into substantially new areas of business (Rumelt 1982). Even though the above literature is not directly relevant to academic entrepreneurial engagements, its basic concept of related and unrelated diversification seems to provide a theoretical background for the discussion of the diversification of entrepreneurial activities by academics.

In order develop a theoretical framework to understand the diversification of academic entrepreneurs, it was necessary to investigate whether it is possible to differentiate academic entrepreneurial activities in terms of their 'relatedness' to the core task of academics, which is to engage in teaching and research activities (Etzkowitz et al. 2000). The academic entrepreneurship literature argues that company creation by academics is substantially different from normal academic duties, while other forms of knowledge-transfer activities are related to normal academic duties (Schartinger et al. 2001; Radosevich 1995; Samson and Gurdon 1993; Daniels and Hofer 1993). On the other hand, to some degree, teaching and research are independent of each other. For example, Marsh and Hattie (2002) have stated that teaching effectiveness and research productivity are mutually exclusive and, thus, concluded that these two activities are independent.

The above discussion suggests that academic entrepreneurial activities might be categorised into three groups, namely, teaching-related activities, research-related activities, and company creation. However, categorising activities into these three groups would not restrict the potential for interactions between these groups. The rationale for such a categorisation is that activities categorised within groups are more similar in terms of their relatedness to normal academic duties than activities between groups. In line with these arguments, 17 academic entrepreneurial activities, identified from the literature, were categorised into three main groups (Table 5.1). Grouping these activities according to the nature of them is a strategy that has been adopted in the academic entrepreneurship literature (e.g. D'Este and Patel 2007).

As discussed above, an academic may engage in a combination of entrepreneurial activities, and using the three types of activities, eight possible combinations of entrepreneurial activities were constructed (i.e. 2^3) (Table 5.2). When the category of academics who had not engaged any activity was excluded, seven combinations could be considered to account for the different portfolio of entrepreneurial activities. Hence, in order to understand the academic entrepreneurial engagements in a resource-constrained environment, it was decided to investigate the portfolio of entrepreneurial activities carried out by academics, named, in this research, as 'plural activity'.

The diversification and portfolio entrepreneurship literature argues that an engagement in multiple entrepreneurial activities provides additional benefits, due to the

Table 5.1 The types of academic entrepreneurial activities

Teaching related	Research related	Company creation
1. External teaching 2. Initiating the development of new degree programmes	1. Working in the industry (research based)	1. Contributing to the formation of joint ventures in which university and industry are the joint partners
3. Placing students as trainees in industry	2. Research-based consultancy for industry through the university	2. The formation of joint venture/(s) privately through collaborating with industry
	3. Research-based consultancy privately (but without forming a company)	3. Contributing to the formation of one or more new spin-off companies
	4. Developing products or services with potential for commercialisation	4. Contributing to the establishment of university incubators and/or science parks
	5. Acquiring research funding from government, non-governmental, or international bodies (those without collaborations with industry)	5. Contributing to the formation of university centres designed to carry out commercialisation activities
4. Conducting seminars and training sessions for industry personnel (Jones-Evans 1997; Jones-Evans and Klofsten 2000; Schmoch 1997; D'Este and Patel 2007)	6. Collaborating with industry through joint research projects 7. Research-related assistance to small business owners (Glassman et al. 2003; Jones-Evans 1997; Louis et al. 1989; Goldfarb and Henrekson 2003; Glassman et al. 2003; Siegel et al. 2004)	6. The formation of your own company/(s) (Radosevich 1995; Samson and Gurdon 1993; Daniels and Hofer 1993; Jones-Evans 1997; Louis et al. 1989; Goldfarb and Henrekson 2003; Clarysse et al. 2005; Di Gregorio and Shane 2003)

synergies that can develop between activities (Westhead et al. 2005; Alsos et al. 2003), which is defined in the literature on systems theory as '*the whole is better than the sum of its parts*' (Von Bertalanffy (1972), pp 407). Therefore, social network (Westhead et al. 2005; Mayer and Schooman 1993), knowledge and skills (Shane 2000; Westhead et al. 2005; Alsos et al. 2003), input–output flows,[1] and physical resources (Westhead et al. 2005; Alsos et al. 2003), identified in the literature as (at least) four types of additional advantages derived from diversification, are regarded as relevant to diversifying academic entrepreneurial activities considered here.

[1] Ability to use outputs of an initial activity as inputs for a subsequent activity.

Table 5.2 The 'plural activity' types adopted by academic entrepreneurs

'Plural activity' types	Teaching related	Research related	Company creation
Type 1 (*only teaching-related AEAs)*	✓		
Type 2 *(only research-related AEAs)*		✓	
Type 3 (*only company creation)*			✓
Type 4 *(teaching-related AEA + research-related AEA)*	✓	✓	
Type 5 (*teaching-related AEA + company creation)*	✓		✓
Type 6 (*research-related AEA + company creation)*		✓	✓
Type7 (*teaching related + research related + company creation)*	✓	✓	✓

AEA-Academic Entrepreneurial Activities
√ indicates that academics have engaged in at least one activity in the given group of activities

It is also stated in the literature that diversification into similar activities generates greater synergistic effects than diversifying into diverse activities, since capabilities and resources could be shared between similar activities (Markides and Williamson 1996). However, the literature also argues that the ability to derive synergies is dependent upon how effectively the linkages between activities are managed (Gupta and Govindarajan 1986). Therefore, it has been argued that, in certain circumstances, poor coordination among similar activities might offset potential synergistic benefits (Zhou 2011). These contradictory arguments have led to the second 'null' proposition of this chapter, which states:

H2 *There is no association between the 'plural activity' of academic entrepreneurs and the extent of synergistic effects generated in resource-constrained environments.*

3 Context

Sri Lanka was chosen as the location for this research on academic entrepreneurship in a resource-constrained environment. According to the classification of the World Bank, Sri Lanka is a lower-middle-income country with the GDP per capita of 2,375 (current US $) in 2010 (The World Bank 2011). Due to the provision of free undergraduate education, the dependence of universities on government funding is very high. However, universities do not receive adequate funding from the government since it has a myriad of other priorities linked to poverty alleviation. For instance, government spending on universities as a percentage of GDP in 2010 was only 0.27 % (which represented only 1.21 % of total government expenditure) (University

Grant Commission Sri Lanka 2011), while it was 1.49 % in East Asia and Pacific (2007), 0.88 % in Europe and Central Asia (2007), 0.66 % in Latin America and Caribbean (2005), and 2.61 % in North America (2007) (International Monetary Fund 2011). Furthermore, in terms of the world bank indicators, Sri Lanka, in relation to other world nations, is in the 50th, 16th, 26th, and 55th percentile ranks with respect to financial, infrastructural, technological, and institutional resources, respectively (higher ranks indicate stronger resource status) (The World Bank 2011). Additionally, a recent study has revealed that Sri Lanka does not have adequate supportive mechanisms and institutional frameworks with which to promote university industry interactions. The same study reported that, except for a few companies, Sri Lankan industry does not actively engage in research and development activities (Esham 2008). These facts clearly illustrate the resource-constrained environment in which Sri Lankan academics operate.

4 Methodology

The total population considered for this study consisted of academics in 13[2] universities in Sri Lanka (employing a total of 4,215 academics as of the first of January 2009) (University Grant Commission 2010). A mixed-methods approach was adopted, conducted in three sequential stages, namely, an initial context-specific data-gathering stage, an on-line survey, and final in-depth interviews. It has been stated in the literature that this approach improves research validity (Tashakkori and Teddlie 1998).

It was decided initially to gather context-specific data, needed to design the major data collection phases (Tashakkori and Teddlie 1998; Menzies 2000; Yang et al. 2006). Hence, telephone interviews were conducted with the registrars of 8 universities.[3] Furthermore, the findings of the initial data-gathering stage were used to assess the appropriateness of categorising academic entrepreneurial activities into the three groups (as illustrated in Table 5.1), which is a strategy recommended in the literature to improve the validity of categorisations solely based on the literature (Tsoukas 1989; Ketchen and Shook 1996; Kwok and Sharp 1998).

The preliminary data gathering was followed by major data collection phases. It was decided first to collect quantitative data by an Internet survey and then to gather detailed qualitative data by in-depth interviews. This approach was considered appropriate since the main purpose of quantitative data was to obtain a broad

[2] Sri Lanka has 15 public universities. There are not any private universities other than some private institutions mainly focused on teaching. Out of the 15 universities, the University of Jaffna was excluded due to the issues related to accessibility. The University of Visual and Performing Arts was considered as a part of the University of Kelaniya since the two bodies were separated recently.

[3] At the time of this study, Sri Lanka did not have Technology Transfer Offices, and thus, registrars were contacted to gather initial information. Even though it was attempted to contact the registrars of all 13 universities, only 8 of them responded.

understanding of the range of entrepreneurial engagements of academics (i.e. academic engagement in 17 academic entrepreneurial activities during and before the last 5 years), while qualitative data was needed to investigate such engagements in detail, which has been argued to improve the internal validity of this research (Downward and Mearman 2007).

Due to the unavailability of a list of elements initially required for the sampling frame, and time and cost concerns (Levy and Lemeshow 2008), it was decided to use a cluster sampling technique for the on-line survey. Even though it might be sensible to assume that universities are 'clusters' consisting of a group of academics, this assumption has been criticised by Fleiss and Zubin (1969) since these 'clusters' do not yield any statistical or mathematical evidence to say that they are homogeneous (which is a requirement of simple cluster sampling technique). Therefore, Arber (2001) had recommended the selection of a representative sample of clusters to reduce sampling errors. Accordingly in this study, the age (Franklin et al. 2001), location, and size of universities (Friedman and Silberman 2003; Agrawal and Henderson 2002) were used as criteria for selecting universities, and academics in 6 out of 13 universities were selected as the sample for the on-line survey. The on-line survey was piloted with 16 academics to improve the construct validity of this research (Bisbe et al. 2007). The response rate for the on-line survey was 30 % (358 responses in total).[4] Furthermore, the multilevel analysis of data using MLwiN software revealed that the variation in terms of entrepreneurial engagements by academics was not explained by variations at the university level which confirms the appropriateness of using cluster sampling technique in this research.

A sample of 78 academic entrepreneurs, derived on the basis of the findings of the on-line survey (i.e. the types of 'plural activity' adopted by academics), was selected for in-depth interviews. The use of the findings of an initial phase to derive a sample for a subsequent phase is a technique successfully adopted in a number of studies in social and behavioural sciences, which is found to generate data with both breadth and depth (Teddlie and Yu 2007).

Data gathered through the on-line survey were analysed quantitatively (using SPSS) to investigate the extent of 'plural activity' by academics, and to test the relationship between 'plural activity' and the synergistic effects of 'knowledge and skills', and social networking. Data gathered through in-depth interviews were analysed qualitatively (using NVivo) to obtain an in-depth understanding of entrepreneurial engagements, which was necessary to test the above research propositions.

[4] query From the survey respondents, 69.8 % of which were males. Respondents consisted of 15 % professors, 54 % senior lecturers, and 31 % lecturers. There were eight major disciplines the respondents had specialised in, namely, the arts (2.5 %), social science (16.2 %), architecture (3.4 %), engineering (23.7 %), computing and information technology (5.3 %), medicine, dentistry, and veterinary practice (6.4 %), agriculture (21.8 %), and the sciences (20.7 %). Nonresponse bias tests (Armstrong and Overton 1977) revealed that respondents do not differ significantly from nonrespondents with respect to their universities $X2(5, 1182) = 2.976$ $p = .704 > 0.05$, gender $X2(1, 1182) = 3.674$ $p = .06 > .05$, academic discipline $X2(7, 1182) = 10.410$ $p = .167 > .05$, and position $X2(2, 1182) = 1.015$ $p = .602 > .05$.

5 Findings

5.1 Academic Entrepreneurial Engagement in a Resource-Constrained Environment

Academic engagement in 17 entrepreneurial activities over the last 5 years (from January 2005 to January 2010) revealed that 87.9 % of survey academics (i.e. 315 out of 358) had engaged in at least one entrepreneurial activity. In order to understand the nature of academic entrepreneurial engagements in detail, data collected via the on-line survey were analysed to identify any 'plural activity' of academics. If survey academics engaged in at least one out of the four teaching-related entrepreneurial activities, one out of seven research-related entrepreneurial activities, and one out of six activities grouped in company creation, they were considered engaged in respective types of entrepreneurial activities. As illustrated in Table 6.1, academic engagement in each type of activity was then used to investigate any 'plural activity' of them. Even if they had engaged in only one teaching-related entrepreneurial activity (or only research-related activity or only company creation), it was considered a form of diversification, since they carried out this in addition to their normal academic duties.

The analysis revealed that, except for 13 survey participants, the rest of the academic ($N = 302$) had adopted type 1 (teaching-related entrepreneurial activities), type 4 (teaching- and research-related entrepreneurial activities), or type 7 (company creation as well as teaching- and research-related entrepreneurial activities) 'plural activity' types. However, not a single academic had engaged in the type 5 category (i.e. teaching-related entrepreneurial activities and company creation) of 'plural activity' (Table 5.3).

It was revealed during in-depth interviews that type 1 (only teaching related), type 4 (teaching and research related), and type 7 (company creation as well as teaching and research related) 'plural activity' types were prominent because of the process adopted by academics when engaging in entrepreneurial endeavour. They started their academic entrepreneurial careers by engaging in teaching-related entrepreneurial activities, and then some of them diversified into research-related entrepreneurial activities and company creation. However, diversifying into company creation had not stopped survey participants (i.e. who had engaged in all three activities) from engaging in other teaching- and research-related entrepreneurial activities, and as a result, they engaged in a mix of entrepreneurial activities. One academic stated:

> ……after creating the company we got more opportunities to engage in consultancy, joint-research projects, and external teaching. Moreover, we were able to use resources in our company to engage in these activities.

These findings are in line with those of Tijssen (2006), who found that academic entrepreneurship is a process, which starts from engaging in 'lesser entrepreneurial' activities and then extends to 'highly entrepreneurial' activities. The prominence of

Table 5.3 'Plural activity' types adopted by academic entrepreneurs – results

Types of 'plural activity'	Teaching related	Research related	Company creation	Frequency
Type 1 (*only teaching-related AEAs)*	✓			**30**
Type 2 (*only research-related AEAs)*		✓		8
Type 3 (*only company creation)*			✓	1
Type 4 *(teaching-related AEA + research-related AEA)*	✓	✓		**150**
Type 5 (*teaching-related AEA + company creation)*	✓		✓	0
Type 6 (*research-related AEA + company creation)*		✓	✓	4
Type 7 (*teaching related + research related + company creation)*	✓	✓	✓	**122**

AEA-Academic Entrepreneurial Activities
√ indicates that academics had engaged in at least one activity grouped under each type of activity

the three 'plural activity' types (i.e. type 1, type 4, and type 7) was further confirmed by the analysis of data collected from academics who adopted other three 'plural activity' types (i.e. type 2, type 3, and type 6). It was revealed that those academics who adopted less prominent 'plural activity' types had also followed the sequence of engagement described above, but due to some personal circumstances, they had not engaged in certain entrepreneurial activities during the last 5 years (but previously they had engaged in these activities, that they will resume them in future). For instance, those who carried out only research-related activities during the last 5 years (i.e. type 2) had previously carried out both teaching- and research-related activities. Had they not encountered some personal circumstances that prevented them from engaging in teaching-related activities, they would have been grouped into type 4, which is a prominent type. Similarly, those who carried out type 3 (only company creation) and type 6 (research-related activities and company creation) 'plural activity' during the last 5 years had previously carried out type 7 'plural activity', which is a prominent type (teaching-related activities, research-related activities, and company creation).

Therefore, it could be concluded that, due to the process in which academics diversify their entrepreneurial engagements, only three 'plural activity' types were prominent in this context. These three 'plural activity' types illustrate the heterogeneity evident among academic entrepreneurs and thus were named as follows:

1. Those who had engaged in only teaching-related entrepreneurial activities (i.e. type 1) were named single-role academic entrepreneurs since they had diversified into activities grouped in one type.
2. Those who had engaged in both teaching- and research-related entrepreneurial activities (i.e. type 4) were named double-role academic entrepreneurs since they had diversified into activities classified into two types.

3. Those who had engaged in teaching- and research-related entrepreneurial activities as well as company creation (i.e. type 7) were named triple-role academic entrepreneurs since they had diversified into activities classified into three types.

Since academic entrepreneurship was found to be an evolutionary process, it is possible that single-role and double-role academics are still in the process of adding activities (mainly with respect to young academics). Therefore, whether the three types of entrepreneurs significantly differ with respect to their age was tested, although the analysis did not find a significant difference F (2, 295) = 0.831, p = 0.437 (single role M = 42 SD = 9, double role M = 44 SD = 10, triple role M = 45 SD = 10). This led to the conclusion that most of the single-role and double-role academics in this sample were those who had decided not to add other activities to their portfolio of entrepreneurial activities.

In order to understand the nature of their engagements further, it was decided to investigate the extent to which academics diversified their engagements into teaching- and research-related entrepreneurial activities.

5.1.1 Teaching-Related Entrepreneurial Activities

A chi-square test revealed that there was a significant difference between the three types of entrepreneurs with respect to the number of teaching-related activities they had engaged in X^2 (6, N = 302) = 48.350, p = 0.000. The majority of single-role academics had engaged in only one (43.3 %) or two (23.3 %) teaching-related activities. Conversely, most of the triple-role academics (43.4 %) had engaged in all four teaching-related activities, and a large proportion of double-role academics had engaged in two (29.3 %) or three (28.7 %) teaching-related activities.

Further analysis of the types of teaching-related activities carried out by the three types of entrepreneurs revealed that a majority of single-role academics had engaged in external teaching (60 %) and designing new degree programmes (53 %), which did not require extensive interactions with industry. However, a relatively low percentage of single-role academics, in comparison to double- and triple-role colleagues, had engaged in other two activities (i.e. finding industrial placements for students, training and seminars for industry personnel), which involved high interactions with industry (Table 5.4).

5.1.2 Research-Related Entrepreneurial Activities

A chi-square test revealed that triple-role academics had engaged in a significantly higher number of research-related entrepreneurial activities (5–7 activities –54.2 %) when compared with double-role counterparts (1–3 activities –56 %) X^2 (7, N = 272) = 56.404, p = 0.000. Further analysis of the types of research-related activities carried out by academics revealed that a relatively high percentage of triple-

Table 5.4 Extent of engagement – teaching-related entrepreneurial activities

Activity	Single role[a]	Double role[a]	Triple role[a]
External teaching	60 % (18)	64.7 % (97)	73.8 % (90)
Introducing new degree programmes	53.3 % (16)	73.3 % (110)	71.3 % (87)
Finding industrial placements for students	46.7 % (14)	68 % (102)	90.2 % (110)
Conducting training and seminars for industry personnel	33.3 % (10)	62.7 % (94)	83.6 % (102)

[a]Values indicate academics who had engaged in each activity as a percent of the total number of academics in respective typologies

Table 5.5 The extent of engagement – research-related entrepreneurial activities

Activity	Double role[a]	Triple role[a]
Working in the industry on secondments	24 % (36)	55.7 % (68)
Research-based consultancy for industry through the university	51.3 % (77)	77 % (94)
Research-based consultancy privately	34 % (51)	54.9 % (67)
Developing products with the potential for securing patents	16.7 % (25)	37.7 % (46)
Acquiring funding from government, non-governmental, or international bodies (those without collaborations with industry)	54 % (81)	63.1 % (77)
Collaborating with industry through joint research projects	70 % (105)	82.8 % (101)
Assisting small business owners to commercialise their innovations	18 % (27)	46.7 % (57)

[a]Values indicate academics who had engaged in each activity as a percent of the total number of academics in respective typologies

role academics than double-role academics had engaged in each of the seven research-related activities (Table 5.5).

Even though there is no comparable previous study carried out in a resource-rich environment to obtain an understanding of the relative extent of academic entrepreneurial engagements, the above analysis clearly illustrates that the resource-constrained environment of Sri Lanka has not inhibited entrepreneurial engagements by academics. Furthermore, it was evident that these academics carried out different ‘plural activity’ types. For instance, single-role academics diversified into a limited number of similar activities (i.e. teaching-related activities), while triple-role counterparts diversified into a higher number of diverse activities (i.e. teaching- and research-related activities and company creation). The engagement of double-role academics was positioned between that of single- and triple-role academics, whereby they diversified into different activities to an average level (i.e. teaching- and research-related activities). However, there was no entrepreneur who had engaged in a higher number of similar activities, one reason for which was found to be a lack of opportunities available in this constrained economic environment to diversify into similar activities. Similarly, there were no entrepreneurs who carried out a limited number of diverse activities, one reason for which was found to be the lack of resources to engage in one activity extensively. The following sections of this chapter intend to discuss the heterogeneity of academic entrepreneurs in terms of their ‘plural activity’ further.

5.2 *‘Plural Activity’ and Synergistic Effects*

As argued in the theoretical context of this chapter, ‘plural activity’ could generate synergistic effects because of interactions between entrepreneurial activities. Since academics in this context were found to adopt different ‘plural activity’ types, it is possible that they might generate varied extents of synergistic effects. Hence, their heterogeneity with respect to ‘plural activity’, illustrated by single-role, double-role, and triple-role academics, was used to test whether there was an association between the degree of synergistic effects and the ‘plural activity’ of academic entrepreneurs. This analysis was performed separately for each of the four types of synergistic effects mentioned in the theoretical context of this chapter, namely, social networks, knowledge and skills, input–output flows, and physical resources.

5.2.1 Synergistic Effect: Social Networks

The analysis of data gathered through in-depth interviews revealed that engaging in teaching-related entrepreneurial activities enabled academics to develop contacts with industry, while carrying out research-related entrepreneurial activities and company creation widened and strengthened their social networks. It was also evident that social networks developed by engaging in one activity were capitalised on, since they led to further activities, which generated the synergistic effects of social networks. These findings are in line with the entrepreneurship literature, which had identified capitalising on social network as a quality of entrepreneurs (Black 1989). A further analysis was carried out to investigate whether the degree of synergistic effects of social networking varied, depending on the complexity of the ‘plural activities’ involved.

It was found that the social networks developed by single-role academics by engaging in external teaching were used to secure opportunities to conduct training and seminars for industry personnel and to find out industrial placements for students. However, it was evident that single-role academic entrepreneurs had not capitalised on their social networks extensively and as a result derived less synergistic effects when compared to double-role and triple-role academics. For example, the following quotation from one double-role academic entrepreneur explained how the social networks developed by engaging in external teaching were helpful when diversifying into other types of entrepreneurial activities:

> The majority of students in external teaching were the employees of industry and such contacts had provided us with opportunities to engage in consultancy projects, conduct

> training and seminars, place students as trainees in industry, and gain access to industrial resources (to engage in research related activities).

The networks of contacts developed by triple-role academics by engaging in teaching- and research-related entrepreneurial activities had paved the path for them to secure opportunities for long-term involvements such as forming joint venture research labs. As a result, they were able to improve the resources of their universities, which were then used to engage in further entrepreneurial activities. For instance, one triple-role academic entrepreneur said:

> We were constantly engaging in providing consultancy services to the company 'X' (which specialises in computer engineering). They have the highest market share (in Sri Lanka) in this industry. The company was extremely happy with our delivery. I think that regular contacts with them enabled us to build trust and reputation. This resulted in them deciding to establish a joint research lab in our university.

As indicated in the above quotations, making use of the social network in order to access resources, to acquire legitimacy, and to identify, and capitalise on, opportunities for diversification is congruent with the literature that has highlighted the benefits of social networks (Birley 1985; Mayer and Schooman 1993; Aldrich and Fiol 1994). After diversifying into company creation, triple-role academics constantly interacted with industry, which enabled them to develop a strong and diverse network of contacts. Developing strong ties has been regarded in the literature as a productive way of making use of social networks (Nicolaou and Birley 2003; Ambos et al. 2008). Since triple-role academics used these social networks to identify, and capitalise on, several opportunities and obtain resources (e.g. access to resources in industry and joint research labs), they generated more synergies than other two types of academics. This was found to be one of the reasons why triple-role academics had diversified into a higher number of teaching- and research-related activities (as illustrated in Tables 5.4 and 5.5).

The findings stated above on how 'plural active' types differ with respect to the generation of the synergistic effects of social networks were further confirmed by an analysis of data collected via the on-line survey. Academics were asked to state to what extent they agree with two statements (i.e. 'I have strong personal contacts with industrial partners' and 'I'm a member of a team(s) that has (have) contacts with industry') on a Likert scale of 1–4 (i.e.1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). The analysis revealed that a significant majority of triple-role academics, in comparison to double-role and single-role academics, had very strong personal contacts with industrial partners X^2 (6, $N = 296) = 54.447$, $p = 0.000$. Similarly, it was found that a significantly higher percentage of triple-role academics, in comparison to double-role and single-role counterparts, were members of a team(s) that had very good contacts with industry X^2 (6, $N = 276) = 43.917$, $p = 0.000$. However, these findings are not surprising when considered the difference among academic entrepreneurs in terms of scale of their operations.

Based on the analysis illustrated above, it could be concluded that the synergistic effects of social network were capitalised on by academics in order to overcome resource barriers. The analysis also revealed that there was an association between the 'plural activity' of academics and the synergistic effects of social network in which carrying out a higher number of diverse activities (e.g. triple-role academics) delivered more synergistic effects than carrying out a limited number of similar activities (e.g. single-role academics).

5.2.2 Synergistic Effect: Knowledge and Skills

In-depth interviews revealed that engaging in teaching-related entrepreneurial activities had assisted academics to understand the needs of industry, while carrying out research-related activities and company creation had enabled them to develop knowledge and skills on business management, entrepreneurship, and applied research. Furthermore, engaging in joint research projects and forming joint ventures with industry had facilitated the exchange of tacit knowledge. Hence, the 'plural activity' of academics generated the positive synergistic advantages regarding knowledge and skills management since they used knowledge and skills developed by engaging in one activity to carry out other entrepreneurial activities elsewhere. A further analysis was carried out to investigate whether the levels of synergistic effects of knowledge and skills varied in relation to the complexity of 'plural activity' types.

An enhanced understanding of the needs of industry, which was developed by engaging in external teaching, had been used by single-role academics when conducting training and seminars for industry personnel. However, single-role academics, when compared to double-role and triple-role colleagues, were found to generate relatively less synergistic effects in terms of knowledge and skills. In-depth interviews revealed that double-role academics made use of their new knowledge to identify and capitalise on opportunities for several entrepreneurial engagements. For example, one double-role academic mentioned:

> I was working in industry on a secondment and that had resulted in me understanding industrial culture and developing business and management skills. After the secondment, I realised the potential for collaborating with industry and started a number of collaborative projects which were completed with a great success. I believe that my experience in working in industry immensely helped me in identifying and engaging in these activities.

In a similar vein, both double-role and triple-role academics mentioned that research-based consultancy, the development of products and/or processes with potential for securing patents, and joint research projects helped them understand industrial culture and improve their applied research and business management knowledge and skills, which were then capitalised on and used to engage in other activities. Furthermore, knowledge and skills gained by engaging in teaching- and research-related activities had positive impacts on the company creation process developed by triple-role academics since new knowledge and skills facilitated the identification of opportunities and the acquisition of financial and infrastructural resources. Moreover, company creation enabled triple-role academics to further develop business management, entrepreneurial, applied research, and market-related knowledge and skills, which had been additionally beneficial when identifying, and capitalising on, opportunities to engage in further teaching- and research-related activities. Hence, the synergistic effect of knowledge and skills was one of the reasons why triple-role academics engaged in a higher number of teaching- and research-related activities than single- and double-role academics (as illustrated in Tables 5.4 and 5.5). For instance, two triple-role academics stated:

> now I know where to go and what to do when I need more money
>
> after forming the company I get more opportunities for consultancy…I feel that in comparison to early stages, I can understand them (industry) very well and provide a better service.

The findings stated above on how 'plural active' types differ with respect to the generation of the synergistic effects of knowledge and skills were further confirmed by the analysis of data collected via the on-line survey. It was revealed that triple-role academics had significantly higher levels of business management skills X^2 $(6, N=278)=10.718, p=0.097<0.1$ and entrepreneurial skills $X^2(6, N=276)=34.426$, $p=0.000$ in comparison to single-role and double-role counterparts. These findings are in line with Westhead et al. (2005), who have stated that portfolio entrepreneurs receive additional advantages through their ability to capitalise on knowledge and skills acquired through diverse engagements.

Based on the analysis illustrated above, it could be concluded that the synergistic effects of knowledge and skills were capitalised on by academics in order to overcome resource barriers. The analysis also revealed that there was an association between the 'plural activity' of academics and the synergistic effects of knowledge and skills in which carrying out a higher number of diverse activities (e.g. triple-role academics) delivered more synergistic effects than carrying out a limited number of similar activities (e.g. single-role academics).

5.2.3 Synergistic Effect: Input–Output Flow

It was also evident that 'plural activities' had made it possible for academics to use the outputs of one activity as inputs for another, which generated additional synergistic effects from these input–output flows. For example, the outputs of carrying out applied research and assisting small business owners were used by triple-role academics as inputs for company creation. This was stimulated by their need to overcome certain barriers in the environment, such as inability to find appropriate industrial partners to commercialise innovations, the lack of opportunities to sell intellectual property rights, and weak intellectual property right laws. Hence, the synergy of input–output flow enabled triple-role academics to overcome these constraints.

A similar flow was also observed in a number of consultancy projects, where the outputs of an initial consultancy were used as inputs to subsequent ones. Similarly, the outputs of short-term joint research projects with industry had been used as inputs for long-term projects. Furthermore, coursework developed for one teaching-related activity was used for numerous other teaching-related activities. Therefore, it could be stated that all the ‘plural activity’ types had generated the synergistic effects of using the outputs of one activity as inputs for others, which in turn was useful to overcome resource constraints. However, sufficient evidence was not available to gauge which type of ‘plural activity’ caused the greatest number of, or best, input–output flows.

5.2.4 Synergistic Effect: Physical Resource

The above analysis of the three types of synergistic effects, namely, social networks, knowledge and skills, and input–output flows, revealed that academics made use of these synergistic effects to overcome resource barriers. The analysis of data gathered via in-depth interviews further revealed that resources acquired by engaging in one entrepreneurial activity were used to engage in other activities, which generated the synergistic effects of physical resources. A further analysis was carried out to investigate whether the amount of synergistic effects generated with respect to physical resources varied, depending on the complexity of ‘plural activity’ types.

Since universities receive limited funding from the government and offer free undergraduate education, clearly, they are financially constrained. The all three academics contributed to ameliorating financial constraints since a portion of additional income gained from engaging in each activity obtained by the universities was reinvested in order to carry out further activities, which had generated financial resource synergies between activities. However, apart from the synergistic effects of financial resources, the engagements of single-role academics were not reported to generate other types of physical resource synergies. Conversely, the engagement of double-role and triple-role academics caused the generation of different types of physical resource synergies between activities. For instance, one double-role academic entrepreneur stated:

> The funding we acquired from industry and international bodies by carrying out consultancy and other research projects had resulted in improving resources such as lab equipment, chemicals, stationary, computers, printers, photocopy machines, and buildings…. When we prepare budgets we always try to include elements to improve resource status of the university………the development of these facilities was important to engage in more activities, which bring additional resources.

The above quotation illustrates how double-role academics have made use of entrepreneurial engagements to improve infrastructural and financial resources of their universities, which were then used to carry out other teaching- and research-related activities. Another double-role academic entrepreneur stated:

> I have expertise in ‘designing and implementing infrastructure development projects’ and my project partner who is working in company ‘y’ (which works on environment and conservation related aspects) has expertise in ‘risk assessment’. These are complementary (with respect to rural development projects)……his expertise and industrial exposure complement with my academic background. I find that working with him allows me to secure more external project funds…………I also get the opportunity to make use of their lab.

This quotation shows how double-role academics have entrepreneurially overcome human (high skilled) and technological resource scarcities and subsequently used these resources to engage in other activities, which generated synergies between activities.

In-depth interviews further revealed that due to university 'red tape', such as bureaucracies, inefficient financial services, and restrictive rules, it was not possible to engage in competitive bidding to secure consultancy projects and to carry out research-related activities efficiently. Furthermore, government regulations in Sri Lanka do not permit universities to establish profit-making companies. Therefore, triple-role academics had entrepreneurially introduced several mechanisms by which to overcome these institutional barriers. One of such strategies was to establish independent, external companies owned by academics, but physically located at their universities, by paying rent for the use of the location and other resources. Since the companies were owned by academics and not by the universities, they were registered as independent profit-making entities, which improved company growth. Furthermore, these companies had their own (efficient) staff, responsible for interacting with industry, which enabled academics to engage in competitive bidding and meet industry requirements efficiently. Additionally, triple-role academics made use of resources in these academic 'spin-off' companies (e.g. new equipments and facilities – infrastructural and technological resources, efficient staff – human resources, and profits – financial resources) to engage in teaching- and research-related activities. Furthermore, it was reported that some of the spin-off companies had contributed to 'departmental funds' (i.e. financial resources) which were used to improve the resource status of the department (e.g. infrastructural, technological, and human resources) and in turn to engage in teaching- and research-related activities. As explained above, triple-role academics were able to generate a higher amount of physical resource synergies than double-role and single-role colleagues, which was one of the reasons why triple-role academics engaged in a higher number of teaching- and research-related activities than the other two (as illustrated in Tables 5.4 and 5.5).

Based on the above analysis, it could be concluded that there is an association between the 'plural activity' of academics and the increased synergistic effects of physical resources in which carrying out a higher number of diverse activities (e.g. triple-role academics) had generated more physical resource synergies than engaging in a limited number of similar activities (e.g. single-role academics).

Although triple-role academics, who engaged in a higher number of diverse activities, generated more synergistic effects in terms of social networks, knowledge and skills, and physical resources than single- and double-role ones, it was revealed that triple-role academics would not have been able to carry out their activities successfully, without the support received from double-role and single-role colleagues. It was evident that three types of academics play different but dependent roles. For example, triple-role academics had engaged in establishing postgraduate institutes, introducing new postgraduate courses, establishing joint research labs, and being the principal investigators of international and industrial funding opportunities. Single-role colleagues, in collaboration with other types of academic entrepreneurs, taught on postgraduate programmes and conducted training and seminar sessions for industry. Similarly, double-role academics, in addition to carrying out teaching-related activities, engaged in research projects and provided consultancy services using resources made available by companies formed by triple-role counterparts (e.g. joint research labs, spin-off companies, and university commercial centres).

6 Conclusions

6.1 The 'Plural Activity' of Academic Entrepreneurs: An Emergent Strategy to Extract Value from Resource-Constrained Environments

Based on the above analysis, it could be stated that resource constraints do not totally inhibit academic engagement in entrepreneurial endeavour in a resource-constrained environment, but academics entrepreneurially overcome various resource barriers. Therefore, the first null proposition, which stated that being entrepreneurial is not a means of overcoming resource barriers in a resource-constrained environment, is rejected. The analysis further revealed that academics were heterogeneous in terms of the nature of their entrepreneurial engagements. Those who had engaged in a higher number of diverse activities (e.g. triple-role academics) were able to overcome resource barriers to a greater extent by capitalising on a relatively high level of synergistic effects generated by their engagements than those who had engaged in a limited number of similar activities (e.g. single-role academics). Therefore, the second null proposition, which asserted that there was no association between the 'plural activity' of academic entrepreneurs and the amount of synergistic effects generated in resource-constrained environments, is also rejected.

Since opportunities were not abundant, capitalising on every minute opportunity was of paramount importance for academics in Sri Lanka. Interestingly, this reflects the way that triple-role academics use resource constraints as a trigger to overcome resource conflicts (Van Dierdonck and Debackere 1988) by engaging in several entrepreneurial activities. Furthermore, companies created by triple-role academics generated a myriad of resources, which were of utmost importance in overcoming resource barriers. Hence, these findings do not agree with the literature which stated that diversifying into similar activities (e.g. diversifying only into teaching-related activities) generates more synergistic effects (since similar activities allows sharing common resources and competencies) (Markides and Williamson 1996). In a resource-constrained environment, there were not enough opportunities to diversify into similar activities extensively. Therefore, the creation of resources, and minimising resource conflicts by engaging in diverse activities, was more important than sharing common resources, which led to the argument that engaging in a higher number of diverse activities is an effective strategy for extracting value from a resource-constrained environment.

Since each academic entrepreneurial engagement demands substantial time commitment and effort (Wright et al. 2004), the investigation of how triple-role academics balance their engagements in a higher number of diverse entrepreneurial activities revealed differential roles played by different academics. While triple-role academics were the initiators and leaders of entrepreneurial activities, they received immense assistance from other types of academics (i.e. double-role and single-role academics) to carry out these activities. Accordingly, it could be stated that, in addition to synergies between activities at the individual level, there were synergies between different entrepreneurs at the university level. Triple-role academics were able to balance their engagements in a number of activities due to these synergies.

Based on the above analysis, a conceptual framework was developed to illustrate the entrepreneurial engagement of academics in a resource-constrained environment (Fig. 5.1). The main aim of this framework is to highlight synergies between entrepreneurial activities at the individual level and between different entrepreneurs at the university level, which are found to be of utmost importance to extract value from a resource-constrained environment.

6.2 Policy Implications and Future Research Avenues

The findings of this study seem to suggest that being entrepreneurial is a means of overcoming resource barriers in a resource-constrained environment, which has important policy implications for such environments, since introducing incentives and support mechanisms for entrepreneurship, as well as university-industry interactions, appears to improve resource status. It was also noted that academic entrepreneurship is a process in which academics start their entrepreneurial engagements by engaging in teaching-related activities, and then some of them subsequently diversify into research-related activities and company creation. The efficacy of this phenomenon suggests the need to nurture this process rather than merely pressurising academics to create business ventures.

The 'plural activity' of academics was found to be a strategy to extract value from a limited opportunity environment, since it generated synergies between activities. Hence, encouraging academic entrepreneurial diversification should be a strategy adopted by universities in resource-constrained environments. It is also worth noting that the amount of synergistic effects generated varied depending on the complexity of the 'plural activity' of academics, in which diversifying into a higher number of diverse activities was found to generate more synergistic effects than diversifying into a limited number of similar activities. However, it was also found that, at a university level, there were synergies between entrepreneurs who adopt both these 'plural activity' types. This underlines the importance of having different and clear role identities (Jain et al. 2009) by which universities might extract value from a resource-constrained environment. Hence, it is a future research objective to investigate what is the best combination of 'plural activity' types that a university should have in order to ensure achieving optimum benefits from academic enterprise.

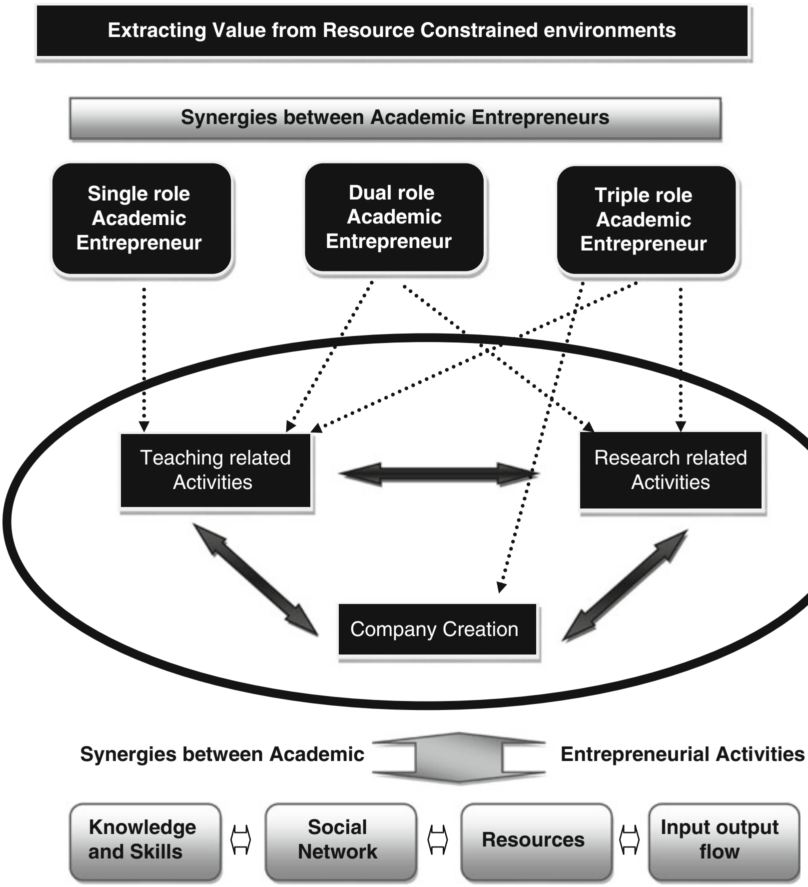

Fig. 5.1 Academic entrepreneurship: an emergent strategy to extract value from resource-constrained environments

Furthermore, this study has revealed that, in addition to the direct contribution of academic companies, which is the generation of profits, these companies provide a myriad of other indirect benefits such as improving the resource status of universities, enhancing opportunities to engage in other entrepreneurial activities, and overcoming institutional inefficiencies. This highlights the importance of taking into account both direct and indirect benefits of academic companies when valuing their worth.

Even though synergistic effects explain the extent of diversification, and the ways of overcoming resource barriers, this chapter did not address extensively why some academics decide to be single- or double-role academic entrepreneurs. In this context, it might be argued that there may be several other micro, meso, and macro level factors that explain what leads academics to adopt different ‘plural activities’, which will be of future research interest. Since this research was performed in a resource-constrained context, its replication in other contexts would allow more robust theory development via wider empirical comparison.

References

Adesola AO (1991) The Nigerian university system: meeting the challenges of growth in a depressed economy. Higher Educ 21:121–133

Agrawal A, Henderson R (2002) Putting patents in context: exploring knowledge transfer from MIT. Manage Sci 48:44–60

Aldrich HE, Fiol CM (1994) Fools rush in? The institutional context of industry creation. Acad Manage Rev 19:645–670

Alexander K, Andenas M (2008) The world trade organization and trade in services. Koninklijke Brill NV, Leiden

Alsos GA, Ljunggren EA, Pettersen LT (2003) Farm-based entrepreneurs: what triggers the start-up of new business activities? J Small Bus Enterprise Dev 10:435–443

Ambos TC, Makela K, Birkinshaw J, D'Este P (2008) When does university research get commercialized? Creating ambidexterity in research institutions. J Manage Stud 45:1424–1447

Arber S (2001) Designing Samples. In: Gilbert N (ed) Researching social life, 2nd edn. Sage, London, pp 58–82

Armstrong JS, Overton TS (1977) Estimating nonresponse bias in mail surveys. J Mark Res 16:396–402

Birley S (1985) The role of networks in the entrepreneurial process. J Bus Venturing 1:107–111

Bisbe J, Batista-Foguet JM, Chenhall R (2007) Defining management accounting constructs: a methodological note on the risks of conceptual misspecification. Account Organ Soc 32:789–820

Black, P. 1989. A Little Help from Her Friends. Venture, July, 52-58

Clarysse B, Wright M, Lockett AV, de Velde E, Vohora A (2005) Spinning out new ventures: a typology of incubation strategies from European research institutions. J Bus Venturing 20:183–216

Claude RP, Weston BH (2006) Human rights in the world community: issues and action. University of Pennsylvania Press, Pennsylvania

D'Este P, Patel P (2007) University–industry linkages in the UK: what are the factors underlying the variety of interactions with industry? Res Policy 36:1295–1313

D'Este P, Perkmann M (2011) Why do academics engage with industry? The entrepreneurial university and individual motivations. J Technol Trans 36:316–339

Daniels G, Hofer C (1993) Characteristics of successful and unsuccessful entrepreneurial faculty and their innovative research teams. In: Churchill N, Birley S, Bygrave W, Doutriaux J, Gatewood E, Hoy F, Wetzel W (eds) Frontiers of entrepreneurship research. Babson College, Wellesley, pp 598–600

Di Gregorio D, Shane S (2003) Why do some universities generate more start-ups than others? Res Policy 32:209–227

Downward P, Mearman A (2007) Retroduction as mixed-methods triangulation in economic research: reorienting economics into social science. Cambridge Journal of Economics 31:77–99

Etzkowitz H, Leydesdorff L (2000) The dynamics of innovation: from National Systems and Mode 2 to a Triple Helix of university–industry–government relations. Res Policy 29:109–123

Etzkowitz H, Webster A, Gebhardt C, Cantisano Terra BR (2000) The future of university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. Res Policy 29:313–320

Eun J-H, Lee K, Wu G (2006) Explaining the "University-run enterprises" in China: a theoretical framework for university–industry relationship in developing countries and its application to China. Res Policy 35:1329–1346

Fleiss JL, Zubin J (1969) On the methods and theory of clustering. Multivar Behav Res 4:235–250

Franklin SJ, Wright M, Lockett A (2001) Academic and surrogate entrepreneurs in university spin-out companies. J Technol Trans 26:127–141

Friedman J, Silberman J (2003) University technology transfer: do incentives, management, and location matter? J Technol Trans 28:17–30

Gilad B, Levine P (1986) A behaviour model of entrepreneurial supply. J Small Bus Manage 24:45–54

Glassman AM, Moore RW, Rossy GL (2003) Academic entrepreneurship: views on balancing the acropolis and the agora. J Manage Inq 12:353–374

Goldfarb B, Henrekson M (2003) Bottom-up versus top-down policies towards the commercialization of university intellectual property. Res Policy 32:639–658

Griffith-Jones S, Bhattacharya A, Antoniou A (2003) Enhancing private capital flows to developing countries in the new international context. Economic Affairs Division of the Commonwealth Secretariat, London

Gupta AK, Govindarajan V (1986) Resource sharing among SBUs: strategic antecedents and administrative implications. Acad Manage J 29:695–714

Hart MM, Stevenson HH & Dail J (1995) Entrepreneurship: a definition revisited. In: Bygrave WD, Bird BJ, Birley S, Churchill NC, Hay M, Keelry RH & Wetzel Jr., WE (Eds.) Frontiers of Entrepreneurship Research: Proceedings of the Fifteenth Entrepreneurship Research Conference. Babson Park: Babson College

Henderson R, Jaffe A, Trajtenberg M (1998) Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988. Rev Econ Stat 80:119–127

International Monetary Fund (2011) Government finance statistics yearbook. http://www.imf.org/external/data.htm. Accessed 25 July 2011

Jain S, Georgeb G, Maltarichc M (2009) Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. Res Policy 38:922–935

Jones-Evans D (1997) Universities, technology transfer and spin-off activities: academic entrepreneurship in different European regions. Targeted Socio-Economic Research Project No 1042, University of Glamorgan. http://www.hm-treasury.gov.uk/d/utheschoolforbusinregiondeveld-jones-evans130203.pdf

Jones-Evans J, Klofsten M (2000) Comparing academic entrepreneurship in Europe: the case of Sweden and Ireland. Small Bus Econ 14:299–309

Ketchen DJ, Shook CL (1996) The application of cluster analysis in strategic management research: an analysis and critique. Strateg Manage J 17:441–460

Kodithuwakku SS, Rosa P (2002) The entrepreneurial process and economic success in a constrained environment. J Bus Venturing 17:431–465

Kwok WCC, Sharp DJ (1998) A review of construct measurement issues in behavioral accounting research. J Account Lit 17:231–254

Lam A (2005) Work roles and careers of R&D scientists in network organizations. Ind Relations 44:42–75

Laukkanen M (2003) Exploring academic entrepreneurship: drivers and tensions of university based business. J Small Bus Enterprise Dev 10:372–382

Levy PS, Lemeshow S (2008) Sampling of populations: methods and applications. Wiley, New Jersey

Louis KS, Blumenthal D, Gluck ME, Stoto MA (1989) Entrepreneurs in academe: an exploration of behaviours among life scientists. Adm Sci Q 34:110–131

Markides JG, Williamson P (1996) Corporate diversification and organizational structure: a resource-based view. Acad Manage J 39:340–367

Mars M, Rios-Aguilar C (2010) Academic entrepreneurship (re)defined: significance and implications for the scholarship of higher education. High Educ 59:441–460

Marsh HW, Hattie J (2002) The relation between research productivity and teaching effectiveness: complementary, antagonistic, or independent constructs? J High Educ 73:603–641

Mayer RJ, Schooman F (1993) An integrative model of organizational trust. Entrepreneurship Theory Pract 17:5–15

McMullan WE, Vesper KH (1987) Universities and community venture development: the spin-off phenomenon: the spirit of entrepreneurship. In: 32nd annual world conference international council for small businesses, Simon Fraser University (Burnaby), Vancouver British Columbia, pp 350–370

Menzies TV (2000) An exploratory study of university entrepreneurship centres in Canada: a first step in model building. J Small Bus Entrepreneurship 15:15–38

Monck C, Segal N (1983) University science parks and small firms. In: National small business conference, Durham University, Sept 1983

Mowery DC, Shane S (2002) Introduction to the special issue on university entrepreneurship and technology transfer. Manage Sci 48:5–9

Mowery DC, Sampat BN, Ziedonis AA (2002) Learning to patent: institutional experience, learning, and the characteristics of U.S. university patents after the Bayh–Dole Act, 1981–1992. Manage Sci 48:73–89

Nicolaou N, Birley S (2003) Academic networks in a trichotomous categorisation of university spinouts. J Bus Venturing 18:333–359

Radosevich R (1995) A model for entrepreneurial spin-offs from public technology sources. Int J Technol Manage 10:879–893

Rumelt RP (1982) Diversification strategy and profitability. Strateg Manage J 3:359–369

Samson KJ, Gurdon MA (1993) University scientists as entrepreneurs: a special case of technology transfer and high technology venturing. Technovation 13:63–71

Schartinger D, Schibany A, Gassler H (2001) Interactive relations between university and firms: empirical evidence for Austria. J Technol Trans 26:255–268

Schmoch U (1997) Indicators and the relations between science and technology. Scientometrics 38:103–116

Scott M, Fadahunsi A, Kodithuwakku S (2000) Tackling adversity with diversity. In: Birley S, Muzyka D (eds) Financial times: mastering entrepreneurship. The complete MBA companion in entrepreneurship. Pearson Education, Harlow

Shane S (2000) Prior knowledge and the discovery of entrepreneurial opportunities. Organ Sci 11:448–470

Shane SA, Stuart T (2002) Organizational endowments and the performance of university start-ups. Manage Sci 48:154–170

Shane S, Venkataraman S (2000) The promise of entrepreneurship as a field of research. Acad Manage Rev 25:217–226

Siegel DS, Waldman D, Atwater L, Link A (2004) Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J Eng Technol Manage 21:115–142

Storey DJ, Tether BS (1998) Public policy measures to support new technology-based firms in the European Union. Res Policy 26:1037–1057

Tashakkori A, Teddlie C (1998) Mixed methodology: combining qualitative and quantitative approaches. Sage, Thousand Oaks

Teddlie C, Yu F (2007) Mixed methods sampling: a typology with examples. J Mixed Method Res 1:77–100

The World Bank (2011) Hyperlink http://data.worldbank.org/%20%5bAccessed http://data.worldbank.org/ [Accessed on 10 April 2011]

Tijssen RJW (2006) Universities and industrially relevant science: towards measurement models and indicators of entrepreneurial orientation. Res Policy 35:1569–1585

Tsoukas H (1989) The validity of idiographic research explanations. Acad Manage Rev 14:551–561

Ucbasaran D, Howorth C, Westhead P (2000) Habitual entrepreneurs: human capital, opportunity search and learning. Paper presented at the Babson-Kauffman conference, Babson College, Wellesley

United Nations Human Settlements Programme (2005) Financing urban shelter: global report on human settlements. Earth Scan, London

University Grant Commission Sri Lanka (2010) http://www.ugc.ac.lk/. Accessed 13 Mar 2011

University Gtant Commission of Sri Lanka (2011) University Statistics. University Grant Commission Sri Lanka, Available at http://www.ugc.ac.lk/ [Accessed on 10 February 2011]

Van Dierdonck R, Debackere K (1988) Academic entrepreneurship at Belgian Universities. R&D Manage 18:341–353

Venkataraman S, MacMillan I, McGrath R (1992) Progress in research on corporate venturing. In: Sexton DL, Kasarda J (eds) The state of the art of entrepreneurship. PWS-Kent, Boston, pp 487–519

Von Bertalanffy L (1972) The history and status of general systems theory. Acad Manage J 15:407–426

Westhead P, Ucbasaran D, Wright M (2005) Decisions, actions and performance: do novice, serial and portfolio entrepreneurs differ? Int Small Bus J 43:393–418

World Bank (2010) Global economic prospects and the developing countries. World Bank Publications, Washington. http://data.worldbank.org/. Accessed 15 June 2011

Wright M, Birley S, Mosey S (2004) Entrepreneurship and university technology transfer. J Technol Trans 29:235–246

Yang PY, Chang Y, Chen M (2006) Factors nurturing academic entrepreneurship in Taiwan. J Enterprising Cult 14:267–290

Zhou YM (2011) Synergy, coordination costs, and diversification choices. Strateg Manage J 32:624–639

Chapter 6
Introducing the University of Applied Science in the Technology Transfer Process

Erik E. Lehmann and Alexander Starnecker

Abstract After WWII, the German economy rapidly increased, and is often described as the "Deutsche Wirtschaftswunder". Within a short period, Germany reached zero unemployment, and human capital became the critical factor and resource in shaping the economic growth. While the bottle neck full of blue collar workers was solved by an active immigration policy that attracted people from Italy, Turkey or Greece, the lack of white collar workers and engineers still remained. At this time, public universities were unable to provide the quantity of well-educated people particularly in engineering sciences. In particular, the high opportunity costs of time made public universities less attractive compared to starting a career in the industry right after dropping out of school. In the mid-1960s, the German government decided to adapt a well-known concept from the theory of the firm – division of labor - to provide high skilled employees. A new type of university was created, the so called Universities of Applied Sciences. Public Universities are focused on basic research, while Universities of Applied Sciences (UAS) provide the economy with applied research and education. While studies at public universities can exceed four to five years, the length of study at a UAS is mainly limited to 3 years (6 semesters). After the Bologna Reform, Bachelor and Master Programs of UAS and public universities are treated equally. In the last decade, this division of labor between UAS and public universities has reached an additional objective the technology transfer process. While the role of public universities and their role within the technology transfer processes is intensively studied (Hülsbeck, Lehmann, & Starnecker, forthcoming), the impact of UAS remains rather under researched. Although they are quite successful in their cooperation with the industry and are nevertheless another backbone in the university-industry relationships, only anecdotal evidence

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on this type of university exists. This paper tries to shed some light on this type of university which could be a role model in particular for countries and regions where small and medium sized firms dominate the industrial landscape as they do in Germany.

1 Introduction

The central role of universities within the technology transfer process is unquestioned. Regions and firms surrounding universities heavily rely on the knowledge created in universities to further develop themselves. Although there exists empirical evidence highlighting the importance of research intense universities and their role in promoting and fostering regional development (Audretsch et al. 2005; Audretsch and Stephan 1996), these studies cover only a small amount of institutions in the higher educational sector: public universities. In contrast, applied universities (Universities of Applied Sciences) are neglected in their impact and importance as a source of spillover and technology transfer (BMBF 2004; Krause 2005). Although public universities (Universitäten) and Universities of Applied Sciences (Fachhochschulen) both belong to the higher educational sector, they differ in several aspects. First, only German Universities have the right to pursue a doctorate degree and to promote for professor. Second, research and teaching in universities is dominated by theoretical approaches, while Universities of Applied Science (UAS) are more practical oriented. Third, in contrast to public universities, UAS are not solely located in the bigger German cities.

The linkage between regional development and universities has been proven for universities in the USA, Germany, and other countries (i.e., Audretsch et al. 2005; Audretsch and Stephan 1996); however, little can be found on UAS. Among other reasons, the reason for this linkage is geographical proximity. Although there is no doubt about higher educational institutes influencing regional development (Florax 1992), not every survey finds statistically significant influences (Anselin et al. 1997). Besides analyses confirming positive impact (i.e., Harding 1989; Malecki 1986; Rees and Stafford 1986), there are some providing no significance (i.e., Beeson 1993; Malecki and Bradbury 1992). Beise and Stahl (1999) is one of the first studies including UAS in their analyses, by asking firms to name useful knowledge resources choosing from universities, UAS, and research institutes. An estimated 40% of the firms that considered the university a useful source were located within a range of 75 km of the university named. In contrast, an estimated 80% of firms naming UAS as useful knowledge resource were within the same range. Proximity seems to be a crucial factor of success for UAS.

In addition, proximity means UAS also have to adjust their education to the special needs required in the region (Fritsch et al. 2007), i.e., the "Hochschule Aalen." Close to this UAS is the headquarters of Zeiss AG, a company employing almost 25,000 people around the world leading in ophthalmic solutions. To address the needs of this company, the UAS in Aalen introduced programs focused on

Table 6.1 Higher education institutes

Higher education institutes (366)	
Universities	109
State owned	75
Owned by church	11
Private	7
Educational	6
Others	10
Art and music colleges	55
Universities of Applied Science	202
State owned	104
Owned by church	21
Private	77

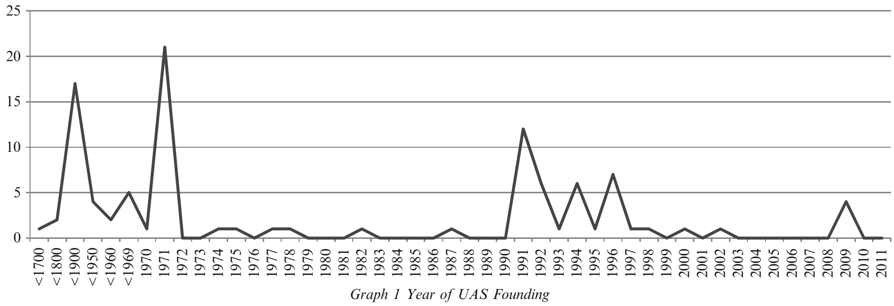
Source: German Rectors' Conference (2011)

ophthalmic optics. In summary, the founding of the UAS and the resulting separation between UAS and public universities lead to at least three major advantages: (1) higher education is more specialized resulting from the division of labor—universities focused on basic research, UAS on applied sciences; (2) the competition between higher educational institutions increases; and (3) peripheral location of these institutions improves geographical proximity to firms.

Unfortunately, the potential of UAS is still underestimated (Hamm and Wenke 2002). To improve this circumstance, this study tries to shift the lenses toward UAS as an important link within the technology transfer process. By analyzing UAS, we introduce a unique German institution to the discussion on knowledge transfer. In contrast to universities who are mainly focused on basic research, UAS are specialized more practically and should therefore be more responsible for enhancing technological development and process innovations than public universities. Although UAS have this assignment, there has hardly been any research analyzing their influence on regional development. To fill this gap, this chapter is arranged as follows: first, we briefly introduce UAS. Second, our dataset is described, followed be analyses providing first insights to the functionality of UAS and their technology transfer processes.

2 The Case of Universities of Applied Science

The Universities of Applied Science (UAS) in their current form of organization were founded in 1969 (BMBF 2004). The intention of this higher educational institution is to offer more practical-oriented studies. In this study, we analyze 100 UAS (see also Table 6.1). Of those 100 UAS around, one third (31) existed before 1969. They have their origin in technical schools, academies for engineers, etc. (BMBF 2004). The first immense period of UAS founding was in 1971, when more than one fifth (21) of the UAS were established. Between 1991 and 1996, right after the reunion of Germany, another 33 UAS were founded, especially in Eastern Germany



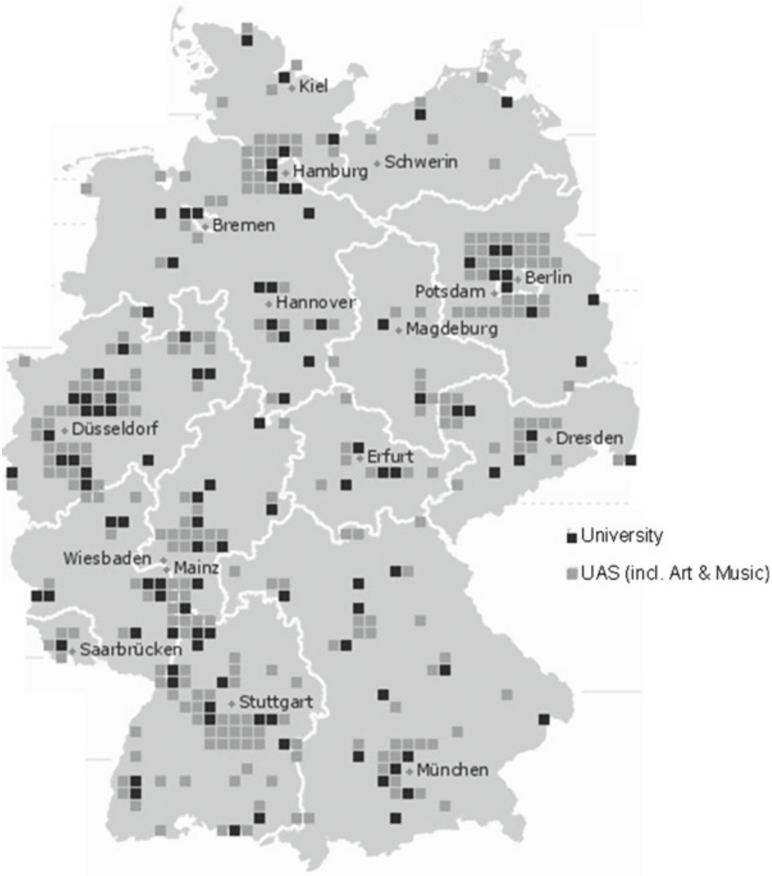
Graph 6.1 Year of UAS founding

to help quickly increase the educational level in the former communist country (BMBF 2004). Besides those major periods, only a few UAS have been established (see also Graph 6.1). Since the reunion of Germany, UAS are established to bring higher education to regions away from the bigger German cities, where they are believed to increase the living standard.

Among others, there are three major structural differences between public university and the UAS. In contrast to the university, the UAS has no means to confer a doctorate and to promote for professor (BMBF 2004; Lehmann and Starnecker 2011). Therefore, the UAS is less attractive for scientists to be employed as research fellows. In conclusion, a UAS consists basically of professor, students, and administration, making basic research projects less feasible. In addition, on the one hand, professors at UAS are contracted to put twice as much time in teaching per week than professors employed at a German University. On the other hand, 60% of the working hours of university professors are intended for research (BMBF 2004). In summary, the structural differences hint at the fact that a UAS is not designed to contribute to basic research.

Since UAS are not meant to contribute to basic research, like universities or private research institutes (i.e., Fraunhofer Institute) do, UAS have to be successful in practical-oriented education. This is supported by Krause (2005), finding that two thirds of all engineers graduate from a UAS. Engineers are most important especially in the sector of mechanical engineering. Due to the fact that around the world Germany is known for its skills in mechanical engineering, the education of engineers is crucial for the success of the German economy. In addition to the education of one of the major pillars of the German economy, UAS also show the highest spin-off activity among other research institutes (Krause 2005). While technology transfer processes are already established in universities (Hülsbeck et al. forthcoming), technology transfer offices are just starting to be implemented in the UAS structures. Despite the missing structures, UAS are succeeding in supporting start-ups based on knowledge generated in the UAS (Krause 2005). In conclusion, the UAS are fulfilling their task not only by offering a practical-oriented education but also by facilitating technology transfer.

Although there are higher numbers of UAS than universities located in Germany, almost 1.4 million students are educated in German Universities, while only 650,000



Graph 6.2 Distribution of universities and UAS in Germany (BMBF 2004)

students in UAS (Fritsch et al. 2007). In conclusion, 66% of all students made their decision in favor of the university, and 30% decided to study at a UAS. There are two major reasons for this observation. First, public universities are located in bigger cities and therefore are addressing more potential students (Fritsch et al. 2007). Second, universities have higher capacities (Fritsch et al. 2007). The higher capacity is resulting from already discussed major structural differences. Universities employ research fellows that are also responsible for the education of the students. Since UAS do not have the rights to confer a doctorate and to promote for professor, research fellows are not attracted to UAS and teaching is done mainly by the professors employed.

While public universities are highly concentrated in large cities like Berlin, Munich, in other areas of high population density (i.e., Ruhrgebiet), UAS are more peripherally located (Graph 6.2). This means that also cities with only around 50,000 inhabitants are provided with a UAS and therefore get closer access to the higher education sector. Most of the studies analyzing the role of universities in the regional innovation system come to the conclusion that the proximity to a higher education institution positively influences regional characteristics as well as industrial performance (i.e., Anselin et al. 1997; Audretsch and Lehmann 2005; Audretsch and Stephan 1996; Beise and Spielkamp 1996; Feldman 1994; Glaeser et al. 1992). The positive effects of geographical proximity are often described by personal contacts between scientist and practitioners, leading to an informal technology transfer (Fritsch and Slavtchev 2007; Grimpe and Fier 2010; Link et al. 2007). The local distribution of UAS leads to close geographical proximity also to small- and medium-sized enterprises and thus should enhance informal technology transfer (Boettcher 2004; Link et al. 2007).

Krause (2005) highlights the importance of the UAS, especially for small- and medium-sized enterprise. The geographical proximity as well as the focus on applied science makes it more feasible for smaller firms to cooperate with the UAS instead of a public university. For example, Dziatzko et al. (2011) explain the need for an innovation manager in small- and medium-sized enterprises, whose responsibility is to put the innovation process into practice. Firms who cannot afford to employ an innovation manager could find a reliable partner in the UAS (Lehmann and Starnecker 2011). Unfortunately, to our knowledge, the contribution of UAS to the technology transfer process has been barely analyzed. The high spin-off activity of UAS (Krause 2005) hints at the potential of UAS. To add to the literature, we provide another factor accounting for technology transfer—the patenting activity.

3 Dataset

The German Rectors' Conference defines 366 higher educational institutions (German Rectors' Conference 2011). For our consideration, only the state-owned institutes are relevant, since education in Germany is a public good and not dominated by private institutions as in other countries (Table 6.1). Of 104 state-owned Universities of Applied Science (UAS), we excluded four,[1] which leads us to 100 UAS and 75 German Universities in our dataset.

In our dataset, we analyze the 100 UAS by their technology transfer performance, which is measured in patent applications between 1991 and 2008, filed at the German Patent and Trademark Office. Before 1991, Germany was divided into the Federal Republic of Germany (Western Germany) and the German Democratic Republic (Eastern Germany). Therefore, comparing data before 1990 would lead to a selection bias between Eastern and Western UAS. The innovation performance is controlled by the size, in terms of the number of professors of the UAS, and by the research

[1] The Alice Salomon Hochschule Berlin, since their main focus is pedagogical studies; the Hochschule der Polizei Hamburg, since their objective is to educate police men; the Hochschule fuer Gestaltung Schwaebisch Gmuend, focusing in art; and the Verwaltungsfachhochschule Wiesbaden, which is focused on studies in general administration.

performance, measured in research funding (Hornbostel 2001). Additional structural variables are the number of students, the amount of material expenditure, and the basic capital. This data is based on the year 2008 and is drawn from the German Federal Statistical Office (Statistisches Bundesamt 2010).

Regional characteristics are classified in labor market regions (LMR) defined in Eckey et al. 2006. In contrast to counties (Kreise), LMR include the commuter workforce and therefore better control for spillovers (Eckey et al. 2006). The regional characteristics are measured with the help of four variables: indication size (population in 2004), overall performance (gross domestic product in 2004), and innovation performance, divided in industry patents (years 2003–2005) and start-up activity (years 2003–2008). The data is extracted from GENESIS dataset of the German Federal Statistical Office. Unfortunately, the GDP could only be collected for 143 of the 150 LMR in Eckey et al. (2006)

4 Describing the University of Applied Science

In the history of Universities of Applied Science (UAS) in Germany, research is not the primary objective, although since 1985 applied research and development is defined as one of the tasks of UAS (BMBF 2004). Recently, the importance is growing. In Germany, not the central government but the local governments of the 16 states (Bundesländer) are in charge of deciding overall educational issues. This is why difference in the definition of the importance of research can be observed throughout Germany.

Although, based on the concept of division of labor, public universities and UAS are specialized in different types of research and teaching, comparing reveals further insight on the functionality (Table 6.2). First, public universities are bigger in all terms that are effected by size, like expenses funding, students, and professors. Second, not surprisingly, universities are older than UAS that had been established in 1969. Third, the funding structure differs a lot. While a very high percentage of almost 40% of funds for the average UAS are provided by the industry, only 2% come from the most important German research funding institute (Deutsche Forschungsgesellschaft, DFG). There are even UAS that get almost 100% of their funding from the industry. Funding from the DFG, which is also used as a proxy for research activity (Hornbostel 2001), is of great importance to the university, while even less than 75% of UAS receive less than 1% of their funding from the DFG. This displays and underlines the argument of the division of labor between UAS and universities.

To verify the impact of these structural differences on technology transfer performances, the number of patent applications between 1991 and 2008 of UAS is used as a proxy. Surprisingly, half of the UAS can be found in the Eastern Germany. This not only shows the importance of UAS for the development of the former communist part of Germany but also implies that those UAS have become serious competitors to their Western counterparts. However, size seems to matter. Patent applications per professor point out that for the years 2007 and 2008, the UAS holding the most

Table 6.2 Comparing the German University and the University of Applied Science

Variable	Obs.	Mean	Std. dev.	Min	Max	Median
University of Applied Science						
Personal expenses[a]	95	19,291	10,859	2,438	62,792	17,579
Impersonal expenses[a]	95	7,914	6,066	942	35,752	5,734
Third-party funding[a]	95	2,571	1,918	340	10,579	2,089
# Students	95	5,014	2,816	435	15,495	4,246
# Professors	95	128	71	15	386	115
Age[b]	100	30	13	2	42	40
% DFG funding	95	2	9	0	78	0
% Industry funding	95	39	23	0	99	36
DFG funding[a]	95	35	91	0	633	0
Industry funding[a]	95	1,050	1,188	0	7,117	703
University						
Personal expenses[a]	75	215,557	186,795	13,273	804,138	167,209
Impersonal expenses[a]	75	142,640	153,489	4,380	569,780	77,517
Third-party funding[a]	75	58,267	51,705	1,696	217,794	43,486
# Students	75	16,916	10,328	1,075	41,782	16,455
# Professors	75	257	147	30	655	245
Age[b]	75	175	189	8	625	65
% DFG funding	75	34	15	0	63	35
% Industry funding	75	21	12	0	59	21
DFG funding[a]	75	23,510	24,257	0	110,420	16,094
Industry funding[a]	75	12,360	14,402	0	74,679	8,716

[a]In 1,000 (year 2008)
[b]On the basis of year 2011

Table 6.3 Top 10 UAS in terms of patenting applications

UAS	# PA 91-08	East	PA/Prof[a]	Rank PA/prof
Jena	65	1	0.053	7
Hildesheim	63	0	0.031	16
Dresden	45	1	0.023	23
Kiel	43	0	0.072	3
Lausitz	38	1	0.091	2
Aix-la-Chapelle	34	0	0.021	25
Zittau/Goerlitz	34	1	0.000	83
Anhalt	30	1	0.046	9
Niederrhein	30	0	0.036	13
Dortmund	29	0	0.033	14

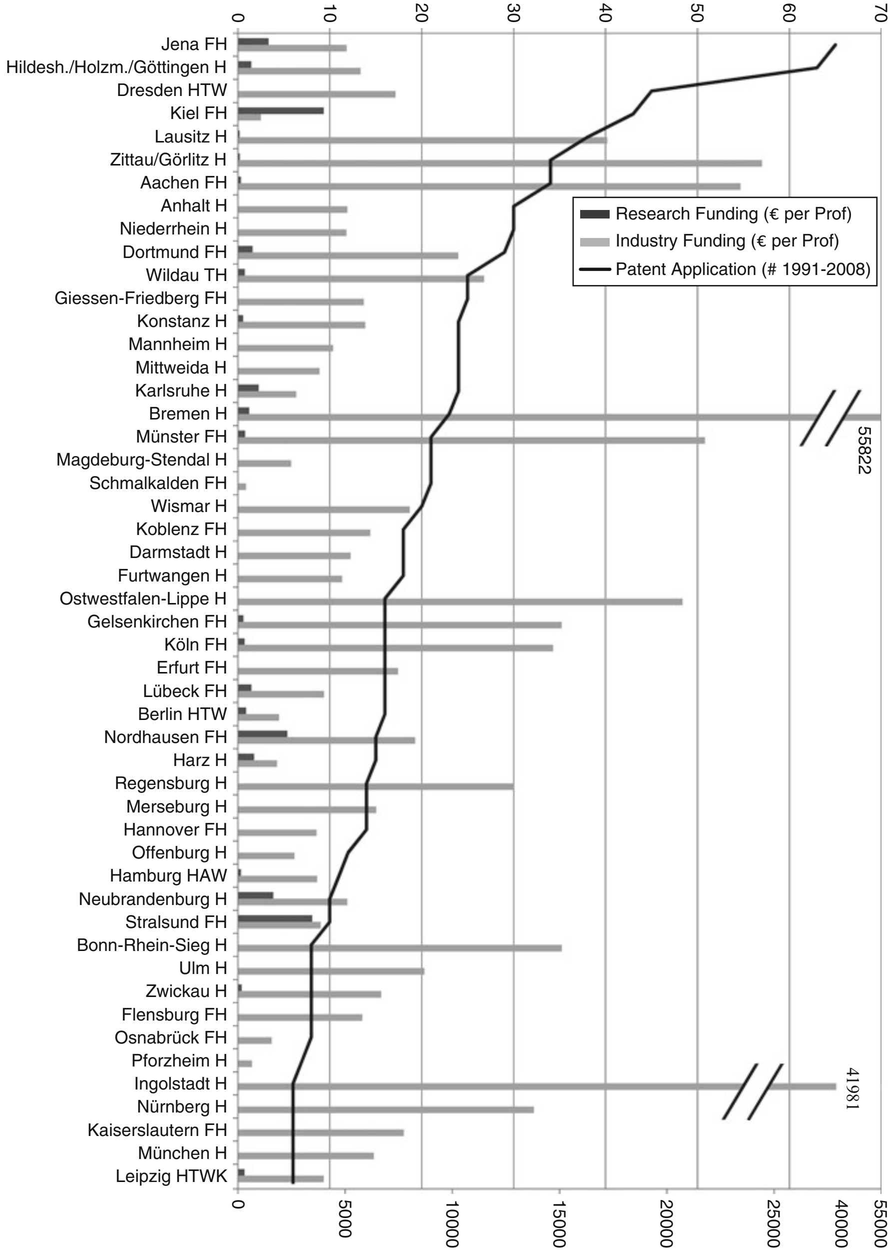
[a]Mean (2007–2008)

patent applications seem to be less successful when controlled for size. At least almost half of the institutions are also top 10 when it comes to patent applications per professor (Table 6.3).

An examination on how this patenting activity is concentrated along the UAS reveals that ten UAS account for 37.8% of the patenting activity of all German UAS. Those UAS, providing 411 patent applications from the 1,088 that can be associated with the UAS in our dataset, are listed in Table 6.3. In addition, Table 6.3 shows that 15.9 (23.3) % of patent applications are assigned to the top 3 (top 5) UAS, which hints at a high concentration of patenting activities (see also Graph 6.3).

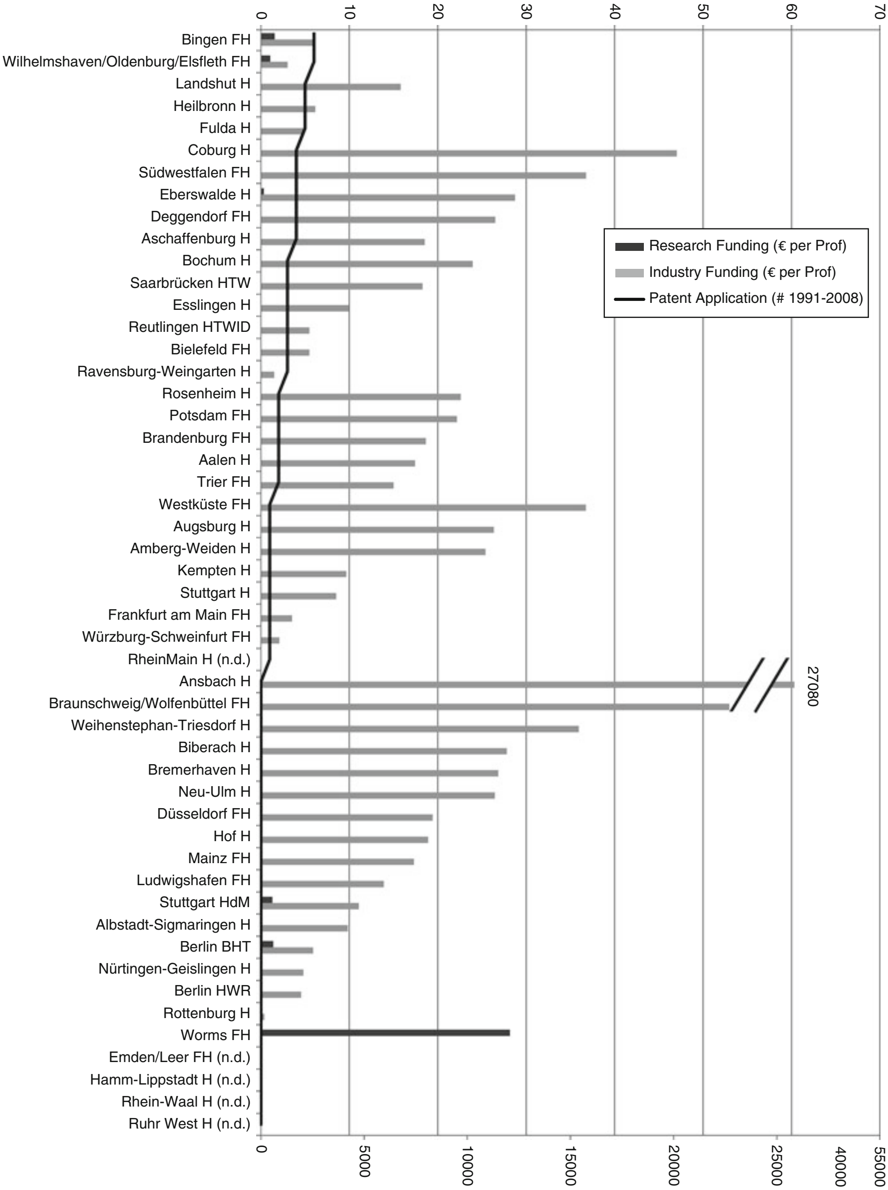
The linkage between public universities in Germany and their technology transfer performance has been examined in several studies (among others, Anselin et al. 1997; Audretsch et al. 2012; Audretsch and Lehmann 2005; Audretsch et al. 2005; Grimpe and Fier 2010; Link et al. 2007). Therefore, we shift the lenses to a further examination of the UAS being a unique institution and responsible for applied research and education. Graphs 6.3 and 6.4 show all UAS in our dataset sorted by the total number of patent applications from 1991 to 2008. As stated already in Table 6.3, the distribution is very concentrated. For a further explanation, two important factors explaining the orientation of the UAS are added—the amount of funding from the industry and the DFG.

The amount of research funding by the Germany Research Society (DFG) is often used as a proxy for research activity, since one has to signal research activity to get funding (Hornbostel 2001). In theory, more research potential should lead to more research and patenting activity. This could not be approved in Graph 6.3. While some UAS seem to follow this assumption, most of them do not. Consequently, more research potential does not always result in more research activity, which is not new at all. However, it can be observed that research activity is significantly higher in Graph 6.3, displaying the higher performing UAS. This leads to the assumption that higher research activity could positively influence patenting activity in certain circumstances. Compared to the industry funding, the funding of the DFG does not seem to make any difference. Industry funding is the major financial resource of UAS. However, a high variance can be observed implying that there is



Graph 6.3 Patenting activity of Universities of Applied Science (top 50)

no significant connection between the amount of industry funding and the technology transfer performance. This is proven by the fact that the top four UAS show a low amount of industry funding compared to the others. All in all, this is surprising, especially since one would expect that the amount of industry founding accounts for



Graph 6.4 Patenting activity of Universities of Applied Science (bottom 50)

the linkage between the UAS and the industry and therefore a better linkage is supposed to lead to a higher technology transfer performance.

There are four UAS that significantly exceed the others in terms of funding. The UAS in Bremen is mainly influenced by big companies like Daimler, Airbus, and EADS, who require for practical orientated experts. The high amount of industry funding of the UAS Ingolstadt is also due to the fact that the headquarters of Audi is located there. In addition, the public university of Ingolstadt is focused on social science. Therefore, the UAS is the only source for human resources required for their manufacturing processes. The UAS in Ansbach is close to companies like Siemens and MAN employing a high percentage of engineers. In contrast to these UAS and to all others, the UAS in Worms exceed all others by far in terms of getting funding from the DFG, which is also a signal for high research activities. The UAS in Worms is quite specialized by only having economics, tourism, and informatics departments, leading to the possibility of focusing on applied research in these fields.

In conclusion, there are structural differences between public universities and UAS in Germany resulting from the division of labor. Taking a closer look at UAS, it reveals that neither the linkage to the industry nor the research activity explains the number of patent applications made by a UAS. Therefore, regional difference might be another explanation.

5 Regional Differences

Literature shows that knowledge is not distributed equally throughout regions, even if they are all within the same national innovation system (Cooke 2001; Fritsch and Slavtchev 2007). While some regions in Germany seem to be more prosperous, others—mainly found in the former German Democratic Republic—show an increase of unemployment and a decrease of economic activities (i.e., Hunt 2006; Uhlig 2008). This is in line with our examination of the 150 labor market regions (Eckey et al. 2006) in Germany. Regions in Germany seem to be very heterogeneous not only in terms of population but also economic indicators. Hence, to control for the size of a region, we use only per capita data (Table 6.4).

Although controlled for size, the determinants of LMR seem to be quite heterogeneous. The variables indicating size, overall performance, and innovation performance show huge differences between the lowest and highest value. Surprisingly, the mean and median differ little, which leads to the conclusion that both sides of the mean are equally distributed and that there are not just a few over performing regions that increase the mean of the indicator. Almost 0.5 patents and 10 start-ups per 1,000

Table 6.4 Determinants of all labor market regions in Germany

Variable	Obs	Mean	Min	Max	Median
Population	150	549,453	63,580	4,442,769	312,523
GDP p.c.	143	25.18	15.78	44.48	25.52
Industry patents p.c.[a,b]	150	0.45	0.02	1.83	0.38
Start-ups p.c.[a,c]	150	9.87	6.80	14.75	9.56

[a]Multiplied by 1,000
[b]Sum 2003–2005
[c]Mean 2003–2005

Table 6.5 Testing differences between regions

	Two-sample *t*-test with equal variances			
	Population	GDP p.c.	Industry patents p.c.[a]	Start-ups p.c.[a]
LMR without UAS	258,626	24.09	0.40	9.57
LMR with UAS	810,829	26.17	0.49	10.15
Diff != 0	0.001	0.013	0.109	0.013

[1]Multiplied by 1,000

inhabitants seem to be an impressive number. This underlines the impression of Germany as being an innovation, enhancing country.

To verify whether or not the differences could be explained by the presence of a UAS, the regions where at least one UAS is located (79) are compared to where it is not (71). This is done via a two-sample *t*-test (with equal variances). Surprisingly, in Table 6.5, four variables show highly significant differences between these two groups, whereof the mean of the LMR with UAS is always higher. Once bending the rules a bit, industry patents per capita could also be regarded to show a significant difference between these groups, also with a higher mean for those including a UAS. Therefore, LMR with UAS seem to be significantly better endowed and higher performing.

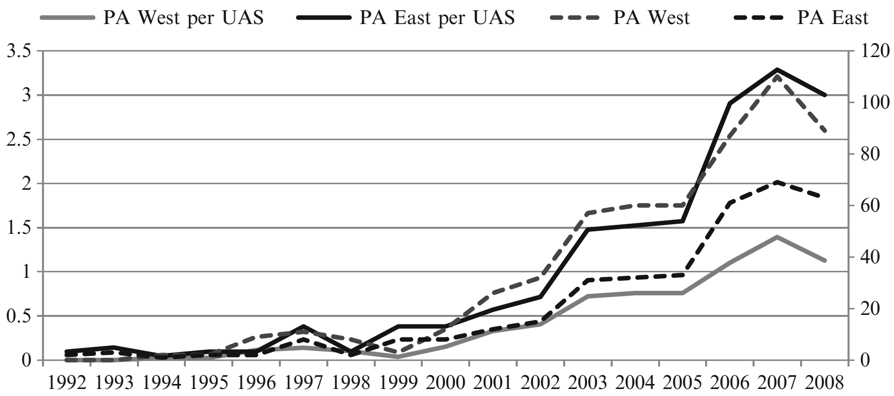
However, these positive implications could not account for the UAS without any doubt. The problem of endogeneity is quite obvious. UAS are located in regions with a high number of people living there and providing a higher overall performance per capita. Further research needs to be done to verify if those regions really developed better after the UAS was established or if the decision to build a UAS was based on the size and the economic power of the region. Another limitation of the study is that of those LMR, a high percentage also hosts a public university (Lehmann and Starnecker 2011). Although differences in population and GDP are hard to refer to the existence of a UAS, the number of patent applications of the industry as well as the number of start-ups in the region could be improved by a UAS. Due to their applied research, they could be believed to enhance regional innovation performance. Again, more research is required to verify these assumptions.

Earlier examinations, especially Table 6.3, showed that a closer look on the differences between UAS in Eastern and Western Germany is necessary. Table 6.6 reveals that no significant differences concerning the source and the amount of funding as well as the student professor ratio between the UAS in the two parts of Germany can be observed. While Eastern UAS are significantly younger, higher economic performance can be observed in the regions of Western Germany. Those differences and similarities are expected; since Western Germany is still better developed than Eastern Germany, there have been numerous founding of UAS after the reunion of Germany, and there is no reason why there should be a better student–professor ration in either of those parts. Surprising is the higher but not significant mean of research funding per professor in Eastern UAS and of course the immensely higher performance of UAS in Eastern Germany in terms of patent applications. This leads to a simple but impressive conclusion: although having access to almost the same amount of funds and being located in less economically developed regions, UAS in

Table 6.6 Comparison between UAS in Eastern and Western Germany

	Students per professor[a]	Research funding p. P[b]	Industry funding p. P.[b]	# Patents[c]	Age UAS[d]	Industry patents p. c.[e]	Start-ups p. c.[f]	GDP p. c.[g]
Western Germany	39.8	320	8,847	8.4	32.0	0.002	0.011	27.87
Eastern Germany	40.8	512	7,561	20.2	23.6	0.001	0.010	20.09
Diff !=0	0.645	0.573	0.544	0.001	0.006	0.001	0.004	0.001
	Observation: West 74/East 21				Observation: West 79/East 21			Obs. 79/17

[a]In 2008
[b]In € in 2008
[c]Sum of patents 1991–2008
[d]Based on year 2011
[e]Sum 2003–2005
[f]Mean 2003–2008
[g]In € 2004



Graph 6.5 Comparing TT performance of Eastern and Western UAS

Eastern Germany contra-intuitively over perform their Western counterparts in terms of patent applications as a proxy for technology transfer performance.

The importance of patents as a result of the linkage between the UAS and the industry increases. While being almost unobservable before the year 2000, the number of patent applications by the UAS has grown with high rates (Graph 6.5). This is in line with the implication of BMBF (2004) suggesting initiatives to increase the focus more on technology. Comparing Western and Eastern UAS again, one not surprisingly finds that UAS in the West have more patent applications. However, controlled for the number of patent application per UAS, the institutions in the East outperform the one in the West already since the mid-1990s. In addition, observing that the line of patent applications per UAS is more flat than the increase of the total number, while the lines of the Eastern UAS seem to be parallel, concludes that the increase in patenting performance is more smoothly distributed in the East, which is important for a long-term success.

To sum up, there are regional differences that could to some extent, be referred to the existence of a UAS. Additionally, UAS in the less economically developed Eastern part of Germany leave the impression to make more out of their resources than UAS in the West. After the reunification of German, policy makers started to find UAS in the Eastern part to support regional development by providing an applied higher education institution. In conclusion, it could be said that what has started as a development program has become a high-performing and technology transfer-enhancing institution.

6 Conclusion

The motivation behind the establishment of Universities of Applied Science (UAS) is simply the division of labor. While public universities in Germany are meant to focus on basic research, the UAS provide applied research and education. There are three major differences between universities and UAS. First, only universities have the right to confer a doctorate and to promote for professor. Second, research and teaching in universities is dominated by theoretical approaches, while UAS are more practical oriented. Third, in contrast to public universities, UAS are not only located in the bigger German cities. Although the importance of UAS is well known (BMBF 2004) and the number of UAS exceeded the number of universities (Lehmann and Starnecker 2011), their potential is still underestimated (Hamm and Wenke 2002).

However, right after the reunification of Germany, the government established several UAS in the former communist part to quickly improve the educational level and to develop the economy. In Eastern Germany, UAS are still located in areas with lower economic (GDP) and innovation (industry patents, start-ups) performance than their Western counterparts. However, they show similarities in the student professor ratio as well as in the source and amount of funding. Surprisingly, Eastern UAS outperform in technology transfer. This simply concludes that although having access to almost the same amount of funds and being located in less economically developed regions, UAS in Eastern Germany contra-intuitively outperform their Western counterparts in terms of patent applications as a proxy for technology transfer performance.

This chapter adds to the literature by shifting the lenses to a uniquely higher educational institution being unjustifiably underestimated. The results of this chapter provide first insights in the important role UAS play in the technology transfer process. First, regarding the sources of funding, besides the government, firms are the most important partner of UAS. Second, neither industry cooperation's nor research activity seems to explain the technology transfer performance. Third, UAS in Eastern Germany succeed in their objective of improving regional development and, by the way, outperform their Western counterparts, who are exposed to a way better economic structure.

However, this study only provides a first step into this field to improve the perception of UAS. Further research should address the incoming factors of the technology transfer process in UAS as well as the outcome before explaining the black box itself. Other studies could also look at comparable institutions in other countries to see if results could be generally applied to higher educational institutions like the UAS.

References

Anselin L, Varga A, Acs Z (1997) Local geographic spillovers between university research and high technology innovations. J Urban Econ 42(3):422–448

Audretsch DB, Lehmann EE (2005) Does the Knowledge Spillover Theory of Entrepreneurship hold for regions? Res Policy 34(8):1191–1202

Audretsch DB, Stephan PE (1996) Company-scientist locational links: the case of biotechnology. Am Econ Rev 86(3):641–652

Audretsch DB, Lehmann EE, Warning S (2005) University spillovers and new firm location. Res Policy 34(7):1113–1122

Audretsch DB, Hülsbeck M, Lehmann EE (2012) Regional competitiveness, university spillovers, and entrepreneurial activity. Small Bus Econ 39:587–601

Beeson PE (1993) The effects of colleges and universities on local labor markets. Rev Econ Stat 75(4):753–761

Beise M, Spielkamp A (1996) Technologietransfer von Hochschulen: Ein Insider-Outsider Effekt (Technology transfer from universities: an insider-outsider effect). ZEW discussion paper, Mannheim, pp 96–10
Beise M, Stahl H (1999) Public research and industrial innovations in Germany. Res Policy 28(4):397–422
BMBF (2004) Forschungslandkarte. Retrieved from June 11th 2012 http://www.bmbf.de/de/6574.php?LANG=DEU
Boettcher M (2004) Der regionale Wissens-und Technologietransfer einer neuen Fachhochschule. Das Beispiel des RheinAhrCampus Remagen. Rheinische Friedrich-Wilhelms-Universität, Bonn
Cooke P (2001) Regional innovation systems, clusters, and the knowledge economy. Ind Corp Change 10(4):945
Dziatzko N, Kielkopf M, Schittenhelm F, Streinwandt A (2011) Die Bedeutung des Innovationsmanagements in mittelständischen Unternehmen – eine empirische Untersuchung. In: Haubrock A, Rieg R, Stiefl J (eds) Zweite Aalener KMU-Konferenz – Beiträge zum Stand der KMU Forschung. Shaker Verlag, Aachen, pp 35–51
Eckey HF, Kosfeld R, Türck M (2006) Abgrenzung deutscher Arbeitsmarktregionen. Raumforschung und Raumordnung 64(4):299–309
Feldman MP (1994) The geography of innovation. Kluwer, Dordrecht
Florax R (1992) The university: a regional booster?: economic impacts of academic knowledge infrastructure. Avebury, Aldershot
Fritsch M, Slavtchev V (2007) Universities and innovation in space. Ind Innov 14(2):201–218
Fritsch M, Henning T, Slavtchev V, Steigenberger N (2007) Hochschulen, innovation, region: Wissenstransfer im räumlichen Kontext, vol 82. Edition Sigma, Berlin, pp 264
German Rectors' Conference (2011) Higher education institutions. http://www.hochschulkompass.de/en/higher-education-institutions.html. Retrieved 2 Feb 2011
Glaeser E, Kallal H, Scheinkman J, Schleifer A (1992) Growth in cities. J Polit Econ 100(6):1126–1152
Grimpe C, Fier H (2010) Informal university technology transfer: a comparison between the United States and Germany. J Technol Transf 35(6):637–650
Hamm R, Wenke M (2002) Die Bedeutung von Fachhochschulen für die regionale Wirtschaftsentwicklung. Raumforschung und Raumordnung 60(1):28–36
Harding CF (1989) Location choices for research labs: a case study approach. Econ Dev Q 3(3):223–234
Hornbostel S (2001) Third party funding of German universities. An indicator of research activity? Scientometrics 50(3):523–537
Hülsbeck M, Lehmann EE, Starnecker A (forthcoming) Performance of technology transfer offices in Germany. J Technol Transf, doi:10.1007/s10961-10011-19243-10966
Hunt J (2006) Staunching emigration from East Germany: age and the determinants of migration. J Eur Econ Assoc 4(5):1014–1037
Krause, P. (2005). Fachhochschulen und KMU – Innovationspartner für die Region Beiträge zur Hochschulpolitik 5/2005. Dokumentation der 34. Jahrestagung des Bad Wiesseer Kreises, pp 47–68
Lehmann EE, Starnecker A (2011) Wissenstransfer aus Hochschulen und regionale Entwicklung. In: Haubrock A, Rieg R, Stiefl J (eds) Zweite Aalener KMU-Konferenz – Beiträge zum Stand der KMU Forschung. Shaker Verlag, Aachen, pp 115–130
Link AN, Siegel DS, Bozeman B (2007) An empirical analysis of the propensity of academics to engage in informal university technology transfer. Ind Corp Change 16(4):641–655
Malecki E (1986) Research and development and the geography of high-technology complexes. In J. Rees (ed.) "Technology, Regions and Policy" Rowman and Littlefield, Totowa, NJ, pp. 51–74.
Malecki EJ, Bradbury SL (1992) R&D facilities and professional labour: labour force dynamics in high technology. Reg Stud 26(2):123–136
Rees J, Stafford HA (1986) Location: their relevance for understanding high-technology complexes. Rowman and Littlefield, Totowa
Statistisches Bundesamt (2010) Monetäre hochschulstatistische Kennzahlen 2008, vol Fachserie 11 Reihe 4.3. Statischtisches-Bundesamt, Wiesbaden
Uhlig H (2008) The slow decline of East Germany. J Comp Econ 36(4):517–541

Chapter 7
The Role of University of Central Florida in Regional Economic Development

Thomas O'Neal and Vernet Lasrado

Abstract A university can play an essential role in regional economic development, especially with respect to innovation and entrepreneurial. The University of Central Florida became a driver and partner to help diversify the economy from a region that was heavily dependent on tourism, hospitality and agriculture, sectors known for lower than average wages.

The University of Central Florida (UCF) has played a key role in the development and maintenance of a rich innovation and entrepreneurial ecosystem in the Orlando/Central Florida region. This rich innovation and entrepreneurial *ecosystem* has enabled an innovation-centric entrepreneurial culture to take root and mature in the Central Florida region. The development of this ecosystem was predicated on the integration of university research, university education, and the overall business development at the university and surrounding communities in the metropolitan area as shown in Fig. 7.1 below.

As a result of this rich ecosystem, an entrepreneur in the surrounding metropolitan area has access to a multitude of complimentary resources in one area that previously would have not been possible. This in turn leads to a viable environment for an entrepreneur to develop an idea into a successful business. Figure 7.2 illustrates all the elements that are available to support the local (Central Florida) entrepreneurs, i.e., the entrepreneurial network, as a result of the rich innovation and entrepreneurial ecosystem.

The UCF Business Incubation Program (UCFBIP) has played an important role in fostering this entrepreneurial culture. Since its inception in 1999, the UCFBIP has been a catalyst for many entrepreneurial initiatives in the form of programs to interest and involve the faculty, student body, and local community in entrepreneurial activities by

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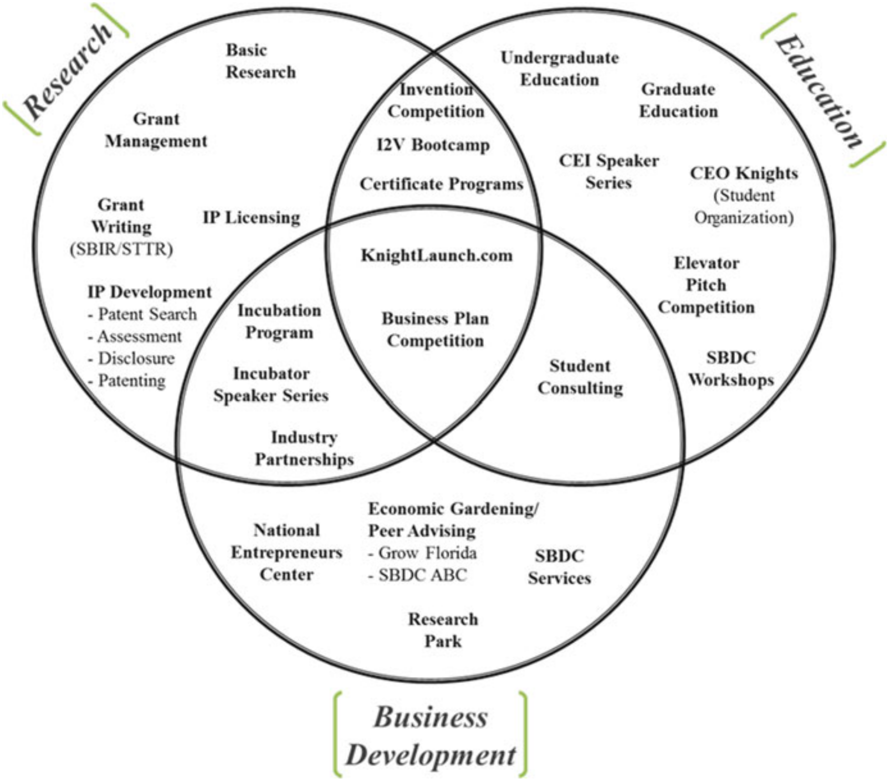

Fig. 7.1 Current UCF entrepreneurship and innovation ecosystem

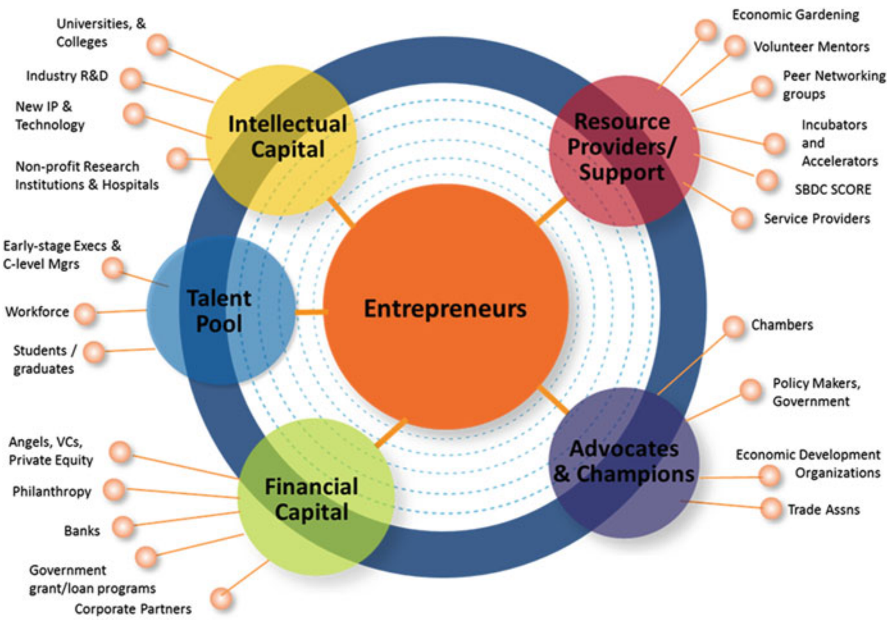

Fig. 7.2 Entrepreneurial network

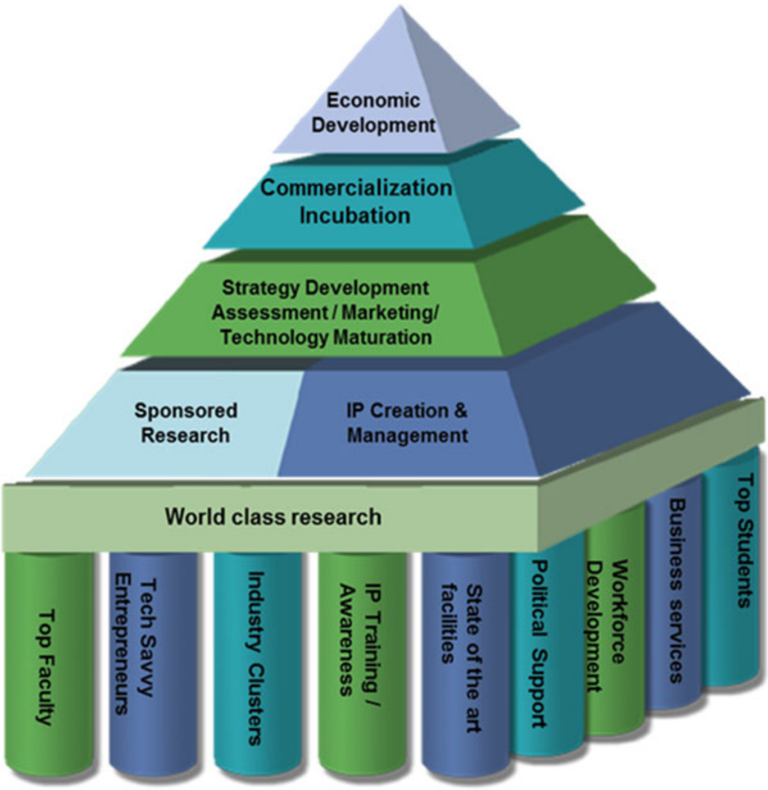

Fig. 7.3 Economic development pyramid

offering speaker series and graduate courses, developing business centers, hosting business plan competitions, etc. The UCF Venture Lab (VL) was formed to provide preliminary support to companies that may not be ready for incubation. The VL helps assess ideas, develop business plans, and provide market research and other support to feed the ecosystem. The incubator has also developed a 4-week, 21-h course that functions as an application process for the incubator. It helps prepare potential client for the program and often will deter a client for entering the program if it becomes apparent that their business opportunity is not as attractive as they thought entering the course.

Figure 7.3 illustrates the role of the UCFBIP in local economic development. The economic development pyramid is held up by a strong foundation of pillars provided for by the innovation and entrepreneurial ecosystem. These in turn enable world-class research which leads to intellectual property (IP) creation and management after which the next step involves the strategic development of the idea which is then commercialized into a product at the UCFBIP. As a result of this commercialization, jobs directly related to the products (primary jobs) and other (supplementary) jobs are created which in turn add to the overall economic development of the region. Finally, as a result of the companies and the primary and supplementary jobs created, the resultant taxes paid aid in repaying the government for providing the necessary funding needed to support the

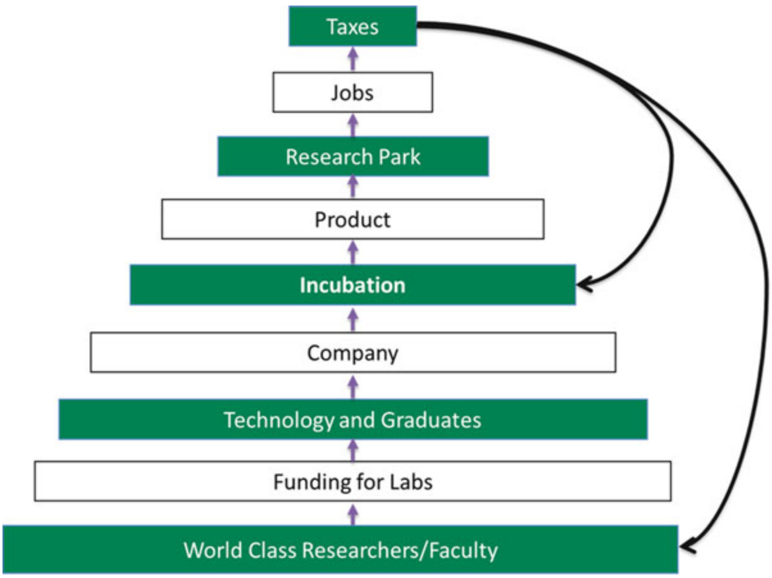

Fig. 7.4 Economic development cycle

UCFBIP and other such initiatives in the local area. Research conducted by real estate research incorporated indicates that for every dollar invested, four dollars of taxes are returned back to the government. These taxes paid then restart the cycle by being provided as funding to support world-class research and the UCFBIP which aids in the commercialization of this research, thereby leading to the creation of more primary and supplementary jobs; this principle can be referred to as the economic development cycle, and it is this observed cycle that over time iteratively aids in regional economic development as illustrated in Fig. 7.4.

1 Conclusion

A university can play an important role in economic development in terms of creating the development of innovation and entrepreneurial capacity of a region. In Central Florida, the university became a driver and partner to help diversify the economy from a region that was heavily dependent on tourism, hospitality, and agriculture, sectors known for lower than average wages.

It takes a village to provide the resources necessary to cultivate an innovation-based sector in a region. This is more pronounced in regions such as Orlando that could be considered subcritical in terms of existing infrastructure necessary for entrepreneurs to find the talent, capital, and subject matter expertise they need to thrive. Without such innovation or entrepreneurial capacity, new companies will have to relocate to succeed.

Part II
Innovation in Firms

Chapter 8
Is It Worth All the Trouble? An Assessment of the Economic Value of Firm Patent Applications with Shared Intellectual Property Rights in the Biotechnology Industry

Heide Fier and Andreas Pyka

Abstract Shared intellectual property rights are connected with complex legal issues and therefore organizations (e.g. firms) that apply for patents have a strong incentive to avoid co-ownership on their patents. In contrast to this the share of EPO firm patent applications with a joint ownership has increased in the biotechnology industry during the last two decades as it has been observed in other industries. From this the question has to be forced, whether joint patent applications are associated with a higher economic potential compared to the patents with no joint ownership so that firms are willing to cope with the legal issues that are associated with shared intellectual property rights on patents. We measure the economic value of a patent by the number of subsequent citations it has received and empirically address this question by the application of a nonparametric matching approach on patent level. We show that there exists a positive causal relationship between the decision of a firm to jointly apply for a patent and the future economic value that is associated with the regarded patent.

1 Introduction

The biotechnology industry as other science-based industry is characterized by rapid advances in scientific research, so firms are steadily urged to absorb external knowledge to keep pace with the speed of knowledge accumulation in the industry

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(Arora and Gambardella 1990; Henderson et al. 1998). As a result firms in the biotechnology industry frequently collaborate on R&D to profit from complementary knowledge and resources of their collaboration partners (Gulati 1998).

Interfirm collaboration on R&D, however, always urges the participating firms to find agreements on the intellectual property rights of possible jointly generated inventions. Usually firms that collaborate on R&D find ex ante or ex post agreements on the intellectual property rights of their common generated inventions and try to avoid shared intellectual property rights on inventions (Luoma et al. 2010). This is mostly due to the fact that shared intellectual property rights on inventions are associated with the need of complex legal agreements between the collaborating firms and none of the collaborating firms can fully appropriate the monopoly rent on the invention (Hagedoorn 2003).

Despite this, Hicks and Narin (2001) have shown that the share of joint patent applications at the United States Patent and Trademark Office (USPTO) has increased over time and the highest shares of jointly owned patents can be observed in knowledge-intensive industries like the biotechnology industry. We show in line that the share of joint patent applications of firms in the field of biotechnology has increased at the European Patent Office (EPO).

Given these contradicting findings, what are the motives and factors associated with joint patent applications of firms in the biotechnology industry? The existing empirical evidence on this topic is rare. A few empirical studies have shown that previous joint patenting experience increases the likelihood of firms to apply a joint patent application (Hagedoorn et al. 2003; Kim and Song 2007). Khoury and Pleggenkuhle-Miles (2011) in line with Kim and Song (2007) show that firms in the biotechnology industry which have jointly applied for patents with other firms develop broader and more diverse research capabilities compared to firms that avoid joint patenting.

Within this study we aim to contribute new empirical evidence on the causal relationship of the decision of firms to jointly apply for a patent on an invention and the economic value associated with the invention. Given the uncertainty associated with inventions in the biotechnology industry (Mazzoleni and Nelson 1998), we assume that firms which collaborate on R&D insist to maintain intellectual property rights on their jointly generated inventions since they could assume that these inventions are associated with a high future economic value which could not be properly assessed during the invention stage.

We investigate this research question by applying a nonparametric matching procedure. We use patent data and show that the decision of firms to jointly apply a patent is driven by the future economic value associated with the patent.

The remainder of this chapter is organized as follows. In Sect. 2 we give an overview on the motives of interfirm R&D collaboration in the biotechnology industry. Section 3 describes the importance of patents as an intellectual property rights protection mechanism, and Sect. 4 addresses some theoretical topics associated with shared intellectual property rights on patents. Section 5 is on existing empirical evidence on the motives and factors associated with joint patent applications of firms in the biotechnology industry and works out our research hypothesis.

Section 6 provides a description of the empirical implementation of our hypothesis, gives an overview on the used data and variables, and shows the descriptive statistics of our sample. Section 7 shows the results of our nonparametric matching approach, and Sect. 8 closes with a conclusion.

Theoretical Part

2 R&D Collaboration Motives of Firms in the Biotechnology Industry: A System of Innovation Approach

It has long been recognized that innovation is not a static process that takes place isolated from the outside surroundings. Instead, various economic studies have shown that innovation should rather be seen as an interactive process of learning that is shaped by various institutions and afflicted by a high degree of uncertainty (Nelson and Winter 1977, 1982; Lundvall 1988). In the economic literature, the innovation systems (IS) approach has been a dominant theory during the last two decades in order to capture these interactive processes of learning that will eventually yield innovations. The IS approach is basically build on two main assumptions. First, knowledge is considered to be the most important resource in modern economy, and second, knowledge can only be gained through interactive learning that takes place in a socially embedded process which is shaped by various institutions (Lundvall 2010). There are various definitions of IS. One of the broadest definitions defines an IS as "all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation" (Edquist 2005, p. 182).

The biotechnology industry like other science-based industries is a good example for the application of the IS approach.

First of all, knowledge is the main production factor and characterized by rapid advances, and moreover, a wide dispersion of the sources that produce knowledge can be observed (Powell and Owen-Smith 1998). In order to not fall behind competitors and state-of-the art research, biotech firms are urged to steadily review and absorb this newly generated knowledge (Arora and Gambardella 1990; Henderson et al. 1998). R&D activities in the biotechnology sector are often characterized by a high degree of financial uncertainty, R&D and technologic uncertainty, regulatory uncertainty, and market uncertainty.

Moreover, biotech R&D activities are often time consuming and expensive[1] (Teece et al. 1997). Because of this, interactive learning plays a crucial role for knowledge acquisition.

Powell et al. (1996) depict that informal R&D collaboration plays an important role in the biotechnology industry since firms heavily rely on their informal networks. Pyka and Saviotti (2005) investigate the permanent nature of R&D collaborations in the biopharmaceutical industry and thus provide evidence that permanent R&D

[1] For example, the development of new drugs.

networks contribute to the survival of dedicated biotech firms next to large diversified pharmaceutical firms.

The motives of firms in the biotechnology industry to engage in interfirm research collaborations are different, depending mainly on their size and background.

Horizontal alliances between firms in the biotech sector link firms of the same size to each other. These alliances have the preliminary goal to achieve explanatory targets by either linking together firms with complementary assets or additional similarities (Gulati 1998). Thereby horizontal alliances are often more difficult to manage due to overlapping competencies even if the participating firms are no direct competitors (Doz et al. 1989; Khanna et al. 1998; Silverman and Baum 2002). Vertical alliances of firms in the biotech sector are often found among small- and medium-sized biotech firms and large pharmaceutical and chemical firms. Thereby, the small- and medium-sized firms in the biotech sector are often former spinoffs from universities or other research institutions or at least have academic founders and thus employ some of the brightest scientists (Fisher et al. 1996). They keep close contact to scientific institutions and often undertake the first step in transferring basic research results in marketable products. However, these small- and medium-sized biotech firms have rather week financial resources and a lack of distributional infrastructure. Thus, for small- and medium-sized biotech firms, such alliances with large firms have been identified to be important for their successful product development as well as for a faster market access and enhanced marketing and distribution mechanisms (Arora and Gambardella 1990; Pisano 1990; Baum et al. 2000). In turn due to large diversity of research activities in biotechnology, large pharmaceutical and chemical firms are permanently facing the threat to fall behind new research technologies. Thus, large firms in the biotech sector permanently have an incentive to get access to complementary technological knowledge which is produced by small- and medium-sized biotech firms (Arora and Gambardella 1990; Baum et al. 2000).

3 The Meaning of Patents for Intellectual Property Rights Protection in the Biotechnology Industry

Prior to the 1980s, international patent protection laws did not allow the protection of living organisms or biologically active substances like single molecules or proteins. As the biotechnology industry emerged and the economic value of biotechnological inventions became more obvious, international patent laws were adjusted and changed to satisfy the needs of intellectual property rights protection for biotechnological inventions.

One breakthrough in the changes of international patent laws was in 1980 when the US Supreme Court ruled that the genetic modification of a bacterium was patentable (Willison and MacLeod 2002). Another major change of the patent protection law in the USA was made in 1992 when it became possible to protect single molecules and proteins (Ko 1992). In the following years patent protection laws in other countries and in the EU were accordingly adjusted to allow the protection of biologically active substances (Leskien 1998).

Several works have shown the importance of patents for the intellectual property rights protection in the biotechnological industry. Cohen et al. (2000) have conducted a large-scale survey on 1,478 R&D laboratories in the USA in 1994 and show that patents in the biotechnology industry are the most important mechanism to protect intellectual property rights. Schankerman (1998) comes to a similar result by outlining that firms in the biotechnology industry are more willing to pay renewal fees on their patents compared to other industries. Arora et al. (2008) presented a measure, so-called patent premium that relates the return of a patented invention to an unpatented invention, and show that the patent premium is only positive for a few knowledge-intensive industries including the biotechnology industry.

4 Shared Intellectual Property Rights on Patents

Shared intellectual property rights on patents occur when two or more assignees are found on one single patent application. This implies that the intellectual property rights are indeed shared between the applicants listed in the joint patent application and as a consequence the applicants that apply for a joint patent[2] have to find several agreements on how, i.e., the patent rent should be divided or how acquisition offers of the joint patent should be handled. Thus, joint patent applications have to be viewed differently from cross licensing agreements or patent infringement agreements where ex post or ex ante agreements between patent holders are negotiated to balance the expected license return losses and gains of the involved actors (Hagedoorn 2003).

The consequences of joint patenting are evidently more far reaching compared to cross licensing agreements and infringement agreements, and usually organizations that are actively conducting research try to avoid a sharing of intellectual property rights on their inventions (Marchese 1999; Luoma et al. 2010).

Shared intellectual property rights on patents usually occur as a result of collaboration and can thus be viewed as a special result of collaborative activity. Hagedoorn (2003) has interviewed US firms in his work which are actively involved in joint patenting and comes to the result that joint patenting mostly results from informal R&D collaboration and small-sized R&D projects were the contributions of the involved partners to the realized invention cannot be properly separated. Hicks and Narin (2001) who have studied the patterns of joint patenting on the basis of USPTO patent data reveal that the share of joint patent applications has increased between the early 1980s and 1999 and patents with multiple applicants are mostly concentrated in highly knowledge-intensive sectors like biotechnology, pharmacy, and medical equipment. In line, Hagedoorn (2003) shows again on the basis of USPTO patent data – using slightly different technology classifications – that the highest proportion of firm-owned patents with shared intellectual property rights can be found in knowledge-intensive sectors like chemicals and pharmaceuticals (including biotechnology) or information technology where patents generally play an important role for knowledge protection.

[2] We use the term "joint patent" synonymously with the term "patents with shared intellectual property rights" throughout the whole chapter.

5 Empirical Evidence on the Rationale of Joint Firm Patents in the Biotechnology Industry

With regard to recent studies and the related literature, a core question occurs in context to firm's patenting strategies: Is there any reason why patents with shared intellectual property rights could be more valuable than patents with a single ownership? Patents with shared intellectual property rights create a lot of administrative and legal work to the jointly assigning firms. So then why do firms assign patents with a shared ownership and why has the share of joint patents increased in knowledge-intensive industries as it has been outlined by Hicks and Narin (2001)? Hagedoorn (2003, p. 1044) puts it this way: "Theoretically it is rather difficult to understand why, given the legal status of joint patents, companies would share their patents with other companies […]".

Recently some few empirical studies have started to investigate motives and factors associated with joint patenting of firms. The existing empirical evidence on this topic is rare though.

Hagedoorn et al. (2003) have constructed a sample of firms and have empirically investigated the relationship between interfirm collaboration experience and the number of joint patent applications. They show that the number of jointly owned patents of the firms does not seem to depend on the general collaboration experience of the firms but rather exclusively on the firm's experience with joint patenting itself. They conclude that firms who have experienced joint patenting might have established some inner organizational experience and guidelines about how joint patent applications can be handled.

Kim and Song (2007) use joint patents as a productivity measure of interfirm R&D alliances in the pharmaceutical industry and show that joint patents that result from interfirm R&D alliances have a nonlinear (inverted U-shaped) relationship with the developing technological base of the collaborating firms. Moreover, they find that joint patenting between alliance partners seems to occur more often when the alliance partners had previous ties with each other.

Some recent work of Khoury and Pleggenkuhle-Miles (2011) relates the experience of biotechnology firms on joint patenting to their evolution of research capabilities. They use a sample based on over 250 biotechnology firms and show that firms which engage in joint patenting develop a broader research capability base compared to those firms that tend to avoid joint patent activities.

Besides the positive effects of prior collaboration experience on the likelihood of joint patenting of firms and the outlined positive effects of joint patenting of firms on the development of their research capabilities, however, less empirical evidence exists on further motives why firms in knowledge-intensive sectors like the biotechnological sector increasingly engage in joint patents.

One alternative explanation to the question why firms file patent applications jointly could be that inventions that are patented jointly are associated with an assumingly high but at the time of the invention unknown expected economic value such that the collaboration partners hesitate to allocate the expected patent rents to a single collaboration partner and fail to find an a priori agreement on the ownership of the patent. One work that could underpin this hypothesis is the paper of Mazzoleni and Nelson (1998) in which the authors state that biotechnology patents are often not marketable at the first glance but might have great economic potential in the future. Given this uniqueness surrounded with patents from knowledge-intensive industries like the biotechnology industry, our major hypothesis is as follows: firms that have created an invention out of joint research have an incentive to maintain their shares on the intellectual property rights of the invention since they regard the joint invention as economically valuable but are not able to properly assess its real economic value and thus might fear to lose patent rents associated with the jointly created invention. We assess this hypothesis via a non-parametric matching approach on the basis of EPO patent data.

Empirical Part

6 Empirical Implementation, Data, Variables, and Descriptive Statistics

6.1 Empirical Implementation: Propensity Score Matching

The aim of our study is to investigate whether joint patent applications of firms are associated with a higher economical value compared to patent applications of firms with a single ownership.

The fact whether a patent is jointly applied or not is the result of a selection bias, since firms that jointly apply for a patent have actively agreed to share intellectual property rights on their invention. This selection bias has the consequence that jointly applied patents will differ from patents with a single ownership in a set of important characteristics.

Several econometric approaches have been developed to correct for the presence of a possible selection bias including differences in differences methods, selection models, instrumental variable estimation, and nonparametric matching procedures (for an overview on recent developments, see Imbens and Wooldridge 2009). Nonparametric matching procedures have been primarily introduced for the evaluation of active labor market policies (e.g., Heckman et al. 1999; Lechner 2002a, b; Blundell et al. 2004). In innovation economics the nonparametric matching methods have mostly been used for the evaluation of public research funding (i.e., Busom 2000; Czarnitzki et al. 2007, 2011). In both application fields, the participation in a public measure (i.e., the participation in a labor market program or the receipt of public funding) is called treatment and is compared to a matched group of nonparticipants. In our case the treatment is a jointly applied patent. With the nonparametric matching approach, the patent value for the group of jointly applied patents can be compared to a simulated counterfactual situation that assesses the patent value for the group of jointly applied patents if they had not been jointly applied. The matching estimator simulates the counterfactual situation on the basis of a constructed control group of patents with single ownerships were each jointly applied patent is matched to a patent with single ownership that shows the same set of characteristics as the jointly applied patent. The matching method thus balances the group of treated observations to the group of untreated observations on a set of characteristics and attributes remaining differences in the outcome (in our case the patent value) to the treatment effect. The *average treatment effect of treatment on the treated (ATT)* can be illustrated by the following equation:

$$ATT = E\left(Y_T \mid S=1\right) - E\left(Y_C \mid S=1\right)$$

Y_T is the outcome variable (the patent value), and S refers to the treatment with $S=1$ being the group of jointly applied patents and $S=0$ being the group of patents with a single ownership. The patent value for the group of jointly applied patents, $E\left(Y_T \mid S=1\right)$, is directly observable. Y_C reflects the potential patent value that would have been realized if the group of jointly applied patents had not been jointly applied. $E((Y_C \mid S=1)$ thus describes the outlined counterfactual situation (the patent value for the group of jointly applied patents if they had not been jointly applied) which is not directly observable and has to be simulated.

We apply a modified propensity matching procedure as it has been proposed by Lechner (1998). The "plain" propensity matching procedure as it has been suggested by Rosenbaum and Rubin (1983) reduces the number of variables that determines the treatment status to a single variable in the matching function, namely the propensity scores which are prior estimated from a probit model on the binary treatment indicator variable. Lechner (1998) suggested a modification which allows the inclusion of several additional variables in the matching function. We construct the control sample by applying the nearest neighbor approach with replacement based on the Mahalanobis distance which includes several variables next to the propensity scores which were prior estimated on the basis of a probit model on the treatment indicator variable (joint patent applications vs. patents with a single ownership). A comprehensive overview on the single steps in the nonparametric matching procedure applied can, e.g., be found in Czarnitzki et al. (2007).

6.2 Data

Our study is based on EPO patent application data. We have a full coverage of the data for the years between 1984 and 2003.[3] The information of the patent data includes the name(s) and country(ies) of origin of the inventor(s) as well as of the assignee(s), citations to other patents and/or citations to other documents (nonpatent citations), and information about the declared IPC classes as well as its application and grant dates.

3 We like to thank the European Patent Office and the Centre of European Economic Research (ZEW) in providing the biotech patent data.

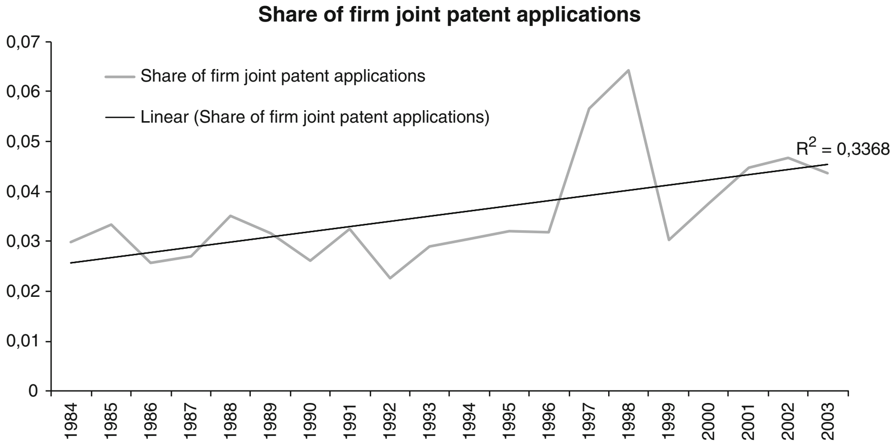

Fig. 8.1 Share of firm joint patent applications for the application years 1984–2003

We use the IPC classes that have been identified to be relevant for biotechnology on the basis of the OECD patent compendium (2008) to identify all patent applications that contain at least one IPC class that is related to biotechnology. Sixty six thousand nine hundred and thirty six patents remain for our further analysis.

On the basis of the identified patents, we conduct a citation analysis and identify all subsequent citations that a biotechnology-related patent has received by other biotechnology-related patents in our sample.

Further we assigned all patent applications to the following classes: firms, research institutions, individuals, and others. We limit our analysis to all patents that are signed by either one or multiple firms and keep 46,083 patents for our further investigation. It is important to note that we solely concentrate on all patent applications that have been jointly applied for by firms, so we drop for our matching approach all patent applications where, e.g., a university is listed as an applicant next to a firm applicant. We drop those joint patents with mixed classes of assignees since we would not be able to find proper control observations for those patents.

Next we restrict our analysis to the five countries that have assigned most of the patent applications in our sample, namely, the USA, Germany, Japan, Great Britain, and France. We chose to restrict our data to only those countries with the highest patenting activity to ensure that we can find proper control patents for our matching approach. The restriction to those five countries implies a loss of 8,955 observations.

For our further analysis, we keep 37,128 patent applications.

6.3 Variables

We create a dummy variable (*JOINT*) which indicates whether a patent application has been jointly filed by two or more firms (*JOINT* = *1*) or not (*JOINT* = *0*). As it has been outlined before, *JOINT* is our treatment indicator variable.

Table 8.1 Descriptive statistics of the full sample (37,128 observations)

	Jointly applied patents (1,426 observations)		Patents with single ownership (35,702 observations)		Two-sided *t*-test on equality of means
	Mean	SD	Mean	SD	
PRIOR	0.661	0.474	0.362	0.481	***
LNMEANANZPAT	3.613	1.749	2.973	1.795	***
NONPATCIT	2.187	4.189	1.869	3.426	***
IPC1	0.090	0.286	0.090	0.286	
IPC2	0.013	0.115	0.011	0.103	
IPC3	0.770	0.421	0.771	0.420	
IPC4	0.004	0.065	0.001	0.025	***
IPC5	0.000	0.000	0.000	0.009	
IPC6	0.000	0.000	0.000	0.012	
IPC7	0.123	0.328	0.127	0.333	
IPC8	0.000	0.000	0.001	0.023	
US	0.429	0.495	0.559	0.496	***
JP	0.227	0.419	0.172	0.377	***
FR	0.028	0.165	0.046	0.208	***
GB	0.195	0.396	0.079	0.269	***
DE	0.121	0.327	0.145	0.352	**
YEAR1	0.013	0.115	0.019	0.137	
YEAR2	0.018	0.134	0.022	0.146	
YEAR3	0.016	0.126	0.024	0.155	**
YEAR4	0.018	0.134	0.028	0.166	**
YEAR5	0.028	0.165	0.032	0.177	
YEAR6	0.028	0.165	0.035	0.185	
YEAR7	0.025	0.157	0.039	0.193	***
YEAR8	0.034	0.180	0.038	0.190	
YEAR9	0.020	0.139	0.039	0.193	***
YEAR10	0.028	0.165	0.035	0.183	
YEAR11	0.034	0.180	0.039	0.194	
YEAR12	0.035	0.184	0.043	0.203	
YEAR13	0.041	0.198	0.048	0.213	
YEAR14	0.086	0.281	0.055	0.227	***
YEAR15	0.118	0.322	0.069	0.253	***
YEAR16	0.063	0.243	0.082	0.274	**
YEAR17	0.083	0.277	0.089	0.284	
YEAR18	0.114	0.317	0.095	0.293	**
YEAR19	0.116	0.320	0.089	0.285	***
YEAR20	0.082	0.275	0.081	0.272	
CITATIONS	0.380	1.112	0.384	1.336	

Note: *** (** , *) indicates a significance level of 1% (5%, 10%).

Figure 8.1 shows the share of joint patent applications of firms in relation to the application years. We can see that the share of joint patent applications of firms in our sample has increased from about 3 % in 1984 to about 4.5 % in 2003. Also the linear trend line suggests that there is a positive trend on the occurrence of joint patent applications. Our findings thus confirm the outlined findings of Hicks and Narin (2001) and Hagedoorn (2003).

We aim to relate the treatment effect of joint patent applications to the value of a patented invention. We therefore have to measure the value of the patent applications in our sample. One popular and straightforward way to proxy the economic value of a patent is the number of subsequent citations it has received (Harhoff et al. 1999; Hall et al. 2001a).[4] The use of patent citations in an economic analysis where patents with different application years are jointly analyzed yields the problem of truncation though since a patent that has been filed earlier in the sample has a greater probability to receive more patent citations compared to a patent that has been filed more recently. This truncation issue has been heavily analyzed and several methods have been proposed to ease this bias (Caballero and Jaffe 1993; Jaffe and Trajtenberg 1999; Hall et al. 2001b). By applying a nonparametric matching approach on the patent data, however, we suggest that the truncation bias can be accounted for by simply including the patent application years in the matching function. Given that the number of control patents is large enough, the matching method will then search for each treated patent a control patent with exactly the same application year. As a result the group with joint patent applications should not differ from the group of patents with single ownership regarding their patent application year frequency distributions.

Our outcome variable *CITATIONS* reflects the number of citations a patent has received from the other subsequent patents in our sample.

Next we describe a set of variables that are likely to influence the decision of a firm to jointly apply for a patent or not. Those variables are important to estimate the propensity scores that are included in the matching function and can further be included in the matching function directly.

As described before the studies of Hagedoorn et al. (2003) and Kim and Song (2007) suggest that there is a positive effect of prior joint patenting experience of firms on the likelihood of firms to apply for a joint patent. We consider the application date of the patents in our sample and create a dummy variable (*PRIOR*) that indicates whether the applicant or one of the applicants of a patent has filed a joint patent with another firm previously to the considered patent application.

Next we include a measure that reflects the overall patenting rate of the applicants and to some extend at least proxies the firm size of the applicants. Generally one would expect a positive relationship between firm size and the number of patent applications on one hand because of differing R&D capacities and on the other hand because of differing financial assets to enforce patent rights (Schettino and Sterlacchini 2009). The relationship between firm size and the number of patent applications in the biotechnological industry is not clear though. Rothaermel and Thursby (2007) examine a sample of biotechnology firms for the years 1980–2000 and find a positive impact of firm size on the number of generated biotech patents for the years 1980–1990; however, they do not find that this positive relationship

[4] Other methods to proxy the economic value of patents have been suggested; for an overview regarding the biotechnological industry, see Albino et al. (2010).

holds for the years 1990–2000. *LNMEANANZPAT* is a continuous variable and contains the cumulative number of patent applications that the firm has applied for up to the application year of the considered patent application. In the case of joint patents, we take the mean value of the cumulative patent application counts of the firms. Due to the fact that the distribution of the mean cumulative number of patent applications is heavily screwed, we include the logarithmic value in our further analysis.

Next we include a variable that controls for the scientific complexity surrounded by the patented invention. We measure the scientific complexity of a patented invention by the total number of nonpatent references cited in the patent application of the patent (*NONPATCIT*). So-called nonpatent citations have been recently used as proxies for science-industry linkages at the invention level (e.g., Cassiman et al. 2008; Lo 2010). In addition to this, van Zeebroeck and van Pottelsberghe (2011) show that the number of nonpatent citations in the search report of a patent can be used to depict the scientific complexity of a patented invention. We hypothesize that if a patented invention is scientifically complex, the firms might be more urged to get access to external knowledge and thus might have a higher probability to collaborate with a firm on this invention which as a consequence could lead to shared intellectual property rights on this invention.
Other control variables:

– Application years: As lined out before, we control for the application years (*YEAR1984–YEAR2003*). On the one hand because we aim to control for the truncation bias of the citations and on the other hand because we observed a positive linear trend on the share of joint patent applications in our sample (Fig. 8.1).
– First digit IPC classes: We control for the first digit IPC class listed as the first IPC class in the patent application of a patent to control for possible differences of the likelihood of joint patent applications due to different technological fields (*IPC1-IPC8*).
– Country dummies: We control for the country of origin of the first applicant listed in the patent application since historical and cultural differences of countries could affect the probability of a firm to jointly apply for a patent (*US, GB, DE, FR, JP*).

6.4 Descriptive Statistics

Table 8.1 shows the descriptive statistics for our full sample.

The two-sided *t*-tests on the equality of means for the two groups show that applicants of joint patents show a higher previous experience with joint patent applications (*PRIOR*) and show a higher previous patenting rate (*LNMEANANZPAT*). Moreover inventions that are patented jointly are of a more complex scientific nature when compared to patents with no shared intellectual property rights (*NONPATCIT*). Besides also the countries of origin of the applicants are significantly

Table 8.2 Probit estimation on the application of a joint patent

Joint	Coef.	Std. err.	
PRIOR	0.541	0.034	***
LNMEANANZPAT	0.004	0.010	
NONPATCIT	0.011	0.003	***
IPC1[a]	−0.138	0.121	
IPC3[a]	−0.209	0.114	
IPC4[a]	1.024	0.292	***
IPC7[a]	−0.157	0.119	
US[b]	−0.608	0.039	***
JP[b]	−0.386	0.043	***
FR[b]	−0.538	0.076	***
DE[b]	−0.532	0.049	***
Constant term	−1.307	0.154	***
Test on the joint significance of year dummies	$\chi(19)=81.01$		***
Pseudo R^2	0.071		
Log likelihood	−5614.977		
# observations	37,101		

Note: 19-year dummies included in the regression; Year1 serves as reference year *** (**, *) indicates a significance level of 1% (5%, 10%).
[a]IPC2 serves as reference class; IPC5, IPC6, and IPC8 dropped since they are only found in the group of patent applications with single ownership, and 27 observations are dropped
[b]Great Britain serves as reference class

different among the two groups. A higher proportion of Japanese applicants (*JP*) and applicants from Great Britain (*GB*) can be found in the group of jointly applied patents compared to the group of patents with a single ownership. It is important to notice that the *t*-test shows no significant difference between the two groups for our outcome variable (*CITATIONS*). In fact, patents with a single ownership receive slightly more patent citations compared to patents with a joint ownership. As we described above, however, our data are biased due to selection, and we account for this bias in the following section by applying a nonparametric matching model.

7 Results from the Nonparametric Matching Procedure

First we estimate a probit model on the application of a joint patent (*JOINT*). The probit model shows that prior joint patenting experience (*PRIOR*) and the scientific complexity of the patented invention has a highly significant impact on the probability of firms to jointly apply for a patent. Moreover, the country dummies and a Wald test on the joint significance of the application years are highly significant. Regarding the IPC classes, we find three IPC (IPC5, IPC6, IPC8) classes that only occur in the group of patents with a single ownership. Those three IPC classes are dropped for the probit estimation, and for this reason we lose 27 observations (Table 8.2).

Next we use the control sample to find a control patent application from the group of patent applications with a single ownership for each treated patent application. We apply the nearest neighbor approach with replacement based on the Mahalanobis distance. Next to the estimated propensity scores from the described probit estimation, we include all independent variables of our probit estimation in the Mahalanobis metric restriction. Due to the fact that we have more than 35,000 possible control patent applications for just 1,426 treated patent applications, we believe that we can apply this really stringent approach to find proper control observations.

Table 8.3 shows the detailed matching results of our approach. It is important to note that we do not lose any observation due to the failure of common support.

The means and corresponding *t*-tests show that none of the employed covariates differ after the matching. Appendix Table 8.5 displays the full matching results including the matching results for the single application years. Concerning the correction of the truncation bias of our outcome variable *CITATIONS* due to different application years, we observe that the truncation bias for the application years is almost completely ruled out by the matching procedure. The *p*-values of the two-sided *t*-test on mean equality for the application years show a range of 0.924–1.000. Also the propensity score (PROPENSITY SCORE) shows no significant difference after the matching.

We do observe however a mean difference in our outcome variable *CITATIONS* which can be attributed to the treatment. Table 8.4 shows the average treatment effect on the treated with bootstrapped standard errors. On average a patent application that has been jointly applied would have received significantly less patent citations if it had not been jointly applied. We can see that this difference amounts to approximately 0.09 patent citations that the jointly applied patent would have received less if it had not been jointly applied. From these findings we assume that there is a causal relationship between the economic value of a patented invention and the decision of firms to share intellectual property rights on this invention.

8 Conclusion

In this chapter we contribute new empirical evidence on the rationale of firms to jointly apply for patents. Existing empirical evidence suggests that previous joint patenting experience has a positive impact on the likelihood of firms to apply for joint patents. Moreover, a positive impact of prior joint patenting experience on the development of a firm's research capabilities has been outlined for the biotechnology industry.

We hypothesize that the decision of a firm to jointly apply for a patent is driven by the future economic value of the jointly applied invention. Given the uncertain

Table 8.3 Matching results based on 37,101 observations

Variable		Mean: Joint patent application	Mean: Patent with single ownership	*P*-value of two-sided *t*-test on mean equality
PROPENSITY SCORE	Unmatched	0.069	0.037	0.000
	Matched	0.069	0.067	0.283
PRIOR	Unmatched	0.661	0.362	0.000
	Matched	0.661	0.644	0.346
LNMEANANZPAT	Unmatched	3.613	2.974	0.000
	Matched	3.613	3.538	0.243
NONPATCIT	Unmatched	2.187	1.870	0.001
	Matched	2.187	2.014	0.259
US	Unmatched	0.429	0.559	0.000
	Matched	0.429	0.435	0.734
JP	Unmatched	0.227	0.172	0.000
	Matched	0.227	0.223	0.823
GB	Unmatched	0.195	0.079	0.000
	Matched	0.195	0.194	0.925
FR	Unmatched	0.028	0.045	0.002
	Matched	0.028	0.027	0.909
DE	Unmatched	0.121	0.145	0.013
	Matched	0.121	0.121	0.954
IPC1	Unmatched	0.090	0.090	0.988
	Matched	0.090	0.088	0.895
IPC2	Unmatched	0.013	0.011	0.366
	Matched	0.013	0.013	1.000
IPC3	Unmatched	0.770	0.771	0.894
	Matched	0.770	0.771	0.929
IPC4	Unmatched	0.004	0.001	0.000
	Matched	0.004	0.004	1.000
IPC7	Unmatched	0.123	0.127	0.599
	Matched	0.123	0.123	1.000
CITATIONS	Unmatched	0.380	0.384	0.910
	Matched	0.380	0.292	0.021

Note: 20-year dummies are not reported; they are not significant after the matching, however. The full matching results are reported in appendix Table 8.5

Table 8.4 Average treatment effect on the treated (ATT)

Variable	Sample	Treated	Controls	Difference	Standard errors
CITATIONS	Unmatched	0.3801	0.3841	–0.0041	0.0359
	ATT	0.3801	0.2917	0.0884	0.0431[a]

[a]Bootstrapped standard errors

true economic potential associated with inventions from knowledge-intensive industries like the biotechnology industry, we assume that firms which have jointly generated an invention insist to maintain the intellectual property rights on their invention if they suppose that their jointly generated invention could feature great economic potential in the future which cannot be properly assessed during the invention stage. In this case the collaborating firms will fail to find a priori agreement on the allocation of the intellectual property rights on their inventions and will thus share the intellectual property rights.

We test this hypothesis via a nonparametric matching approach on EPO patent data. We show that a causal relationship exists on the decision of firms to jointly apply for a patent and the economic value of the patented invention for the biotechnology industry. We find that patents with shared intellectual property rights would have significantly received fewer citations if they had not been jointly applied.

Our approach has some severe shortcomings though. First of all it is unlikely that we included all relevant covariates that determine the decision of a firm to jointly apply for a patent in our probit estimates. Although we applied very stringent restrictions to the construction of our control sample, it is still likely that patents with a joint ownership differ from patents with a single ownership in important characteristics. We also totally neglected the financing background of the firms in our sample. Kortum and Lerner (2000) show for US manufacturing industries that that there is a positive relationship between the venture capital activities and the patenting rate in an industry. Assuming that venture capital-financed firms might have a greater probability to apply for a patent compared to not venture-backed firms, it would be important to control for the financing background of the firms in our sample.

Despite these shortcomings, however, we believe that this chapter contributes new evidence on the rationale of firms to jointly apply for patents in the biotechnology industry. Moreover, we show that the nonparametric matching approach can be a powerful method to determine causal relationships not only on firm level but also on patent level.

Further research has to be done however to reveal more factors that are associated with the firm's decision to jointly apply for patents. One attempt could be to control for the financing background of the applicant firms.

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Appendix

Table 8.5 Full matching results

Variable		Mean: Joint patent application	Mean: Patent with single ownership	*P*-value of two-sided *t*-test on mean equality
PROPENSITY SCORE	Unmatched	0.069	0.037	0.000
	Matched	0.069	0.067	0.283
PRIOR	Unmatched	0.661	0.362	0.000
	Matched	0.661	0.644	0.346
LNMEANANZPAT	Unmatched	3.613	2.974	0.000
	Matched	3.613	3.538	0.243
NONPATCIT	Unmatched	2.187	1.870	0.001
	Matched	2.187	2.014	0.259
US	Unmatched	0.429	0.559	0.000
	Matched	0.429	0.435	0.734
JP	Unmatched	0.227	0.172	0.000
	Matched	0.227	0.223	0.823
GB	Unmatched	0.195	0.079	0.000
	Matched	0.195	0.194	0.925
FR	Unmatched	0.028	0.045	0.002
	Matched	0.028	0.027	0.909
DE	Unmatched	0.121	0.145	0.013
	Matched	0.121	0.121	0.954
IPC1	Unmatched	0.090	0.090	0.988
	Matched	0.090	0.088	0.895
IPC2	Unmatched	0.013	0.011	0.366
	Matched	0.013	0.013	1.000
IPC3	Unmatched	0.770	0.771	0.894
	Matched	0.770	0.771	0.929
IPC4	Unmatched	0.004	0.001	0.000
	Matched	0.004	0.004	1.000
IPC7	Unmatched	0.123	0.127	0.599
	Matched	0.123	0.123	1.000
Year1984	Unmatched	0.013	0.019	0.112
	Matched	0.013	0.013	1.000
Year1985	Unmatched	0.018	0.022	0.356
	Matched	0.018	0.018	1.000
Year1986	Unmatched	0.016	0.024	0.044
	Matched	0.016	0.016	1.000
Year1987	Unmatched	0.018	0.028	0.024
	Matched	0.018	0.018	1.000
Year1988	Unmatched	0.028	0.032	0.370
	Matched	0.028	0.028	1.000
Year1989	Unmatched	0.028	0.035	0.142
	Matched	0.028	0.028	1.000

(continued)

Table 8.5 (continued)

Variable		Mean: Joint patent application	Mean: Patent with single ownership	P-value of two-sided t-test on mean equality
Year1990	Unmatched	0.025	0.039	0.009
	Matched	0.025	0.025	1.000
Year1991	Unmatched	0.034	0.038	0.437
	Matched	0.034	0.034	1.000
Year1992	Unmatched	0.020	0.039	0.000
	Matched	0.020	0.020	1.000
Year1993	Unmatched	0.028	0.035	0.174
	Matched	0.028	0.028	1.000
Year1994	Unmatched	0.034	0.039	0.286
	Matched	0.034	0.034	1.000
Year1995	Unmatched	0.035	0.043	0.136
	Matched	0.035	0.035	1.000
Year1996	Unmatched	0.041	0.048	0.214
	Matched	0.041	0.040	0.924
Year1997	Unmatched	0.086	0.055	0.000
	Matched	0.086	0.086	1.000
Year1998	Unmatched	0.118	0.069	0.000
	Matched	0.118	0.119	0.954
Year1999	Unmatched	0.063	0.082	0.012
	Matched	0.063	0.064	0.939
Year2000	Unmatched	0.083	0.089	0.501
	Matched	0.083	0.083	1.000
Year2001	Unmatched	0.114	0.095	0.021
	Matched	0.114	0.114	1.000
Year2002	Unmatched	0.116	0.089	0.001
	Matched	0.116	0.116	1.000
Year2003	Unmatched	0.082	0.080	0.831
	Matched	0.082	0.081	0.946
CITATIONS	Unmatched	0.380	0.384	0.910
	Matched	0.380	0.292	0.021

References

Albino V, Messeni Petruzzelli A, Rotolo D (2010) Measuring patent value: an empirical analysis of the US Biotech Industry. Working paper series, Polytechnic of Bari

Arora A, Gambardella A (1990) Complementarity and external linkages: the strategies of the large firms in biotechnology. J Ind Econ 38(4):361–379

Arora A, Ceccagnoli M, Cohen WM (2008) R&D and the patent premium. Int J Ind Organ 26(5):1153–1179

Baum JAC, Calabrese T, Silverman BS (2000) Canadian biotechnology start-ups, 1991–1997: role of incumbents' patents and strategic alliances in controlling competition. Soc Sci Res 29(4):503–534

Blundell RM, Meghir C, Costas Dias M et al (2004) Evaluating the employment impact of a mandatory job search program. J Eur Econ Assoc 2:569–606
Busom I (2000) An empirical evaluation of the effects of R&D subsidies. Econ Innov New Technol 9(2):111–148
Caballero RJ, Jaffe AB (1993) How high are the giants' shoulders: an empirical assessment of knowledge spillovers and creative destruction in a model of economic growth. NBER working papers 4370, National Bureau of Economic Research
Cassiman B, Veugelers R, Zuniga P (2008) In search of performance effects of (in)direct industry science links. Ind Corp Change 17(4):611–646
Cohen WM, Nelson RR, Walsh JP (2000) Protecting their intellectual assets: appropriability conditions and why U.S. manufacturing firms patent (or not). NBER working paper 7552, National Bureau of Economic Research
Czarnitzki D, Ebersberger B, Fier A (2007) The relationship between R&D collaboration, subsidies and R&D performance: empirical evidence from Finland and Germany. J Appl Econometrics 22(7):1347–1366
Czarnitzki D, Hanel P, Rosa JM (2011) Evaluating the impact of R&D tax credits on innovation: a microeconometric study on Canadian firms. Res Policy 40(2):217–229
Doz Y, Gary H, Prahalad CK (1989) Collaborate with your competitors – and win. Harv Bus Rev 67(1):133–139
Edquist C (2005) Systems of innovation: perspectives and challenges. In: Fagerberg J, Mowery DC, Nelson RR (eds) The Oxford handbook of innovation. Oxford University Press, New York, pp 181–208
Fisher D, Grosjean JA, House D (1996) Changes in academy/industry/state relations in Canada: the creation and development of the networks of centres of excellence. Res Policy 39(3):299–325
Gulati R (1998) Alliances and networks. Strateg Manage J 19(5):293–317
Hagedoorn J (2003) Sharing intellectual property rights—an exploratory study of joint patenting amongst companies. Ind Corp Change 12(5):1035–1050
Hagedoorn J, van Kranenburg H, Osborn RN (2003) Joint patenting amongst companies – exploring the effects of inter-firm R&D partnering and experience. Manager Decis Econ 24(2–3):71–84
Hall BH, Jaffe AB, Trajtenberg M (2001a) Market value and patent citations: a first look. Berkeley, Mimeo, UC Berkeley
Hall BH, Jaffe AB, Trajtenberg M (2001b) The NBER patent citation data file: lessons, insights and methodological tools. NBER working papers 8498, National Bureau of Economic Research
Harhoff D, Narin F, Scherer FM et al (1999) Citation frequency and the value of patented inventions. Rev Econ Stat 81(3):511–515
Heckman JJ, Lalonde RJ, Smith JA (1999) The economics and econometrics of active labour market programs. In: Ashenfelter A, Card D (eds) Handbook of labour economics, vol 3. North-Holland, Amsterdam, pp 1866–2097
Henderson R, Jaffe AB, Trajtenberg M (1998) Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988. Rev Econ Stat 80:127–199
Hicks D, Narin F (2001) Strategic research alliances and 360 degree bibliometric indicators. In: Strategic Research Partnerships: Proceedings from an NSF Workshop, Arlington, VA (NSF 01-336)
Imbens GW, Wooldridge JM (2009) Recent developments in the econometrics of program evaluation. J Econ Lit 47(1):5–86(82)
Jaffe AB, Trajtenberg M (1999) International patent flows: evidence from patent citations. Econ Innov New Technol 8:105–136
Khanna T, Gulati R, Nohria N (1998) The dynamics of learning alliances: competition, cooperation, and relative scope. Strateg Manage J 19(3):193–210
Khoury TA, Pleggenkuhle-Miles EG (2011) Shared inventions and the evolution of capabilities: examining the biotechnology industry. Res Policy 40(7):943–956
Kim C, Song J (2007) Creating new technology through alliances: an empirical investigation of joint patents. Technovation 27:461–470

Ko Y (1992) An economic analysis of biotechnology patent protection. Yale Law J 102:777–804
Kortum S, Lerner J (2000) Assessing the contribution of venture capital to innovation. Rand J Econ 31(4):674–692
Lechner M (1998) Training the East German labour force: microeconometric evaluations of continuous vocational training after unification. Physica-Verlag, Heidelberg
Lechner M (2002a) Program heterogeneity and propensity score matching: an application to the evaluation of active labor market policies. Rev Econ Stat 84(2):205–220
Lechner M (2002b) Some practical issues in the evaluation of heterogeneous labour market programmes by matching methods. J R Stat Soc (Ser A) 165:659–682
Leskien D (1998) The European patent directive on biotechnology. Biotechnol Dev Monit 36:16–19
Lo SS (2010) Scientific linkage of science research and technology development: a case of genetic engineering research. Scientometrics 82:109–120
Lundvall BA (1988) Innovation as an interactive process: from user–producer interaction to the national system of innovation. In: Dosi G, Freeman C, Nelson RR et al (eds) Technical change and economic theory. Pinter Publishers, London, pp 349–369
Lundvall BA (ed) (2010) National systems of innovation: toward a theory of innovation and interactive learning. Anthem Press, London
Luoma T, Paasi J, Valkokari K (2010) Intellectual property in inter-organisational relationships – findings from an interview study. Int J Innov Manage 14(3):399–414
Marchese D (1999) Joint ownership of intellectual property. Eur Intellect Prop Rev 21:363–369
Mazzoleni R, Nelson RR (1998) The benefits and costs of strong patent protection: a contribution to the current debate. Res Policy 27(3):273–284
Nelson RR, Winter SG (1977) In search of useful theory of innovation. Res Policy 6(1):36–76
Nelson RR, Winter SG (1982) An evolutionary theory of economic change. Harvard University Press, Cambridge, MA
OECD (2008) Compendium of patent statistics. OECD, Paris
Pisano G (1990) The R&D boundaries of the firm: an empirical analysis. Adm Sci Q 35(1):153–176
Powell WW, Owen-Smith J (1998) Commercialism in universities: life sciences research and its linkage with industry. J Policy Anal Manage 17(2):253–277
Powell WW, Koput KW, Smith-Doerr L (1996) Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. Adm Sci Q 41(1):116–145
Pyka A, Saviotti P (2005) The evolution of R&D networking in the biotech industries. Int J Entrep Innov Manage 5:49–68
Rosenbaum PR, Rubin DB (1983) The central role of the propensity score in observational studies for causal effects. Biometrika 70:41–55
Rothaermel FT, Thursby M (2007) The nanotech versus the biotech revolution: sources of productivity in incumbent firm research. Res Policy 36(6):832–849
Schankerman M (1998) How valuable is patent protection? Estimates by technology field. Rand J Econ 29(1):77–107
Schettino F, Sterlacchini A (2009) Reaping the benefits of patenting activities: does the size of patentees matter? Ind Innov 16(6):613–633
Silverman BS, Baum JAC (2002) Alliance-based competitive dynamics in the Canadian biotechnology industry. Acad Manage J 45(4):791–806
Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. Strateg Manage J 18(7):509–533
Van Zeebroeck N, van Pottelsberghe B (2011) Filing strategies and patent value. Econ Innov New Technol 20(6):539–562
Willison DJ, MacLeod SM (2002) Patenting of genetic material: are the benefits to society being realized? Can Med Assoc J 167(3):259–262

Chapter 9
The Impact of Technological Acquisitions on Innovation Quality

Philipp Buss

Abstract In recent years M&A has been as a prominent strategy in the context of inter-firm technology transfer. Prior literature has evaluated the latter by using different types of post-merger innovation measurements. In this connection the chapter provides a framework to analyze the effects of corporate acquisitions on innovation quality. The approach presumes that an acquirer's post-merger innovation outcome is a function of learning capabilities with respect to recent technologies.

We investigate a sample of German domestic and cross-border takeovers, in order to analyze the ex-ante determinants of post-merger innovation quality. The data is based on patent information from the German Patent and Trade Mark Office.

The results show that especially middle-aged and specialized acquirers achieve improved innovation quality subsequent to takeovers. Furthermore, the measurement via patent citations allows a more direct consideration of the value created by corporate acquisitions.

1 Introduction

Mergers and acquisitions (M&A) are primarily known for the ability to provide new opportunities for market entry and as a helpful tool to achieve scale and scope economies (Chakrabarti et al. 1994). Besides that, the acquisition of external knowledge and technologies has become an important motivation to engage in corporate takeovers. Due to rising competition induced by globalizing economies, companies are forced to innovate faster and more efficiently. Simultaneously, they have to enhance their existing products and continuously advance their quality (Acs and

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Preston 1997). Successful innovations at the product level change market structure, decrease the price elasticity of demand, and thereby reduce competitive pressure (Smolny 1998). However, especially companies which are embedded in industries with rapid technological change are often not able to internally develop a sufficient amount of technologies to persist in this competitive environment (Ranft and Lord 2002). Consequently, the acquisition of additional knowledge and capabilities has become an important motivation to engage in corporate takeovers (Dushnitsky and Lenox 2005).

Hence, a part of the academic literature has focused on the effects on innovation performance resulting from takeovers (e.g., Hitt et al. 1991, 1996; Ahuja and Katila 2001; Cloodt et al. 2006; Desyllas and Hughes 2010; Hussinger 2011). In this context, innovation outcome is measured via a variety of approaches such as R&D inputs and outputs or new product announcements (Cassiman et al. 2005; Prabhu et al. 2005). Other important proxies are patent counts, also referred to as innovation quantity.

However, researchers indicate that a sole consideration of patent counts is not a sufficient dimension to capture the inventions' value (Ahuja and Katila 2001; Lanjouw and Schankerman 2004). Thus, a growing number of empirical studies started to use citation counts to account for innovation quality aspects (Harhoff et al. 1999). Nevertheless, in the context of M&A and innovation, most empirical studies have focused on innovation quantity rather than on innovation quality. Additionally, prior findings suggest that innovation quality has a major impact on a company's decision to engage in takeover activities (Grimpe and Hussinger 2008; Zhao 2009). Therefore, the purpose of this study is to develop a framework which can help to explain effects on innovation quality resulting from mergers and acquisitions. Specifically, this chapter addresses the following question: Can an acquirer's post-merger innovation quality be explained by ex ante determinants? From a theoretical point of view, it is assumed that an acquirer's post-merger innovation outcome is a function of learning capabilities with respect to recent technologies.

The empirical analysis is carried out using a sample of German domestic and cross-border takeovers, obtained through ZHEPHYR database. Additional data is based on patent information from the German Patent and Trade Mark Office (GPTO). The implications of this study can be addressed to companies and their managers as well as competition authorities.

The remainder is structured as follows. The next section gives an overview over relevant aspects discussed in prior literature. Section 3 is concerned with the theoretical underpinnings and presents the relevant hypotheses. Section 4 explains the configuration of the underlying data set followed by the empirical results. The latter are discussed in Sect. 6 together with directions for future research.

2 Literature Review

In the connection of M&A and innovation, one can generally identify two bodies of literature. On the one hand, there are studies which examine innovation options inherent in potential takeover targets and bidders and draw conclusions on acquisitions determinants and takeover likelihoods (e.g., Zhao 2009). On the other hand, there are a number of surveys which try to capture the post-merger innovation outcome measured by subsequent input and output parameters like R&D expenditures and patent applications (e.g., Desyllas and Hughes 2010).

Companies screen technology markets prior to acquisition actions (Hussinger 2010), but acquirers face information asymmetries in this context (Akerlof 1970). This is especially given when it comes to the evaluation of small- and medium-sized enterprises (SME) (Shen and Reuer 2005; Capron and Shen 2007). Hence, potential acquirers rely on signals (Spence 1973) in order to evaluate potential targets faster and more efficiently.

In line with these predictions, further surveys confirm that potential target firms become more attractive to acquirers when they feature valuable signals such as large patent stocks or a high pre-acquisition R&D intensity (Grimpe and Hussinger 2008; Desyllas and Hughes 2009). However, the attractiveness of a potential takeover target decreases in cases where technological assets are bound to key inventors or owner-managers (Lehmann et al. 2011). Nonetheless, takeover motivations are not exclusively shaped by external signals but can also be driven by internal factors. Zhao (2009) finds that companies which suffer from declining innovation output are more likely to engage in takeover activities in order to improve their innovation performance. This is especially given for firms, which have experienced decreasing innovation quality. In this context, Grimpe and Hussinger (2008) find that target companies holding high-quality patents are seen to be more valuable targets and therefore bidders are more likely to accept higher deal values.

In literature, post-merger innovation output is mainly measured through the number of new product launches and announcements or patent counts (Hagedoorn and Cloodt 2003). Scholars studying the impact of M&A on output measures find neutral (Prabhu et al. 2005) or negative (Hitt et al. 1991, 1996) outcomes in general. Only Desyllas and Hughes (2010) find that an acquirer's post-merger R&D intensity is positively affected by takeover activities, whereas R&D productivity declines afterward. As expected, findings suggest that acquisitions involving no technical components have no effect on innovation performance (Ahuja and Katila 2001).

Furthermore, Ahuja and Katila (2001) as well as Cloodt et al. (2006) indicate that companies with large knowledge stocks should focus on relatively smaller targets, whereas Hagedoorn and Duysters (2002) find that merging companies of equal size lead to a better post-merger innovation performance. Additionally most results indicate that companies should have a moderate overlap in their knowledge bases and find an inverted U-shaped relationship (Ahuja and Katila 2001; Prabhu et al. 2005; Cloodt et al. 2006). This is the case because theory suggests that mutual learning is best when a part of the acquired knowledge is closely related to the already known (Cohen and Levinthal 1990).

Moreover, the breadth and depth of an acquirer's knowledge prior to the takeover seem to be an important factor. Both have a positive impact on innovation quantity (Prabhu et al. 2005). Firms with a higher breadth of prior knowledge are seen to be more able to integrate external knowledge across different fields (Henderson and Cockburn 1994). Furthermore, firms, which show a high pre-merger R&D concentration, are more likely to achieve increasing post-merger R&D productivity, when engaging in takeovers with companies from the same industry. However, if acquirers engage in unrelated acquisitions, post-merger R&D productivity is affected negatively by a high pre-merger R&D concentration (Desyllas and Hughes 2010). According to theory, firms with a higher depth in key fields are less likely to be affected by technological lockouts and thus are more able to innovate after takeovers (Cohen and Levinthal 1990).

In summary, first, innovation quality seems to be a key driver in takeover decisions (Grimpe and Hussinger 2008; Zhao 2009). Second, surveys examining innovation performance resulting from takeovers rely mainly on measurements which aim to capture innovation quantity rather than innovation quality (e.g., Cloodt et al. 2006). Additionally, researchers claim that in the context of technological takeovers and innovation, different and more accurate measurement must be implied to evaluate the potential effects on value creation (Ahuja and Katila 2001). Thus, the intention of this study is to propose a framework which can help to explain effects on innovation quality resulting from mergers and acquisitions.

3 Theoretical Framework and Hypotheses

3.1 Absorptive Capacity

The concept of absorptive capacity is described as a firm's ability to recognize the value of new external information, assimilate it, and apply it to commercial ends (Cohen and Levinthal 1990). Hence, this implies in general terms that companies with a superior absorptive capacity tend to gain higher profits and benefits from mergers and acquisitions as well as from other external sourcing activities. According to theoretical arguments, there are two main reasons.

First, companies with a higher absorptive capacity are more capable of identifying appropriate sources and selecting corresponding targets due to their strategic objectives (Bowman and Hurry 1993). Second, they are more capable of integrating it into the organization and finally combine it effectively with compatible internal correspondents (Zahra and George 2002).

However, a firm's capability of absorbing external knowledge better than others is not exogenous but must be acquired and developed over time (Cohen and Levinthal 1994; Zahra and George 2002). The building and accumulating of absorptive capacity is conveyed in general terms through R&D activities (Cohen and Levinthal 1989).

3.2 Innovation Quality

To be more precise, a first distinction between innovation and invention should be made. Inventions are usually referred to when talking about the creation of new ideas and their implementation. The notion of innovation is used in the context of commercializing the actual invention (Schumpeter 1934). In this chapter, the focus is restricted on the creation of inventions and furthermore measured via patent counts and citations. Nevertheless, due to its predicate as a set phrase, we use innovation quality and invention quality as synonyms (e.g., Zhao 2009).

Prior studies have argued that simple patent counts are not capable of distinguishing breakthrough inventions from less-important ones. This is because the main value is mainly concentrated only in a few patents (Griliches 1990; Harhoff et al. 1999). Hence, researchers analyzing patent data claim that an invention's value is better reflected by its citation intensity (Harhoff et al. 1999). Following Ahuja and Lampert (2001), these breakthrough inventions are more likely to be discovered by companies which experiment with nascent or pioneering technologies (Ahuja and Lampert 2001). These findings are in turn based on Fleming's (2001) assumption that new inventions emerge by combining and recombining already existing knowledge elements. Technology exhaustion occurs due to the fact that the life-cycle time of the particular technology is exceeded and useful inventions become more unlikely (Fleming 2001).

Consequently, one can conclude that focusing on new technologies inherits a higher chance of creating radically new knowledge and further additional inventions which are considered to be useful. Thus, we further assume that acquiring companies can achieve better results in matters of innovation quality when exhibiting absorptive capacity with respect to recent technologies. This main aspect is taken into account when regarding the different measurements in this study. To sum up and employ a stylized fact, we refer to the perception of recent technologies in the following.

3.3 Hypotheses

3.3.1 Firm Age

As stated above superior absorptive capacity is not exogenous but needs to be developed over time via R&D efforts (Cohen and Levinthal 1990). Those actions are path dependent and furthermore result in learning outcomes and developed routines that are both stored in the organizational memory (Levitt and March 1988; Cohen and Levinthal 1990). Situations and results associated with success tend to be favored and therefore are more likely to be replicated. Over time, perpetual trial and error experiences lead to learning adjustments which finally lead toward specialization (Levinthal and March 1993). This is what can be called core competencies (Leonard-Barton 1992). On the one hand, the resulting specialization seems to be favorable due to the fact that the firm has acquired valuable experience and knowledge in a specific field. This in turn enhances the potential and realized absorptive capacity (Zahra and George 2002). Nevertheless, if a company follows the path of success for too long, rigid routines can come along with the establishment of so-called competence or learning traps. Blinded by past success, firms tend to maintain their focus on current or even departed technologies and therefore neglect the exploration of emerging ones (Levitt and March 1988; Levinthal and March 1993). Those core rigidities make organizations more reluctant toward emerging technologies and experimentation with new knowledge (Leonard-Barton 1992).

Therefore, middle-aged firms are seen to be more capable of improving their innovation quality subsequent to technological takeovers relative to companies which have a lack of experience. Nevertheless, learning and competence traps are more likely to occur with proceeding time, due to competence building and resulting technology reluctance. Hence, we conclude that incumbent firms are less likely to improve their innovation quality resulting from technological takeovers relative to middle-aged companies. Furthermore, the latter are more likely to improve their innovation quality compared to entrants due to a higher absorptive capacity.

Hypothesis 1 *The relationship between the acquirer's firm age and the change in innovation quality subsequent to technological takeovers will be curvilinear (inverted U-shaped).*

3.3.2 Technological Proximity

Reviewing prior literature regarding mergers and acquisitions, the mutual knowledge base relatedness plays an important role (Ahuja and Katila 2001; Hagedoorn and Duysters 2002; Cassiman et al. 2005; Cloodt et al. 2006). According to arguments from absorptive capacity, an acquisition is better served when a fair amount of the external knowledge is already known (Cohen and Levinthal 1990). In this case, the potential absorptive capacity is leveraged for two reasons.

First, it enhances the acquisition of a target's information in terms of a faster and more precise identification of relevant technologies (Zahra and George 2002). Second, the knowledge assimilation is improved due to a better understanding of the relevant information as a result of common languages and shared skills (Cohen and Levinthal 1990; Lane and Lubatkin 1998). But if the acquired knowledge base is too similar, positive innovation outcomes might be hampered as the result of missing new insights and technologies (Cohen and Levinthal 1990). Thus, mutual learning should be best when there is a moderate overlap between two knowledge bases. Concerning the arguments above and recalling again Ahuja's and Lampert's (2001) findings, we conclude that mutual learning with respect to recent technologies should provide higher chances of discovering untried combinations of knowledge which provide high usefulness (Ahuja and Lampert 2001).

Hypothesis 2 *The relationship between technological relatedness (in terms of recent technologies) and the change in innovation quality subsequent to technological takeovers will be curvilinear (inverted U-shaped).*

3.3.3 Acquirer's Knowledge Base Concentration

As noted previously, the building of absorptive capacity is history and path dependent, and the process of capability building shapes a company's preferences (Cohen and Levinthal 1990). Successful learning outcomes lead to specialization, which is favorable on the one hand (Leonard-Barton 1992), but might also inherit negative consequences due to learning traps and lock-in effects on the other hand (Levitt and March 1988; Leonard-Barton 1992; Levinthal and March 1993). Nonetheless, regarding the case of quality inventions, we presume that companies which have developed specialization in recent technologies are less likely to be threatened by learning and competence traps, which only occur after longer periods of time (Ahuja and Lampert 2001). According to that we impose that specialization in recent technologies outweighs negative effects resulting from traps and appearances like the not-invented-here syndrome (Katz and Allen 1982; Cohen and Levinthal 1990).

Following Desyllas's and Hughes's (2010) description of specialization, we conclude that the greater a firm's knowledge base concentration concerning recent technologies, the greater is its expertise in that specific field. Hence, firms with a higher concentration of recent knowledge in a specific field should have the ability to identify and combine external knowledge faster and more efficiently. Therefore, these firms have a greater chance to be the first ones to discover breakthrough inventions of high usefulness.

Hypothesis 3 *The relationship between the concentration of an acquirer's knowledge base (in terms of recent technologies) and the change in innovation quality subsequent to technological takeovers will be positive.*

3.3.4 Acquirer's Knowledge Base Size

Absorptive capacity is acquired over time via R&D efforts (Cohen and Levinthal 1989). Therefore, the size of a company's accumulated knowledge base reflects the amount of its past R&D and external sourcing activities and therefore the extent of its potential and realized absorptive capacity (Desyllas and Hughes 2010). Nevertheless, in the context of innovation quality, we recall the previous arguments from Ahuja and Lampert (2001). Hence, not only the amount of prior knowledge plays an important role but also the amount of knowledge concerning recent technologies (Ahuja and Lampert 2001).

Hypothesis 4 *The relationship between the acquirer's knowledge base size (in terms of recent technologies) and the change in innovation quality subsequent to technological takeovers will be positive.*

4 Methodology

4.1 Sample

The underlying data set was constructed from several sources. Information about mergers and acquisitions in Germany were obtained through ZEPHYR database of Bureau van Dijk Electronic Publishing (BvDEP). Information on the acquiring and target firms' patent activities were obtained from the database of the German Patent and Trade Mark Office. Additional information regarding characteristics of targets and acquirers such as firm age, were sourced through AMADEUS database (BvDEP).

First, we identified all firms located in Germany which acquired either domestic firms or companies located in the extended European Union (EU 27) in the period 1997–2004. Second, we only retained deals in the manufacturing industry according to the European industrial classification (NACE) within the classes 15–36. These sectors were selected due to fact that more than 90% of R&D expenditure in Germany is conducted in the secondary sector (Lang 2009).

Third, we restricted the data set to high-tech deals from chemicals, electronics, engine construction, aircraft, and spacecraft (Cloodt et al. 2006). Further, we retained all deals where the bidder acquired at least 50% of the target firm and therefore achieved majority control. Acquirers which owned less than 50% after the bid were eliminated from the sample. In order to capture pre- and post-merger innovation performance, we only included pairs with a specific patent history. Acquirer and target had to show at least a 3-year pre-acquisition patent activity. The acquirers also had to apply for patents at a minimum level of 3 years after the takeovers. With respect to these requirements, we were able to identify 105 M&A pairs.

4.2 Measurements

4.2.1 Dependent Variable

To construct this measurement, we identified the number of citations received on all patents that an acquirer applied for in the 3-year pre-M&A window. Thereby, we counted all citations received up to 3 years after the patents' application dates. Afterward, we divided the sum of citations received by the total number of patents a firm applied for in the 3 years before the takeover. This procedure was done analogous to an annual citation per-patent ratio. The same was done for the 3-year post-M&A window. We choose the 3-year construction in order to present a medium-term view on a company's innovation quality. Elsewise, relying simply on annual citations rates, a comparison of ex ante and ex post values could have been biased toward annual deviations (Hall et al. 2001). Hence, to account for the change in post-merger innovation quality, we simply subtracted the ex ante from the ex post value.

4.2.2 Firm Age

Firm age was simply constructed by accounting the years since an acquiring company's foundation until the date of the takeover. Furthermore, a quadratic term is included in order to test the nonlinear effect.

4.2.3 Technological Proximity

The measurement of the merging firms' technological proximity was further calculated following Jaffe (1986). The basic idea of this approach is to map each company's technology profile based on the eight patent classes (A–H) according to the International Patent Classification (IPC) (Hussinger 2010). First, a firm's patent stock is calculated as follows:

$$PS_{it} = PS_{it-1}\left(1-\delta\right) + patent\ applications_{it} \tag{9.1}$$

The constant δ represents the knowledge depreciation which is set to 15% according to prior estimations (Hall et al. 1990). In particular, we choose this approach to weight recent technologies more strongly than older ones. Thus, this approach underlies the assumption that patents with an application date that is closer to the takeover are based on more recent technologies. In summary, by using this approach, we try to account for the fact that recent technologies play a more important role in the context of innovation quality due to the theoretical arguments above (Ahuja and Lampert 2001).

Hence, every merging pair is represented by two technology vectors with the acquirer's profile expressed as $F_i = (PS_{iA}, PS_{iB}, \ldots, PS_{iH})$ as well as the target's profile represented by $F_j = (PS_{jA}, PS_{jB}, \ldots, PS_{jH})$. To calculate the technological proximity between the merging companies, we use the angular separation or uncentered correlation of the vectors F_i and F_j according to Jaffe (1986):

$$Technological\ Proximity = \frac{F_i F_j}{\left(F'_i F_j\right)\left(F'_i F_j\right)} \tag{9.2}$$

Resulting from the calculation above, the merging firms' technological proximity can be expressed by a value with a range between 0 and 1. Furthermore, we include a quadratic term to account for a potential nonlinear relationship.

4.2.4 Knowledge Concentration

The calculation of the acquirer's knowledge base concentration was conducted by using the Hirschman-Herfindahl index (Desyllas and Hughes 2010). Again, the following approach is based on the technology classes according to the IPC. We calculated the distribution of the patent applications across the technology classes A–H in the 3 years preceding the takeover. A 3-year period only captures patents applications which are of low age and therefore represent recent inventions, as argued above (Ahuja and Lampert 2001). Based on the eight patent classes defined by the IPC, the concentration index was calculated as follows:

$$Knowledge\ Concentration = \sum_{i=1}^{n} \left(\frac{P_i}{P} \right)^2 \tag{9.3}$$

Accordingly, the number of patents, which fall into each class from A to H in the preceding 3-year window, is represented by *Pi*. Furthermore, let n be the relevant patent classes and P be the total number of patents a company holds. The results of the Hirschman-Herfindahl index take figures from zero to one.

4.2.5 Knowledge Base Size

It has been common in literature to capture absorptive capacity via R&D expenditures or R&D intensity (Cohen and Levinthal 1990). According to Desyllas and Hughes (2010), using the patent stock as a proxy for a company's knowledge base is favorable compared to R&D expenditure, because patent counts do not suffer from time discontinuities in comparison to R&D expenditure series. Therefore, the size of the acquirer's knowledge base is represented by the company's patent stock at the time of the takeover (Dushnitsky and Lenox 2005). Equal to the approach applied in terms of technological proximity, the patent stock is calculated through the following:

$$PS_t = PS_{t-1}(1-\delta) + patent\ applications_t \tag{9.4}$$

In contrast to the approach used to calculate technological proximity, this one does not distinguish between the different technology classes. Hence, PS_t stands for the patent stock in the takeover period including all patents of all eight patent classes. We again assume a depreciation rate of 15% per year (Hall et al. 1990). The distribution of the number of patents per acquirer is skew. For the empirical analysis, the logarithm of the pre-merger patent stock is used.

4.2.6 Control Variables

Furthermore, we include a number of control variables to account for possible additional effects on the change of innovation quality resulting from M&A activities. The variables related to the acquirer are *relative size of the acquired knowledge* *base*, *cross-border acquisition*, *multiple acquisition*, and *public acquirer*. They have been suggested to affect post-merger innovation performance in prior studies (e.g., Ahuja and Katila 2001; Shen and Reuer 2005; Desyllas and Hughes 2010). Additionally, we include a dummy variable to distinguish between public and private targets. This is due to the fact that publicly traded firms are favored acquisition targets. This is because in the case of private ones higher transaction costs and information asymmetries are seen as elements hindering the integration and innovation process (Shen and Reuer 2005). Obtaining pre-merger information on private firms is quite difficult due to the fact that especially financial statements and annual reports must not be published (Veugelers 2006; Hussinger 2010). Thus, we set the value to one if the target company is publicly traded. We set the value to zero if the target company is a private firm (Desyllas and Hughes 2010).

5 Results

5.1 Descriptive Statistics

Table 9.1 summarizes the descriptive statistics of the independent variables included in the analysis. Furthermore, it shows the correlation matrix as well as the variance inflation factors (VIF). The mean values and standard deviations of the explanatory variables firm age, knowledge base concentration, and knowledge base size correspond to the characteristics of the acquiring firms. Technological overlap and relative size of the knowledge base explain pre-merger relationships among the acquiring firm and the acquisition target.

The summary statistics show that the acquiring firms are on average 83 years old, which indicates that mainly companies with market experience engage in technological takeovers. Moreover, the summary statistics show that in the present sample the merging firms' knowledge stocks overlap by 0.74. This might indicate that targets with a higher technological proximity become more attractive to acquirers and are therefore more likely to be selected. The mean relative knowledge base size, defined as the ratio of the target's knowledge base size value to the acquirer's, is 0.52. Regarding a company's patent stock as an equivalent for firm size (Audretsch and Acs 1991), one can see that acquirers generally prefer companies which are relatively smaller. This might be originated in the fact that small firms are generally found to be more innovative at the product level (Link and Rees 1990).

Furthermore, the summary statistics reveal that more than 66% of the acquirers in the present sample are public companies. In addition to this, the statistics show that only 29% of the targets from the present sample were public firms. Given the findings from Shen and Reuer (2005), one should expect a higher share of public targets due to lower transaction costs and less information asymmetries (Shen and Reuer 2005). Furthermore, Table 9.1 shows that 60% of all deals inherent in the

Table 9.1 Descriptive statistics, correlation matrix, and variance inflation factors

	Mean	Std. dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	VIF
Firm age	83.44	62.52	1.00	–	–	–	–	–	–	–	–	1.25
Technological proximity	0.74	0.32	–0.00	1.00	–	–	–	–	–	–	–	1.06
Knowledge concentration	0.64	0.22	–0.18*	0.08	1.00	–	–	–	–	–	–	1.46
Log (knowledge base)	4.72	1.68	0.15	0.04	–0.50***	1.00	–	–	–	–	–	1.75
Relative size knowledge bases	0.52	1.48	0.21*	–0.04	0.03	–0.30**	1.00	–	–		–	1.23
Multiple acquisition	0.60	0.49	0.15	0.01	–0.07	0.22**	–0.06	1.000	–	–	–	1.31
Cross-border acquisition	0.38	0.48	0.19*	–0.18*	–0.18*	–0.00	0.07	–0.27**	1.00	–	–	1.22
Public target	0.29	0.45	–0.00	0.06	–0.06	0.15	–0.00	–0.02	0.14	1.00	–	1.09
Public acquirer	0.66	0.47	–0.07	–0.04	0.06	0.13	–0.08	0.29**	–0.14	0.15	1.00	1.20

*$p < 0.1$; **$p < 0.05$; *** $p < 0.01$

present sample are multiple deals, which means that, beside a specific deal, the acquiring company carried out at least one more takeover in the relevant period from 1997 to 2004. Additionally, the summary table reveals that 38% of all targets in the present sample were acquired cross-border.

5.2 Regression Results

The hypotheses were tested using ordinary least squares estimates (OLS), and the results are presented in Table 9.2. Nine different specifications are shown. The first is the base model which solely includes the control variables. The models 2–7 include the single explanatory variables of interest, whereas model 8 represents the full model.

The first hypothesis focused on a curvilinear relationship between the acquirer's firm age and the change in innovation quality. Table 9.2 depicts statistically significant effects. Model 3 and 8 show that the linear coefficient of firm age is positive, whereas the squared terms exhibit negative signs.

Moreover, model 8 shows that the technological proximity between acquirer and target has a negative impact, which is significant at the 10% level. Model 5 on the contrary reveals that Hypothesis 2, which indicates an inverted curvilinear relationship has to be rejected. However, the results can be only confirmed partly, due to the fact that the coefficient in model 4 is insignificant. Nevertheless, these results provide at least proof for fact that too much overlap might affect innovation quality in a negative manner. Hence, we simply exclude the quadratic term from model 8 and solely include the linear term, which seems to describe the relationship between technological proximity and the independent variable more accurately.

In Hypothesis 3, a positive relationship was proposed between an acquirer's knowledge base concentration and the change in innovation quality as a result of technological takeovers. This prediction can be confirmed with the results from Table 9.2.

Contrary to this, Hypothesis 4, which proposes a positive impact of the acquirer's knowledge base size on the change in innovation quality, cannot be confirmed with statistically significant results. Nevertheless, the coefficient shows a positive sign, but due to the absence of statistically significant results the proposed theoretical arguments from Hypothesis 4 cannot be supported.

6 Discussion

Previous studies have investigated the relationship between M&A and innovation performance proxied by patent data. Moreover, they identified several determinants influencing the post-merger innovation outcome (e.g., Ahuja and Katila 2001; Cloodt et al. 2006). Nevertheless, most studies referred to innovation quantity than

Table 9.2 Estimation results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm age	–	0.001**	0.001***	–	–	–	–	0.001***
		(0.4e–3)	(0.4e–3)					(0.4e–3)
Firm age^2	–	–	–0.1e–4**	–	–	–	–	–0.1e–4**
			(0.4e–5)					(0.4e–5)
Technological proximity	–	–	–	–0.116	0.028	–	–	–0.137*
				(0.082)	(0.139)			(0.077)
Technological proximity^2	–	–	–	–	0.416	–	–	–
					(0.324)			
Knowledge concentration	–	–	–	–	–	0.227*	–	0.342***
						(0.116)		(0.128)
Log (knowledge base)	–	–	–	–	–	–	0.006	0.018
							(0.017)	(0.019)
Relative size	–0.053***	–0.061***	–0.046**	–0.054***	–0.057***	–0.055***	–0.051***	–0.046**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)	(0.019)	(0.018)
Multiple acquisition	0.022	–0.011	–0.046	0.020	0.021	0.039	0.017	–0.036
	(0.059)	(0.060)	(0.060)	(0.058)	(0.058)	(0.058)	(0.060)	(0.058)
Cross-border acquisition	–0.042	–0.070	–0.057	–0.058	–0.054	–0.020	–0.043	–0.051
	(0.056)	(0.056)	(0.055)	(0.057)	(0.057)	(0.056)	(0.056)	(0.055)
Public target	0.014	0.016	0.003	0.023	0.017	0.020	0.011	0.014
	(0.059)	(0.058)	(0.056)	(0.059)	(0.059)	(0.058)	(0.060)	(0.055)
Public acquirer	–0.017	–0.002	0.009	–0.024	–0.024	–0.027	–0.017	–0.017
	(0.059)	(0.058)	(0.057)	(0.058)	(0.058)	(0.058)	(0.059)	(0.056)
R^2	0.094	0.134	0.188	0.122	0.127	0.128	0.095	0.264
F	2.052*	2.523**	3.207**	2.059*	2.012*	2.397*	1.713	3.377***

N = 105 (standard errors in parentheses)
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

to innovation quality. Hence, the study at hand provides one approach to measure post-merger innovation quality performance. Besides that, the theoretical part offers several theoretical considerations, which might help to explain post-merger effects on innovation quality. The results show that especially specialized and middle-aged acquirers can produce higher-quality innovations post M&A. Furthermore, technological proximity is seen to affect post-merger innovation quality in a negative manner.

In the first instance, we find that middle-aged acquirers are more likely to benefit from technological takeovers in terms of an enhanced innovation quality. Younger companies and start-ups seem to lack experience, financial resources, and the necessary absorptive capacity. Furthermore, these results emphasize the presumption that companies tend to develop competence traps with increasing age as a result of path dependencies (Levitt and March 1988; Ahuja and Lampert 2001). Therefore, the limited scope of search for potential matching knowledge seems to outweigh an increased absorptive capacity over time. The results can be slightly confirmed by Balasubramanian and Lee (2008). They show that especially the technical quality measured through patent citations falls with increasing firm age.

The second finding suggests that pre-merger technological proximity between targets and acquirers does not exhibit a curvilinear relationship with the change of innovation quality. Previous studies found an inverted U-shaped relationship between the acquirer's and target's technological relatedness and the pre-merger patent counts (Ahuja and Katila 2001; Cloodt et al. 2006). But the theoretical arguments do not seem to hold in the context of innovation quality. However, these results do not seem to be too unlikely for several reasons. First, the results confirm at least that an overlap that is too high will diminish learning outcomes and will furthermore be harmful to the development of high-quality inventions. Second, due to theoretical arguments, it can be useful to bring together knowledge which is mainly diverse in order to discover breakthrough inventions which are radically new (Ahuja and Lampert 2001).

Furthermore, we find that acquirers with developed core competencies do profit from technological takeovers and have the ability to enhance their innovation quality. This denotes that core competencies prior to takeovers in terms of recent technologies might improve the interfirm knowledge transfer. These findings can be seen in line with Hughes and Desyllas (2010). They find that acquirers which show a high pre-merger R&D concentration are more likely to achieve increasing post-merger R&D productivity.

The empirical results regarding mergers and acquisitions in general are heavily discussed in literature, especially against the background that theory and corresponding findings are contradictory, which in turn stirs up the debate between theory and practice. This is especially given in the context that corporate takeovers are frequently blamed to be the main drivers of value destruction (e.g., Moeller et al. 2005).

Regarding M&As in the light of innovation quality, highly cited patents do not only provide value for a specific company; they also serve as an indicator for social benefits generated by the invention, which can lead to an increased consumer sur-plus (Trajtenberg 1990). Thus, cartel authorities should ponder the losses and gains of specific corporate takeovers. This should be done against the background that the potential threat of monopoly building might be outweighed by a higher welfare resulting from high-quality inventions.

Furthermore, researchers analyzing patent data have stated that patent citations can constitute good indicators for knowledge spillovers (Hall et al. 2001). Additionally, economic growth theorists have often argued that R&D spillovers are important factors of economic growth (Romer 1986; Jaffe et al. 1993). Hence, it is conceivable that technologically motivated mergers and acquisitions make significant contributions to economic growth when incorporating increasing patent citation rates. Authorities should keep this in mind when evaluating takeovers in the light of antitrust concernings.

Several limitations should be noted when regarding the results. First, the results are limited to industries where research and development as well as patenting play an important role. This can be the ones which were included in this study (Cloodt et al. 2006). Furthermore, one might also regard emerging high-tech sectors such as food, soaps, and plastics (Makri and Lane 2007). Another limitation of this study might be seen in missing lag measurements for the dependent variable. This is due to the fact that acquisitions effects need longer time horizons to materialize (Hagedoorn and Duysters 2002). Hence, it becomes more likely that innovation outcomes lag the takeover activities, and therefore, a longer time horizon post M&A should be considered (Makri et al. 2010). It may be that thus, given the measurement in this study, the full post-merger innovation outcome might not be displayed. Unfortunately, the inclusion of time lags would have reduced the sample size vehemently. Nevertheless, several prior studies have also measured innovation performance with similar time horizons (e.g., Ahuja and Katila 2001; Cloodt et al. 2006; Sampson 2007; Valentini 2011).

Third, one has to take the problem of endogeneity into account due to a nonrandom sample selection (Greene 2003). One must assume that the decision to engage in technological takeover activities cannot be regarded as exogenous. Nevertheless, literature provides several approaches which can help to overcome this problem (Winship and Morgan 1999). One potential approach might be the application of matching estimators (Valentini 2011). This is seen to be a fruitful recommendation for future research.

References

Acs ZJ, Preston L (1997) Small and medium-sized enterprises, technology, and globalization: introduction to a special issue on small and medium-sized enterprises in the global economy. Small Bus Econ 9(1):1–6

Ahuja G, Katila R (2001) Technological acquisitions and the innovation performance of acquiring firms: a longitudinal study. Strateg Manage J 22(3):197–220

Ahuja G, Lampert MC (2001) Entrepreneurship in the large corporation: a longitudinal study of how established firms create breakthrough inventions. Strateg Manage J 22(6–7):521–543

Akerlof GA (1970) The market for “lemons”: quality uncertainty and the market mechanism. Q J Econ 84(3):488–500

Audretsch DB, Acs ZJ (1991) Innovation and size at the firm level. South Econ J 57(3):739–744

Balasubramanian N, Lee J (2008) Firm age and innovation. Ind Corp Change 17(5):1019–1047

Bowman EH, Hurry D (1993) Strategy through the option lens: an integrated view of resource investments and the incremental-choice process. Acad Manage Rev 18(4):760–782

Capron L, Shen JC (2007) Acquisitions of private vs. public firms: private information, target selection, and acquirer returns. Strateg Manage J 28(9):891–911

Cassiman B, Colombo MG, Garrone P, Veugelers R (2005) The impact of M&A on the R&D process: an empirical analysis of the role of technological- and market-relatedness. Res Policy 34(2):195–220

Chakrabarti A, Hauschildt J, Süverkrüp C (1994) Does it pay to acquire technological firms? R&D Manage 24(1):047–056

Child J. (1972) “Organization structure, environment, and performance: The role of strategic choice”, Sociology, Vol. 6 (January 2971), pp: 1–22

Cloodt M, Hagedoorn J, Kranenburg HV (2006) Mergers and acquisitions: their effect on the innovative performance of companies in high-tech industries. Res Policy 35(5):642–654

Cohen WM, Levinthal DA (1989) Innovation and learning: the two faces of R&D. Econ J 99(397):569–596

Cohen WM, Levinthal DA (1990) Absorptive capacity: a new perspective on learning and innovation. Adm Sci Q 35(1, Special Issue: Technology, Organizations, and Innovation):128–152

Cohen WM, Levinthal DA (1994) Fortune favors the prepared firm. Manage Sci 40(2):227–251

Desyllas P, Hughes A (2009) The revealed preferences of high technology acquirers: an analysis of the innovation characteristics of their targets. Camb J Econ 33(6):1089–1111

Desyllas P, Hughes A (2010) Do high technology acquirers become more innovative? Res Policy 39(8):1105–1121

Dushnitsky G, Lenox MJ (2005) When do firms undertake R&D by investing in new ventures? Strateg Manage J 26(10):947–965

Fleming L (2001) Recombinant uncertainty in technological search. Manage Sci 47(1):117–132

Greene W (2003) Econometric analysis. Prentice Hall, Upper Saddle River

Griliches Z (1990) Patent statistics as economic indicators: a survey. J Econ Lit 28(4):1661–1707

Grimpe C, Hussinger K (2008) Pre-empting technology competition through firm acquisitions. Econ Lett 100(2):189–191

Hagedoorn J, Cloodt M (2003) Measuring innovative performance: is there an advantage in using multiple indicators? Res Policy 32(8):1365–1379

Hagedoorn J, Duysters G (2002) The effect of mergers and acquisitions on the technological performance of companies in a high-tech environment. Technol Anal Strateg Manage 14(1):67–85

Hall BH, Berndt E, Levin RC (1990) The impact of corporate restructuring on industrial research and development. Brookings Pap Econ Activ Microecon 1990:85–124

Hall BH, Jaffe AB, Trajtenberg M (2001) The nber patent citations data file lessons, insights and methodological tools. NBER working paper series (8498), pp 1–74

Harhoff D, Narin F, Scherer FM, Vopel K (1999) Citation frequency and the value of patented inventions. Rev Econ Stat 81(3):511–515

Henderson R, Cockburn I (1994) Measuring competence? Exploring firm effects in pharmaceutical research. Strateg Manage J 15(S1):63–84

Hitt MA, Hoskisson RE, Ireland RD, Harrison JS (1991) Effects of acquisitions on R&D inputs and outputs. Acad Manage J 34(3):693–706

Hitt MA, Hoskisson RE, Johnson RA, Moesel DD (1996) The market for corporate control and firm innovation. Acad Manage J 39(5):1084–1119

Hussinger K (2010) On the importance of technological relatedness: SMEs versus large acquisition targets. Technovation 30(1):57–64

Hussinger K (2011) Absorptive capacity and post-acquisition inventor productivity. J Technol Trans, August 2012, 37(4):490–507

Jaffe AB (1986) Technological opportunity and spillovers of R&D: evidence from firms' patents, profits, and market values. Am Econ Rev 76(5):984–1001

Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. Q J Econ 108(3):577–598

Katz R, Allen TJ (1982) Investigating the not invented here (NIH) syndrome: a look at the performance, tenure, and communication patterns of 50 R&D project groups. R&D Manage 12(1):7–20

Lane PJ, Lubatkin M (1998) Relative absorptive capacity and interorganizational learning. Strateg Manage J 19(5):461–477

Lang G (2009) Measuring the returns of R&D: an empirical study of the German manufacturing sector over 45 years. Res Policy 38(9):1438–1445

Lanjouw JO, Schankerman M (2004) Patent quality and research productivity: measuring innovation with multiple indicators. Econ J 114(495):441–465

Lehmann EE, Braun T, Krispin S (2011) Entrepreneurial human capital, complementary assets, and takeover probability. J Technol Trans, October 2012, 37(5):589–608

Leonard-Barton D (1992) Core capabilities and core rigidities: a paradox in managing new product development. Strateg Manage J 13(S1):111–125

Levinthal DA, March JG (1993) The myopia of learning. Strateg Manage J 14(S2):95–112

Levitt B, March JG (1988) Organizational learning. Annu Rev Sociol 14:319–340

Link AN, Rees J (1990) Firm size, university based research, and the returns to R&D. Small Bus Econ 2(1):25–31

Makri M, Lane PJ (2007) Responding to technological maturity: a sociocognitive model of science and innovation in technological communities. J High Technol Manage Res 18(1):1–14

Makri M, Hitt MA, Lane PJ (2010) Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. Strateg Manage J 31(6):602–628

Moeller SB, Schlingemann FP, Stulz RM (2005) Wealth destruction on a massive scale? A study of acquiring-firm returns in the recent merger wave. J Finance 60(2):757–782

Prabhu JC, Chandy RK, Ellis ME (2005) The impact of acquisitions on innovation: poison pill, placebo, or tonic? J Mark 69(1):114–130

Ranft AL, Lord MD (2002) Acquiring new technologies and capabilities: a grounded model of acquisition implementation. Organ Sci 13(4):420–441

Romer PM (1986) Increasing returns and long-run growth. J Polit Econ 94(5):1002–1037

Sampson RC (2007) R&D alliance and firm performance: the impact of technological diversity and alliance organization on innovation. Acad Manage J 50(2):364–386

Schumpeter J (1934) The theory of economic development. Harvard University Press, Cambridge, MA

Shen JC, Reuer JJ (2005) Adverse selection in acquisitions of small manufacturing firms: a comparison of private and public targets. Small Bus Econ 24:393–407

Smolny W (1998) Innovations, prices and employment: a theoretical model and an empirical application for west German manufacturing firms. J Ind Econ 46(3):359–381

Spence AM (1973) Job market signaling. Q J Econ 87(3):355–374

Trajtenberg M (1990) A penny for your quotes: patent citations and the value of innovations. Rand J Econ 21(1):172–187

Valentini G (2011) Measuring the effect of M&A on patenting quantity and quality. Strategic Management Journal, March 2012, 33(3):336–346

Veugelers R (2006) Literature review on M&A and R&D. In: Cassiman B, Colombo MG (eds) Mergers & acquisitions: the innovation impact. Elgar, Northampton

Winship C, Morgan SL (1999) The estimation of causal effects from observational data. Annu Rev Sociol 25(1):659–706

Zahra SA, George G (2002) Absorptive capacity: a review, reconceptualization, and extension. Acad Manage Rev 27(2):185–203

Zhao X (2009) Technological innovation and acquisitions. Manage Sci 55(7):1170–1183

Chapter 10
External Technology Supply and Client-Side Innovation

Christian Peukert

Abstract Flexibility in response to competitive pressure from globalized markets and increasingly individualized costumer desires has become vital for firms. A common strategy to address this challenge is to employ a dynamic concept of organization and reach beyond the boundaries of the firm. Accordingly, technology transfer from providers of knowledge intensive business services attracts more and more attention.

In this context we focus on external supply of information technology and client-side innovation. The aim of this chapter is to contribute to resolving an empirical puzzle arising from the prior literature. Some authors find beneficial effects of IT outsourcing, others underline that firms often fail to achieve expected strategic goals.

Our stylized theoretical model combines a knowledge production function framework and transaction cost economics. We hypothesize that the right balance between internal and external knowledge is critical for innovation.

The empirical application is German firm-level data covering a wide range of industries, 2003-2006. Our results largely support the theoretical arguments and suggest a positive linear relationship between the level of outsourcing and process innovation. For product innovation we find a hump-shape.

1 Introduction

Make-or-buy decisions have a long history. For example, already in the ancient Roman Empire, tax collection was given in private hands (Kakabadse and Kakabadse 2002, p. 189). Hence, long before the Industrial Revolution, division of labor has

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been identified as a source of efficiency enhancement. The literature has addressed this question from a variety of perspectives. One approach is to look at models of two regions with asymmetric factor endowments to explain how firms decide on where to locate different stages of the production process (Krugman 1991; Antràs and Helpman 2004; Grossman and Helpman 2005; ener and Zhao 2009). With the advent of new technologies that render transportation costs of information negligible, recently also more knowledge-intensive corporate functions are subject to make-or-buy decisions (Freund and Weinhold 2002; Amiti and Wei 2006). As firms seek flexibility in response to globalized markets and increasingly individualized customer desires, research and development (R&D) services and most dominantly computer, and information and communication technology (ICT) services are traded (World Trade Organization 2011).

Despite its growing practical relevance, empirical research on external supply of information technology (IT) is still scarce. An *IT outsourcing paradox* persists in the literature: While a number of large scale firm- and industry-level studies find positive impacts on productivity in the short run (Ohnemus 2007; Knittel and Stango 2008; Han et al. forthcoming), client organizations often report to be dissatisfied in terms of long run strategic goals such as innovation (Miozzo and Grimshaw 2005; Overby 2007, 2010; Bacheldor 2010). Evidence from case study research and insights from simulation models suggests that this is due to myopic management and opportunistic vendor behavior (Barthélemy 2001; Rouse 2009; Windrum et al. 2009). In contrast, there is a substantial body of work showing that firms benefit from linkages with related types of knowledge-intensive business services (KIBS) (Bessant and Rush 1995; Antonelli 1998; Muller and Zenker 2001; Czarnitzki and Spielkamp 2003; Howells 2006; Tether and Tajar 2008; Huang and Yu 2011; Görg and Hanley 2011).

In this chapter, we aim to contribute a differentiated explanation for this prevailing empirical puzzle. We change the focus from cost cutting to a more strategic perspective by recognizing IT outsourcing as a source of external knowledge and expertise (Scarbrough 1998). In a stylized theoretical model, we extend the knowledge production framework with insights from transaction cost economics. Specifically we ask: Can IT outsourcing impact the innovative capabilities of the client? Our hypothesis is that, depending on the strategic importance of the service subject to outsourcing, firms face a trade-off between make and buy. That is, the optimal mix of internal and external knowledge is critical in order to achieve innovative outcomes (Harrigan 1984; Arora and Gambardella 1990; Audretsch et al. 1996; Piga and Vivarelli 2004; Afuah 2001; Cassiman and Veugelers 2006; Grimpe and Kaiser 2010). Among Weigelt and Sarkar's (2009) paper on vendor-induced knowledge spillovers, ours is one of the first studies to empirically investigate the relationship between IT outsourcing and innovation. The empirical application is German firm-level data spanning a wide range of industries observed in 2003–2006.

We find that IT outsourcing is positively associated with cost-reducing process innovation. The impact on demand-enhancing product innovation is found to be hump-shaped. External knowledge embodied in IT services seems to positively contribute to client-side innovation up to a tipping point, after which the relationship becomes steeply decreasing. That is, we can explain negative outcomes with over-outsourcing. The remainder is structured as follows: We start off with a discussion of the related literature and present a stylized theoretical model of outsourcing and innovation. Data and methodology are described in the next sections, followed by a discussion of our results. Finally, we conclude and give some directions for further research.

2 Background Discussion

According to the information systems literature, we can define IT outsourcing as a "*significant contribution by external vendors in the physical and/or human resources associated with the entire or specific components of the IT infrastructure in the user organization*" (Loh and Venkatraman 1992, p. 9). Lacity et al. (2009) distinguish three categories of sourcing decisions: "total outsourcing" (at least 80% of the IT budget is represented by third-party responsibility), "total insourcing" (at least 80% of the IT budget is managed and provided internally), and "selective sourcing" (selected IT functions are provided externally, the remaining 20–80% of the budget is provided internally).

Ever since Eastman Kodak decided to hand over its entire data center to IBM in 1989 (Loh and Venkatraman 1992, p. 8), the market for IT outsourcing has grown extensively in all parts of the world (Lacity and Willcocks 2001, p. 2 sq.). In Germany, for example, 66% of firms with at least ten employees have been outsourcing IT activities in 2007. Only Finland and Denmark have a higher percentage share in the EU15 countries (Eurostat data, see Fig. 10.6). According to industry analysts, the global outsourcing market had an average size of $88.4 billion in terms of total contractual value from 2007 to 2010 (TPI 2011).

A number of authors have looked at the outsourcing decision from a cost perspective, suggesting that firms consider outsourcing if expected production cost savings outweigh transaction costs (Dibbern et al. 2004). These cost savings can come in the form of vendor buying power in terms of hard- and software, access to specialized human capital, increased capacity utilization, or fixed cost degression.

However, empirical research on the outcome is still scarce. Some studies find evidence that IT outsourcing is associated with productivity growth. Ohnemus (2007), for example, shows that labor productivity of German firms that outsource basic IT services is significantly higher compared to non-outsourcing firms. Han et al.'s (2011) analysis of US industry-level data suggests a 2–4% increase in productivity. Knittel and Stango (2008) also find a 30% reduction in operating costs for US cooperative banks.

Nevertheless, case study research (Miozzo and Grimshaw 2005) and trade press articles (e.g. Overby 2007, 2010; Bacheldor 2010) report that clients often fail to reach innovation as a long-term strategic goal. Only 24% of 290 respondents to an online survey of subscribers to the CIO magazine indicate that outsourced activities contributed most to IT innovation (compared to 76% in-house). The discrepancy between expected and actual outcomes of IT outsourcing, at the same time with wide diffusion across industries and countries, is what researchers have called the *IT outsourcing paradox*.

Based on case study research, Rouse (2009) concludes that this is mainly due to myopic management and opportunism. Similarly, Overby (2010) argues that innovation is expected but often not properly defined and sometimes not recognized because traditional business metrics fail to properly measure innovation outcomes. This suggests a trade-off between cost advantages for (specialized) input and a holdup problem (Klein et al. 1978; Grossman and Helpman 2002). The simulation model of organizational innovation by Windrum et al. (2009) goes in the same direction. They posit that IT radically expands technical opportunities for the outsourcing of production and significantly lowers external coordination costs. A short run consequence of outsourcing is a reduction in the depth of hierarchy. This results in a reduction of fixed cost and gains in productivity. Accordingly, because managers have short run objectives, this increases the probability that the firm will choose the outsourcing option again. The firm becomes locked-in to an outsourcing trajectory. Innovation in the sense of a recombination of organizational activities in response to changing business needs then is difficult to achieve as it demands coordination with the external supplier. The result is a long run productivity decline.

Given such a trade-off, Hecker and Kretschmer (2010) argue that the holdup effect dominates unless vendor-side production cost decreasing scale effects increase at an increasing rate. They suggest that this could be the case due to network externalities where the client's utility is increasing in the number of other clients of the supplier. Among gains from modularization, knowledge spillovers can be a type of such network externalities. Vendors accumulate expertise from the combination of explicit and implicit knowledge gained in the interaction with other clients (double-loop learning), which finally results in superior solutions to individual problems (Antonelli 1998). In a sense, suppliers can be seen as "bees cross-pollinating between firms, carrying experiences and ideas from one location or context into another" (Bessant and Rush 1995, p. 102). A relatively large body of literature supports this argument in related settings. It is found that clients benefit from linkages with KIBS,[1] and also KIBS themselves are more innovative compared to firms in all service sectors (Muller and Doloreux 2009). Weigelt and Sarkar (2009) explicitly look at the role of vendors in the innovation adoption of clients in IT outsourcing relationships. The application is US cooperative banks and

[1] KIBS are defined as firms from the NACE 72–74 sectors, that is, *computer and related activities, research and development*, and *other business services* such as *legal services, accounting, and advertising* (Muller and Doloreux 2009).

electronic banking innovations. The core finding is similar: Clients contracting a technically and organizationally more experienced vendor have a higher propensity to adopt innovation.

In the following, we propose another explanation for the prevailing empirical puzzle. We argue that the scale of outsourcing is crucial to explain both positive and negative outcomes. From a theoretical perspective, our work is related to Windrum et al. (2009). Under certain conditions we can derive similar implications. A central assumption in their paper is that firms face a binary decision between in-house provision and outsourcing. The setting of our study allows for a continuum of cooperative (partial) types of outsourcing decisions. With this we can replicate the main result that firms are better off without outsourcing, however, only when the specificity of the IT service subject to outsourcing is sufficiently high. In all other cases, we hypothesize a positive effect on outsourcing compared to in-house provision. From an empirical perspective, the most related papers are Weigelt and Sarkar (2009) and Grimpe and Kaiser (2010). In contrast to Weigelt and Sarkar (2009), we focus on the client-side and do not consider vendor characteristics directly. Further, we are able to observe in-house provision, partial and complete outsourcing. Finally, our dependent variables measure client-induced innovation rather than adoption of new technology. Grimpe and Kaiser (2010) are related in the sense that the authors also observe a range of outsourcing decisions. However, the subject is R&D outsourcing. Interestingly, our analysis partly produces similar results: The main finding of Grimpe and Kaiser (2010) is that outsourcing exerts a curvilinear relationship with product innovation. We additionally look at process innovation and find evidence for a different (increasing) relationship in this case.

3 A Stylized Model of Innovation and Outsourcing

From a knowledge perspective organizations may be characterized as "social communities in which individual and social expertise are transformed into economically useful products and services by the application of a set of higher-order organizing principles" (Kogut and Zander 1992, p. 384). That is, choosing the optimal sourcing strategy implies understanding IT outsourcing not only "as the product of a decision process but, more fundamentally, as a particular way of organizing knowledge" (Scarbrough 1998, p. 137). The process of gathering and sharing tacit experience and articulating and codifying it into explicit knowledge (Nonaka and Takeuchi 1995) involves exploring and exploiting competencies both internal and external to the firm. Consider this process to be specified as a knowledge production function (Griliches 1979), such that

$$K_t = K_{t-1} + R(E) - c_\theta E, \tag{10.1}$$

$$K_t = K_0 + t \cdot [R(E) - c_\theta E], \tag{10.2}$$

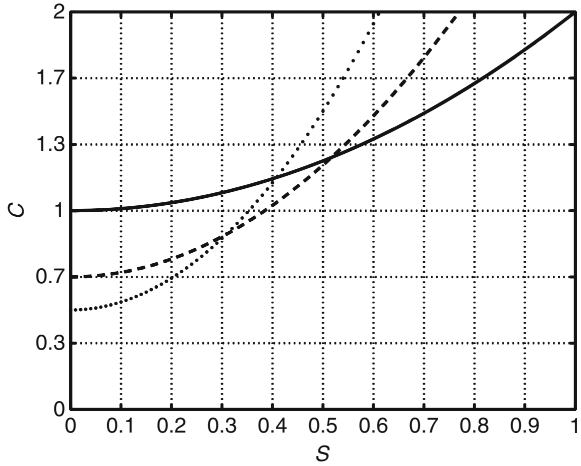

Fig. 10.1 Transaction costs (Similar to Williamson (1991), Fig. 10.1, p. 284)

where expertise E can be provided internally as well as by sources external to the firm. It is assumed that returns increase with expertise, such that $\partial R / \partial E > 0$. This reflects the intuition that more valuable expertise adds more to the knowledge stock of the firm.

Of course, there is a cost to accessing expertise. According to transaction cost economics (Williamson 1975, 1985, 1991), bounded rationality and opportunism raise issues that lead to heterogenous transaction costs c_θ among different types of organization θ. We follow Audretsch et al. (1996) and focus on a ceteris paribus analysis of transaction costs as a function of the degree of specificity, leaving other determinants such as uncertainty and complexity aside. Therefore, assume that expertise can vary in its specificity s. If s is low, expertise is very generic. If s is high, it is very firm specific. Williamson (1985) argues that markets provide high-powered incentives and are better able to curtail bureaucratic distortion compared to internal organization and cooperation. However, control of opportunistic behavior is most effective in a hierarchical organization. The risk of holdup rises with specificity. A particular reason is that switching to alternative technologies and modes of provision is costly (Whitten and Wakefield 2006; Peukert 2011). Accordingly, we specify transaction costs according to

$$c_{\theta,s} = (\frac{1}{\alpha}s)^2 + \alpha;\ \alpha = \frac{1}{1+\theta};\ \theta,\ s \in [0,1], \tag{10.3}$$

where θ is the outsourcing level.

The transformation of knowledge into new processes, products, and services is finally modeled as the probability that the stock of accumulated knowledge exceeds a certain threshold level τ. Economically this may be interpreted as the net value of

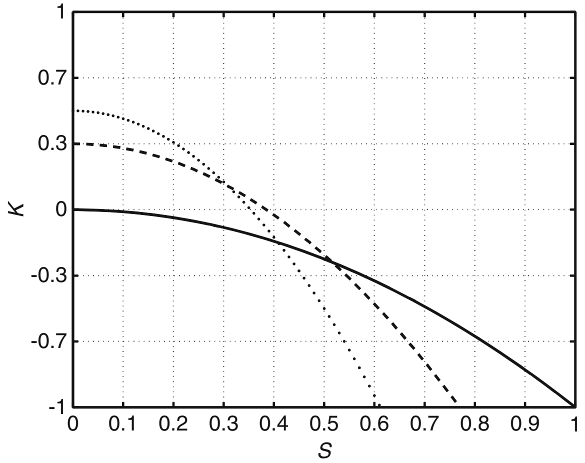

Fig. 10.2 Accumulated knowledge (Similar to Williamson (1991), Fig. 10.1, p. 284)

an invention: If the invention is promising enough, the firm starts the implementation or places it on the market.[2] Hence, the probability to innovate is given by

$$\text{Prob}(\text{Inno}_t) = \text{Prob}(K_t > \tau) = 1 - \text{Prob}(K_t \leq \tau) = 1 - \int_{-\infty}^{\tau} f(y)dy \quad \forall \tau \in \Re, \quad (10.4)$$

where $f : \Re \to [0, \infty]$ is the pdf of K.

Following Williamson (1991), Fig. 10.1 compares the transaction costs of the three types of organization: in-house ("hierarchy", $\theta=0$), partial outsourcing ("hybrid", $\theta=0.5$), and complete outsourcing ("market", $\theta=1$). Analogously, in the graphical representation of (10.2) in Fig. 10.2, the optimal organizational form is defined by the envelope of the three curves.[3] Sourcing from the market is best when specificity is modest. For semi-specific assets, a hybrid mode of organization is optimal, and in case of high specificity, the highest stock of knowledge is achieved in a hierarchical organization.

Figure 10.3 shows the relationship between outsourcing and knowledge production.[4] Holding specificity fixed at a low level of s, the upper left panel indicates a steadily increasing relationship. Once we increase s, this relationship changes. For intermediate values, the relationship is inversely U-shaped, and for high values of s, it is steadily decreasing.

Dependent on the level of specificity, the model suggests different functional forms for the relation between knowledge production and the level of outsourcing.

[2] Note that we are not considering a cost of implementation, such as liquidity constraints or advertising. That is, we implicitly assume this cost C to be zero in Prob($K-C>\tau$).

[3] For simplicity, we set $K_0=0$ and $t=E=1$, such that $K = 1 - c_{w,s} \forall \omega \in \{\theta = 0, \theta = 0.5, \theta = 1\}$.

[4] See Fig. 10.7 for a plot of the three dimensions: K, s, and θ.

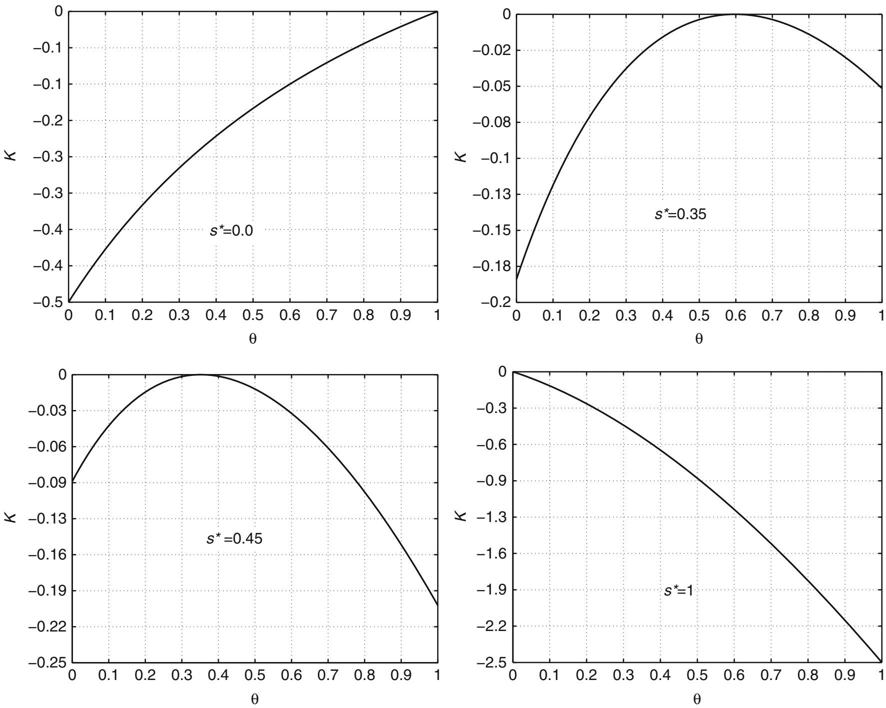

Fig. 10.3 Accumulated knowledge as a function of the outsourcing level. Accumulated knowledge K as a function of the outsourcing level θ, holding asset specificity s fixed

For low levels of specificity, the results point to an increasing relation (upper panel of Fig. 10.3). For medium levels, the model suggests a hump shape, and for high levels of specificity, the model predicts a decreasing relation.

4 Data and Empirical Specification

The empirical analysis is based on the *ZEW ICT Survey*, a telephone survey conducted every 3 years with a special focus on diffusion and use of ICT in German companies. While the data offer information on the use of ICT in the firm, we also observe variables on innovation, personnel and human capital, export, industry affiliation, and location. To incorporate a time lag needed for innovation to be created and successfully launched and to cover the potential issue of reverse causality, data from two waves is used. Innovation variables are employed from the 2007 data and refer to the time span of 2004–2006. Variables on IT outsourcing and controls are taken from the 2004 data and refer to 2003. Due to item nonresponse and panel attrition, the sample size is 1,582 observations.

The data allow to distinguish between product innovation and process innovation, where both are defined to be *new or markedly improved*. The majority of firms in the sample have been innovating during 2004–2006. About 59% report to have launched new products and services, while roughly 66% report to have introduced improved or new processes. Correspondingly, about one quarter has done both product and process innovation.

Firms are asked whether they are using specific types of IT services j and indicate the mode of provision: in-house, partial outsourcing, or complete outsourcing.[5] That is, S_i^j is defined as

$$S_i^j = \begin{cases} 0, \text{not in use} \\ 1, \text{in-house} \\ 2, \text{outsourced partially} \\ 3, \text{outsourced completely} \end{cases} \tag{10.5}$$

From this information we construct a firm-specific measure of the outsourcing ratio, defined as the proportion of outsourced IT on total IT:

$$\tilde{\theta}_{i,\gamma} = \frac{\overbrace{\gamma \sum_{j=1}^{J} I(S_i^j = 2)}^{Pi} + \overbrace{\sum_{j=1}^{J} I(S_i^j = 3)}^{Ci}}{\underbrace{\sum_{j=1}^{J} I(S_i^j > 0)}_{T_i}}, \tag{10.6}$$

where I(·) is the indicator function. Because "partial" is not further defined, we assume a weight of $\gamma \in (0,1)$. Another issue becomes evident when considering the following example: Firm a has only one IT service in use ($T_a = 1$), firm b uses the whole range of IT services ($T_b = J$), both are complete outsourcers ($P_a = P_b = 0$; $C_a = 1$; $C_b = J$). While those firms are clearly different, both exhibit the same outsourcing ratio $\tilde{\theta}_{i,\gamma} = 1$. In order to consider the firm-specific importance of IT in our measure of outsourcing, we weight $\tilde{\theta}_{i,\gamma}$ with a measure of IT intensity η_i, such that

$$\theta_{i,\gamma} = \eta_i \cdot \tilde{\theta}_{i,\gamma} \in [0, 1]. \tag{10.7}$$

We operationalize η_i with the percentage of *computerized workplaces*.[6] In the following, we use the term *outsourcing ratio* for $\tilde{\theta}_{i,\gamma}$ and the term *outsourcing level* for $\theta_{i,\gamma}$.

Treating the theoretical construct of the knowledge stock as a latent variable that is indirectly observed in the decision to innovate (see Eq. 10.4), we estimate sets of

[5] Those IT services are *installation of new hard- and software*, *system support and maintenance*, *support help desk*, *software development*, *Internet/web maintenance and design*, *IT training*, *IT security,* and *on-demand computing*.

[6] Descriptive statistics on IT intensity can be found in Table 10.1.

probit models. Two specifications each for product and process innovation and $\gamma \in \{0.1, 0.2, \ldots, 0.9\}$ are used. The first is given as

$$inno_{i,t,\gamma} = f(\alpha + \beta\theta_{i,t-1,\gamma} + \delta' x_{i,t-1} + \varepsilon_{i,t,\gamma}), \qquad \text{(Specification A)}$$

where α, β, δ are (vectors of) coefficients and ε_i is an error term. To test the predictions of our stylized theoretical model, we also estimate a quadratic specification, that is,

$$inno_{i,t,\gamma} = f(\alpha + \beta_1\theta_{i,t-1,\gamma} + \beta_2\theta^2_{i,t-1,\gamma} + \delta' x_{i,t-1} + \varepsilon_{i,t,\gamma}). \qquad \text{(Specification B)}$$

As control variables x_i, we include the following:

Log Employees: Audretsch and Acs (1991) and Acs et al. (1994), among others, show that firm size is an important determinant of innovative activity.[7] Kretschmer et al. (2012) consider the fact that firm scale (size) is endogenous to the innovation decision. We measure size by the logarithm of the number of employees working for the firm in Germany on average in 2003 (including apprentices and part-time employees and excluding secondary labor force).

University, Job Training: A firm's technological competence is crucial to innovation – as a source of ideas, as a direct influence on R&D, and as a way to enable the capability to adopt a new technology (Cohen and Levinthal 1989; Hoffman et al. 1998). As modeled above, technological competence is created endogenously by accumulation of knowledge in a continuous process of learning in production (Cantwell and Fai 1999). We control two types of human capital: formal education, that is, the proportion of staff with a university degree, and firm-specific human capital, that is, a dummy for job training (Bauernschuster et al. 2009).

Business Situation: Innovation can occur pro- and anticyclically (Mowery and Rosenberg 1979; Geroski and Walters 1995). On the one hand, newly introduced products compete for customer spending. Within a boom situation, the market grows and can therefore absorb more new products in a given period of time without reducing the profitability of each. Firms will therefore place their innovative products when demand is high or expected to rise. On the other hand, in a recession, a decrease of existing rents relative to expected returns of innovation represents an incentive to innovate. Moreover, the implementation of new processes requires to divert resources from operational to strategic tasks, which is less costly in a recession when current activities are relatively less profitable.

Export: The openness of a firm, that is, access to remote markets, acts as a multiplier of innovation drivers surrounding the firm (Eaton and Kortum 2006). The

[7] See Acs and Audretsch (2003) for a summary of key issues in the empirical literature in favor of a firm size effect on innovation.

firm is faced with increased market pressure resulting from a relative increase in the number of competitors compared to the home market. Moreover, export activity expands the boundaries of the (national) innovation network (cf. Bertschek 1995). That is, openness adds sources of knowledge (Baldwin and Gu 2004). It should be noted that export is likely to be endogenous (Kirbach and Schmiedeberg 2008; Becker and Egger forthcoming). We neglect this issue since we are more interested in exports as a control variable than in a causal interpretation of the coefficient. Our measure is a dummy variable coded one if firms report to have exported in 2003, zero otherwise.

East Germany: Taking a macro-location effect into consideration, we aim at controlling for persistent differences between Eastern and Western Germany in terms of resources, innovation, and productivity (Lehmann et al. 2004; Audretsch et al. forthcoming; Smolny forthcoming).

Industry Dummies: To control for heterogeneity among industries, dummies for 14 industries, classified according to two-digit NACE codes, are included.[8]

5 Results

Table 10.1 shows some descriptive statistics for a categorization of outsourcing levels. Following Lacity et al. (2009), we distinguish between *IN-HOUSE* ($\theta_\gamma < 0.2$), *LOW* ($0.2 \leq \theta_\gamma < 0.5$), *MEDIUM* ($0.5 \leq \theta_\gamma < 0.8$), and *COMPLETE* ($\theta_\gamma \geq 0.8$). The distribution is skewed to the right. That is, dependent on the assumed weight of "partial," in between 30% and 50% of the firms in our sample resort to IT outsourcing. Most strikingly, looking at the means reveals that the proportion of innovating firms varies significantly across classes of outsourcing levels. Independent of γ, the descriptive statistics suggest a nonlinear relationship between product innovation and the outsourcing level, where the maximum is at levels in between 0.2 and 0.5. Minima can be found at levels in between 0.5 and 1. The picture for process innovation is less clear, but a general positive correlation with fluctuations is visible. Firms relying on higher levels of outsourcing seem to be smaller in size, report a worse business situation, have a lower propensity to export, and are more often located in East Germany. Further, the descriptive statistics reveal a positive correlation between the percentage of employees with a university degree and the outsourcing level. For moderate levels of γ, maxima are at outsourcing levels in between 0.5 and 0.8. The proportion of firms with employees in on-the-job training varies across classes of the outsourcing level as well. The data suggest an overall positive correlation; however, there is a kink for outsourcing levels in between 0.5 and 0.8.

[8] See Table 10.4 for an industry classification.

Table 10.1 Descriptive statistics

	Outsourcing level							
	In-house $\theta_\gamma < 0.2$		Low $0.2 \leq \theta_\gamma < 0.5$		Medium $0.5 \leq \theta_\gamma < 0.8$		Complete $\theta_\gamma \geq 0.8$	
$\gamma = 0.3$								
Product innovation	0.583	(0.493)	0.640	(0.481)	0.426	(0.497)	0.498	(0.505)
Process innovation	0.659	(0.474)	0.661	(0.474)	0.585	(0.495)	0.702	(0.462)
Log employees	3.975	(1.643)	3.687	(1.560)	3.062	(1.387)	2.342	(1.026)
% University	0.135	(0.225)	0.162	(0.235)	0.225	(0.300)	0.154	(0.273)
Job training	0.824	(0.381)	0.880	(0.325)	0.798	(0.404)	0.872	(0.337)
Business situation	0.663	(0.473)	0.664	(0.473)	0.670	(0.473)	0.553	(0.503)
Export	0.510	(0.500)	0.482	(0.500)	0.277	(0.450)	0.213	(0.414)
East	0.278	(0.448)	0.278	(0.449)	0.234	(0.426)	0.170	(0.380)
IT intensity η	0.393	(0.325)	0.657	(0.272)	0.831	(0.163)	0.971	(0.067)
Observations	1,099		342		94		47	
$\gamma = 0.6$								
Product innovation	0.562	(0.496)	0.670	(0.471)	0.493	(0.502)	0.463	(0.503)
Process innovation	0.637	(0.481)	0.696	(0.461)	0.642	(0.481)	0.685	(0.469)
Log employees	3.901	(1.633)	3.951	(1.623)	3.347	(1.504)	2.330	(0.984)
% University	0.119	(0.216)	0.179	(0.240)	0.221	(0.291)	0.150	(0.258)
Job training	0.803	(0.398)	0.895	(0.307)	0.845	(0.364)	0.889	(0.317)
Business situation	0.659	(0.474)	0.661	(0.474)	0.703	(0.459)	0.574	(0.499)
Export	0.495	(0.500)	0.538	(0.499)	0.324	(0.470)	0.204	(0.407)
East	0.278	(0.448)	0.263	(0.441)	0.297	(0.459)	0.167	(0.376)
IT intensity η	0.337	(0.308)	0.636	(0.260)	0.852	(0.152)	0.975	(0.063)
Observations	923		457		148		54	
$\gamma = 0.9$								
Product innovation	0.546	(0.498)	0.678	(0.468)	0.557	(0.498)	0.479	(0.502)
Process innovation	0.626	(0.484)	0.705	(0.457)	0.655	(0.477)	0.667	(0.474)
Log employees	3.827	(1.620)	4.067	(1.631)	3.635	(1.638)	2.737	(1.213)
% University	0.107	(0.210)	0.174	(0.231)	0.195	(0.268)	0.246	(0.310)
Job training	0.787	(0.410)	0.892	(0.311)	0.866	(0.342)	0.917	(0.278)
Business situation	0.644	(0.479)	0.674	(0.469)	0.711	(0.454)	0.635	(0.484)
Export	0.488	(0.500)	0.547	(0.498)	0.412	(0.494)	0.240	(0.429)
East	0.282	(0.450)	0.264	(0.441)	0.278	(0.449)	0.208	(0.408)
IT intensity η	0.307	(0.302)	0.575	(0.258)	0.832	(0.152)	0.967	(0.058)
Observations	811		481		194		96	

Means are reported, standard deviation in parentheses
Product and process innovation between 2004 and 2006 (0/1)
Natural logarithm of the average number of employees in 2003 (apprentices and part timers included)
Percentage of employees holding a university degree compared to all employees on average in 2003
Employees have attended any type of job training in 2003 (0/1)
Good/rather good business situation (0/1) at the time of the interview (2004)
Firm has exported in 2003 (0/1)

Table 10.2 Probit models for specification A

	$\gamma=0.3$		$\gamma=0.6$		$\gamma=0.9$	
Product innovation						
Outsourcing level	0.2064	(1.13)	0.2160	(1.28)	0.2022	(1.35)
Log employees	0.0961***	(3.91)	0.0958***	(3.92)	0.0949***	(3.91)
% University	0.0054***	(3.20)	0.0054***	(3.14)	0.0053***	(3.10)
Job training	0.1669*	(1.69)	0.1627	(1.64)	0.1603	(1.61)
Business situation	0.1906***	(2.61)	0.1907***	(2.61)	0.1907***	(2.61)
Export	0.6308***	(7.77)	0.6280***	(7.73)	0.6261***	(7.70)
East	−0.1132	(−1.45)	−0.1139	(−1.46)	−0.1151	(−1.47)
Constant	−0.9906***	(−5.68)	−1.0004***	(−5.72)	−1.0016***	(−5.74)
Industry dummies	Yes		Yes		Yes	
Pseudo-R^2	0.1559		0.1561		0.1562	
Observations	1,582		1,582		1,582	
Process innovation						
Outsourcing level	0.2864	(1.61)	0.3351**	(2.04)	0.3369**	(2.31)
Log employees	0.1761***	(6.95)	0.1768***	(7.03)	0.1761***	(7.04)
% University	−0.0001	(−0.04)	−0.0002	(−0.15)	−0.0004	(−0.22)
Job training	0.3471***	(3.69)	0.3390***	(3.60)	0.3333***	(3.53)
Business situation	0.2804***	(3.90)	0.2809***	(3.90)	0.2812***	(3.90)
Export	−0.0021	(−0.03)	−0.0072	(−0.09)	−0.0113	(−0.14)
East	−0.2297***	(−3.04)	−0.2295***	(−3.04)	−0.2307***	(−3.05)
Constant	−0.9347***	(−5.56)	−0.9621***	(−5.71)	−0.9742***	(−5.81)
Industry dummies	Yes		Yes		Yes	
Pseudo-R^2	0.0858		0.0866		0.0871	
Observations	1,582		1,582		1,582	

The dependent variables are product innovation and process innovation between 2004 and 2006 (0/1)
Proportion of outsourced IT on total IT weighted by the percentage of computerized workplaces, where γ gives the weight of "partial"
Natural logarithm of the average number of employees in 2003 (apprentices and part timers included)
Percentage of employees holding a university degree compared to all employees on average in 2003
Employees have attended any type of job training in 2003 (0/1)
Good/rather good business situation (0/1) at the time of the interview (2004)
Firm has exported in 2003 (0/1)
See Table 10.4 for an industry classification; "other business-related services" is the omitted category
z statistics in parentheses, $^{*}p<0.10$; $^{**}p<0.05$; $^{***}p<0.01$

Estimation results according to specification A are reported in Table 10.2. The coefficients of our control variables are strikingly similar across all values of γ. Therefore, the tables only report coefficients for models with $\gamma=0.3$, $\gamma=0.6$, and $\gamma=0.9$. In Fig. 10.4, the coefficient of outsourcing ($\hat{\beta}$) and the corresponding 90% confidence band are plotted as a function of γ. Regardless of the parameter γ, there is no significant effect of outsourcing on the probability of product innovation in this specification (see left-hand panel of Fig. 10.4). Concerning the control variables, the results depicted in the top row of Table 10.2 are intuitive. The estimates suggest that firm size is a significantly positive predictor of product innovation. A higher fraction of employees with a university degree also increases the probability of product innovation. Firm-specific human capital is not significant for higher values of γ. Our estimates suggest that investment in innovation is pro-cyclical. Export is highly significant and positive. We do not find a significant difference between East and West German firms.

Concerning process innovation, the right-hand panel of Fig. 10.4 indicates a significantly positive effect of outsourcing when setting $0.4 \leq \gamma \leq 0.9$. That is, on a very reasonable interval, independent of how we operationalize "partial outsourcing," external technology supply has a positive and significant effect on client-side process innovation. Also, the estimated coefficients for the control variables reported in the bottom row of Table 10.2 are different compared to the results for product innovation. Formal education does not play a significant role here. At the same time, firm-specific knowledge (measured by job training) seems to be a significant predictor of process innovation. Also, firms in East Germany have a significantly lower probability of process innovation.[9]

Estimation results according to specification B are reported in Table 10.3. Again, coefficients for control variables are strikingly similar across all values of γ. Therefore, the tables only report coefficients for models with $\gamma = 0.3$, $\gamma = 0.6$, and $\gamma = 0.9$. Figure 10.5 plots the coefficients of the outsourcing level $(\hat{\beta}_1, \hat{\beta}_2)$ and the corresponding 90% confidence band as a function of γ.

For product innovation (left-hand panel), we find significant effects when setting $0.4 \leq \gamma \leq 0.9$. The corresponding signs of the coefficients indicate an inverse U shape.[10] The corresponding maximum is at an outsourcing level of about 0.5.

The right-hand panel of Fig. 10.5 indicates similar, yet insignificant, estimates of $\hat{\beta}_1$ and $\hat{\beta}_2$ for process innovation. In consequence, we are unable to confirm an inversely U-shaped relation of outsourcing and process innovation. For both models, coefficient estimates of control variables are not largely different from those in specification A.

Overall, these results are robust to a number of different specifications. First, comparable results can be found when lagged innovation variables are included as independent variables, testing a "success breeds success" hypothesis (Flaig and Stadler 1994; Peters 2009). Second, to account for interdependencies between different types of innovation (Kretschmer et al. 2012), we estimated a simultaneous bivariate probit model to allow the error terms of both equations to be correlated.

[9] In some sense, this is in line with the literature on productivity gaps between East and West Germany. See, for example, Smolny (2012).

[10] A test with the null of a U shape (negative slope at the lower bound and positive slope at the upper bound) or monotone function (sign of the slope is equal at both bounds) can be rejected for $\gamma > 0.4$. See Lind and Mehlum (2010) for a description of the test.

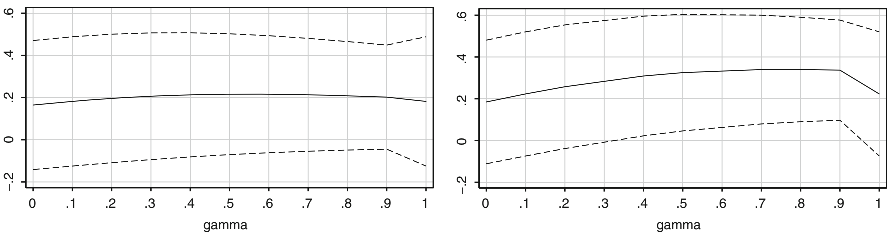

Fig. 10.4 Estimated probit coefficients $\hat{\beta}(\gamma)$, product and process innovation. Estimated probit coefficient of $\hat{\beta}$ as a function of γ, and 90% confidence interval, according to specification A without a squared term

Third, we tried to tackle the possible issue of nonrandom selection into outsourcing more explicitly. With information on whether the firm has considered consultancy with regard to the Y2K problem in the late 1990s (see Ohnemus 2007 for a detailed description), the dataset offered a reasonably good instrument for our measure of outsourcing. However, we still lacked a second exclusion restriction. Coding the outsourcing variable discretely $((\theta_\gamma < 0.2) = 0$, $(0.2 \le \theta_\gamma < 0.8) = 1$, $(\theta_\gamma \ge 0.8) = 2)$ and estimating separate bivariate probit models for in-house versus partial, in-house versus complete, and partial versus complete allowed us to correct for endogeneity using only one exclusion restriction. Because results obtained in this setting are comparable, we chose to show the most straightforward specification here. We are aware that this doesn't allow to establish causality.

6 Discussion

To sum up, we find a positive relation between innovation and the outsourcing level. That is, our specification indicates a positive effect of outsourcing on process innovation and a hump-shaped effect of outsourcing on product innovation.[11] Our stylized theoretical model implies both results, dependent on the specificity of knowledge underlying the innovation decision. The upper panel of Fig. 10.3, with low values of specificity, suggests a monotonically increasing relation between knowledge growth and the level of outsourcing. A hump-shaped and monotonically decreasing relationship is implied in the lower panel of Fig. 10.3, where higher levels of specificity are depicted. Although a limitation of the empirical analysis presented here is that

[11] The fact that the coefficients are insignificant in the respective other specification can be explained by looking at the descriptive statistics in Table 10.1. First, the proportion of firms that report product innovation at the lower end of the outsourcing level does not largely differ from those at the upper end. Second, although there is a kink in the proportion of firms reporting process innovation for a medium level of outsourcing, differences between the lower and the upper end are rather substantial. Figures 10.8–10.11 further illustrate our findings.

Table 10.3 Probit models for specification B

	$\gamma=0.3$		$\gamma=0.6$		$\gamma=0.9$	
Product innovation						
Outsourcing level	0.8121*	(1.73)	1.1906***	(2.62)	1.5113***	(3.46)
Outsourcing level²	−0.8017	(−1.35)	−1.2637**	(−2.22)	−1.5842***	(−3.08)
Log employees	0.0931***	(3.77)	0.0866***	(3.50)	0.0797***	(3.22)
% University	0.0054***	(3.19)	0.0054***	(3.19)	0.0056***	(3.29)
Job training	0.1602	(1.62)	0.1536	(1.54)	0.1520	(1.52)
Business situation	0.1872**	(2.56)	0.1849**	(2.53)	0.1831**	(2.50)
Export	0.6238***	(7.67)	0.6128***	(7.52)	0.6030***	(7.38)
East	−0.1188	(−1.52)	−0.1239	(−1.59)	−0.1256	(−1.61)
Constant	−1.0151***	(−5.78)	−1.0316***	(−5.88)	−1.0407***	(−5.97)
Industry dummies	Yes		Yes		Yes	
Slope lower bound	0.8121**	(1.73)	1.1906***	(2.62)	1.5113***	(3.46)
Slope upper bound	−0.7913	(−1.02)	−1.3367**	(−1.80)	−1.6571***	(−2.60)
Extreme point	0.5065	0.4711	0.4770			
90% Fieller-CI	*Out of range*		[0.3594, 0.8335]		[0.3985, 0.6186]	
U-test	1.02		1.81**		2.60**	
Pseudo-R²	0.1569		0.1587		0.1610	
Observations	1,582		1,582		1,582	
Process innovation						
Outsourcing level	0.1874	(0.41)	0.3634	(0.83)	0.3092	(0.73)
Outsourcing level²	0.1333	(0.24)	−0.0374	(−0.07)	0.0343	(0.07)
Log employees	0.1766***	(6.93)	0.1765***	(6.91)	0.1764***	(6.90)
% University	−0.0001	(−0.04)	−0.0002	(−0.15)	−0.0004	(−0.22)
Job training	0.3481***	(3.70)	0.3387***	(3.59)	0.3335***	(3.53)
Business situation	0.2809***	(3.90)	0.2808***	(3.90)	0.2814***	(3.90)
Export	−0.0009	(−0.01)	−0.0077	(−0.10)	−0.0107	(−0.13)
East	−0.2289***	(−3.02)	−0.2298***	(−3.04)	−0.2305***	(−3.05)
Constant	−0.9308***	(−5.51)	−0.9629***	(−5.70)	−0.9736***	(−5.80)
Industry dummies	Yes		Yes		Yes	
Slope lower bound	0.1874		0.3633		0.3092	
Slope upper bound	0.4540		0.2886		0.3777	
Extreme point	−0.7028		4.8600		−4.5110	
90% Fieller-CI	*Out of range*		*Out of range*		*Out of range*	
U-test	*Trivial rejection*		*Trivial rejection*		*Trivial rejection*	
Pseudo-R²	0.0858		0.0866		0.0871	
Observations	1,582		1,582		1,582	

Slope lower bound = $\hat{\beta}_1 + 2\hat{\beta}_2 \cdot 0$; slope upper bound = $\hat{\beta}_1 + 2\hat{\beta}_2 \cdot 1$
Extreme point = $-\hat{\beta}_1 / 2\hat{\beta}_2$. U-test according to Lind and Mehlum (2010)
z statistics in parentheses, $^{*}p<0.10$; $^{**}p<0.05$; $^{***}p<0.01$

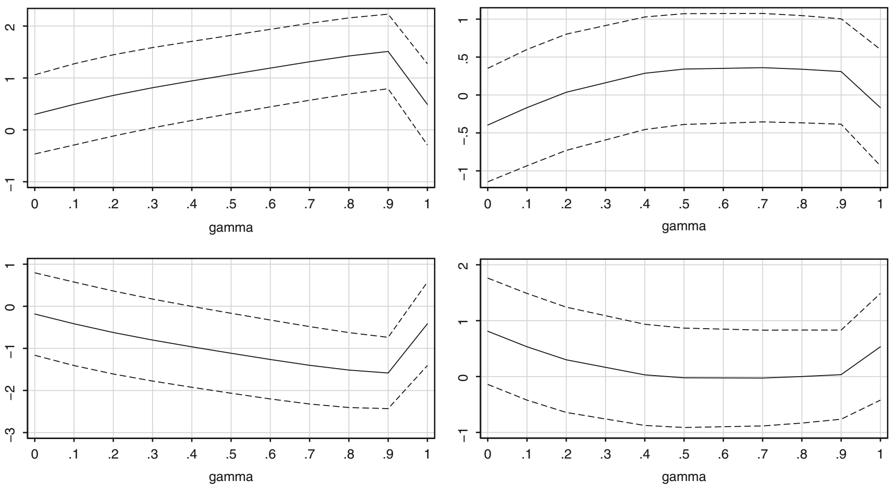

Fig. 10.5 Estimated probit coefficients $\hat{\beta}_1(\gamma)$, $\hat{\beta}_2(\gamma)$, product and process innovation. Estimated probit coefficients of $\hat{\beta}_1$, $\hat{\beta}_2$ as a function of γ, and 90% confidence interval, according to specification B with a squared term. Left hand-side figures refer to product innovation, right hand-side figures refer to process innovation

specificity cannot be measured directly, we argue that it provides some evidence for the theoretical reasoning above. Inspired by Barras (1986), innovation can be seen as a cycle that starts with process improvements to increase efficiency to go on with process innovations that increase quality and finally stimulates the development of new products and services. In each stage, more specific knowledge is needed to reach the next stage. In essence, we argue that $s_{proc} < s_{\mathrm{prod}}$, that is, product innovation and process innovation differ in terms of knowledge specificity. Hence, if the knowledge needed to generate IT-enabled product innovation is more specific than the knowledge needed to generate IT-enabled process innovation, the empirical results fit the results of our stylized theoretical model quite well. Our results are in line with the study by Gooroochurn and Hanley (2007) who find that the probability to outsource process innovation is twice as high as product innovation in UK Community Innovation Survey data.

To see why there are different effects on product and process innovation in the specific setting of IT outsourcing, consider the case study discussed by Kumar and Snavely (2004) as an example. A company from the printing industry decided to develop a new Internet-based service that allows its customers to individualize their print projects. Mainly due to a lack of internal competence, the implementation was outsourced and became a success. The outsourcing contract implied that the external vendor was integrated in the internal management process, that is, it was a partial outsourcing relationship. Kumar and Snavely (2004) stress that vendor-client cooperation was the key driver of success in this case. This example shows that IT-enabled product innovation can be very firm specific. In a recent study using microlevel data on providers of knowledge-intensive business services, Engelstätter and Sarbu (2010) underline this argument from a different perspective. The authors find that enterprise software, specifically developed for the firm, has a positive impact on the probability of service (i.e., product) innovation. Less customized, industry-specific software, however, turns out to have no significant impact on service innovation. A common reason why firms use standardized software aims at improvements in productivity and flexibility instead of increasing demand. If IT is widely used for operational tasks, improvements in technology are very likely to have effects on business processes. Hence, by the nature of expertise needed to develop standardized versus customized software solutions, IT-enabled process innovation should be easier achieved than IT-enabled product innovation. Another explanation why we don't observe a tipping point in our results for process innovation is a difference in the required vendor-client coordination. Weeks and Feeny (2008) argue that in the case of process innovation, soft factors like trust and communication are less critical for success. Hence, outsourcing too much is less harmful.

7 Conclusion

While the market for external supply of IT has seen rapid growth during the last decade, scientific research has been largely silent on an important aspect of client-side effects so far. For firms operating in globalized markets and increasingly individualized customer desires, IT-enabled innovation is an important source of value creation. While some studies have found a positive effect on productivity, client organizations often report to be dissatisfied with the vendor.

We employ a stylized theoretical model based on transaction cost economics to explore knowledge creation across the boundaries of the firm. The model suggests that knowledge growth, and therefore innovation, depends on the specificity of knowledge and the scope of outsourcing decisions. When the knowledge needed to generate innovation is not very specific, completely outsourcing knowledge production is always better than cooperation or in-house production. For intermediate levels of specificity, however, the optimal mode of organization is a hybrid one. When required knowledge is more specific, in-house production is optimal.

Our empirical strategy involves testing the theoretical predictions with German micro-data. Following a knowledge production function approach, we estimate probit models for product and process innovation. By combining several variables, we construct a measure of the firm-specific importance of IT outsourcing, reflecting both external supply of IT services and firm-specific IT intensity. We find a positive linear effect on process innovation and a hump-shaped effect on product innovation.

We argue that innovation can be seen as a multistage process of improvements in efficiency and quality that finally stimulates the development of new products and services. In consequence, the specificity of knowledge needed is increasing in each stage. That is, if knowledge needed to generate process innovation is less specific than knowledge required to generate product innovation, the empirical results fit the results of our stylized theoretical model quite well, although we cannot observe asset specificity directly. We are aware that we cannot establish causality in this analysis. Future work should try to address this issue, directly incorporate the underlying specificity of knowledge in the empirical analysis and possibly control for vendor-specific effects. Another extension could be to investigate the performance implications of innovation, that is, differentiate quantity and quality of innovation.

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Appendix

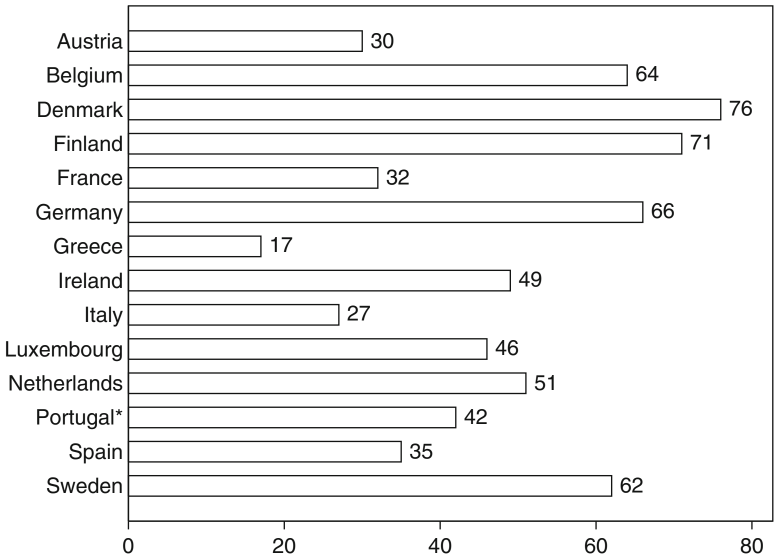

Fig. 10.6 IT outsourcing in the EU15 countries in 2007. Percentage share of all enterprises with at least ten persons employed, grouped by sector where external suppliers performed (fully or partly) ICT functions requiring ICT specialists (IT outsourcing) during 2007. *Due to data restrictions without financial sector, data for the United Kingdom is not available (Source: Eurostat, information society statistics on enterprises 2007)

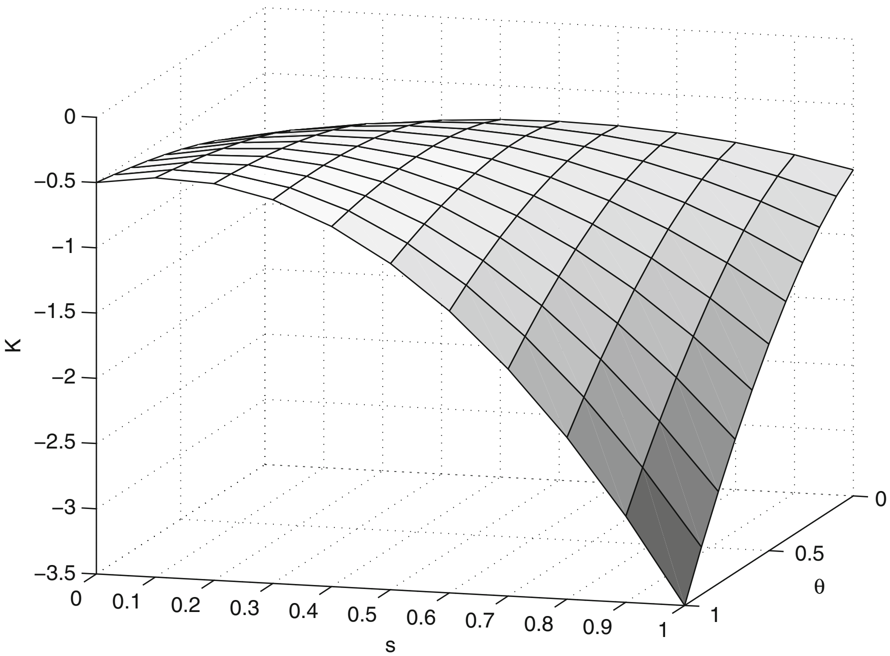

Fig. 10.7 Accumulated knowledge as a function of the outsourcing level and specificity

Table 10.4 Industry classification

Industry	NACE
Consumer goods	15–22, 36–37
Chemical industry	23–24
Other raw materials	25–27
Metal and machine construction	28–29
Electrical engineering	30–32
Precision instruments	33
Automobile	34–35
Wholesale trade	51
Retail trade	50, 52
Transportation and postal services	60–63, 64.1
Banks and insurances	65–67
Electronic processing and telecommunication	72, 64.2
Technical services	73, 74.2, 74.3
Other business-related services	70–71, 74.1, 74.4–74.8, 90

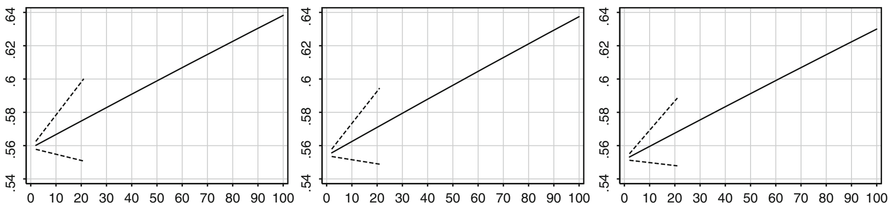

Fig. 10.8 Predicted probability of product innovation: γ=0.3, γ=0.6, and γ=0.9 (A). Predicted probability of product innovation as a function of θ, and 90% confidence interval, according to specification A without a squared term. All covariates fixed at the mean

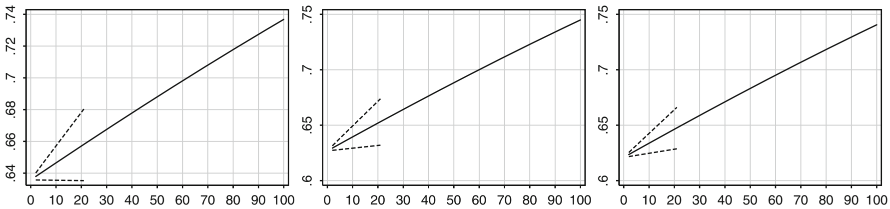

Fig. 10.9 Predicted probability of process innovation: γ=0.3, γ=0.6, and γ=0.9 (A). Predicted probability of process innovation as a function of θ, and 90% confidence interval, according to specification A without a squared term. All covariates fixed at the mean

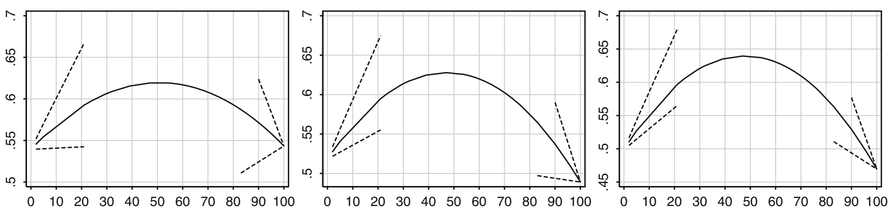

Fig. 10.10 Predicted probability of product innovation: γ=0.3, γ=0.6, and γ=0.9 (B). Predicted probability of product innovation as a function of θ, and 90% confidence interval, according to specification B with a squared term. All covariates fixed at the mean

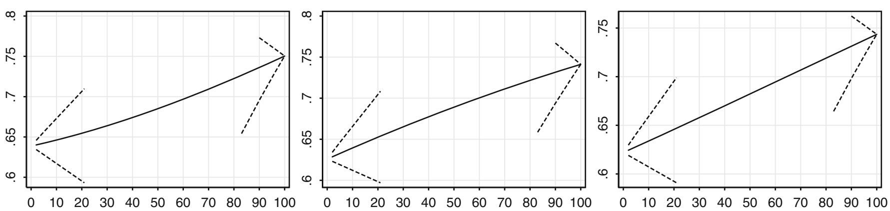

Fig. 10.11 Predicted probability of process innovation: γ=0.3, γ=0.6, and γ=0.9 (B). Predicted probability of process innovation as a function of θ, and 90% confidence interval, according to specification B with a squared term. All covariates fixed at the mean

References

Acs Z, Audretsch D (2003) Innovation and technological change. In: Acs Z, Audretsch D (eds) Handbook of entrepreneurship research – an interdisciplinary survey and introduction. Springer, New York, pp 55–79

Acs Z, Audretsch D, Feldman M (1994) R&D spillovers and recipient firm size. Rev Econ Stat 76(2):336–340

Afuah A (2001) Dynamic boundaries of the firm: are firms better off being vertically integrated in the face of a technological change. Acad Manage J 44(6):1211–1228

Amiti M, Wei SJ (2006) Service offshoring and productivity: evidence from the United States. NBER working paper:11926

Antonelli C (1998) Localized technological change, new information technology and the knowledge-based economy: the European evidence. J Evol Econ 8(2):177–198

Antràs P, Helpman E (2004) Global sourcing. J Polit Econ 112(3):552–580

Arora A, Gambardella A (1990) Complementarity and external linkages: the strategies of the large firms in biotechnology. J Ind Econ 38(2):361–379

Audretsch D, Acs Z (1991) Innovation and size at the firm level. South Econ J 57(3):739–744

Audretsch D, Menkveld A, Thurik A (1996) The decision between internal and external R&D. J Instit Theor Econ 152:519–530

Audretsch D, Hülsbeck M, Lehmann E (2012) Regional competitiveness, university spillovers, and entrepreneurial activity. Small Bus Econ, 39(3):587–601

Bacheldor B (2010) Innovation in outsourcing: you want IT. Do you get it. CIO Magazine. http://tinyurl.com/bacheldor10

Baldwin J, Gu W (2004) Trade liberalization: export-market participation, productivity growth, and innovation. Oxf Rev Econ Pol 20(3):372–392

Barras R (1986) Towards a theory of innovation in services. Res Pol 15(4):161–173

Barthélemy J (2001) The hidden costs of IT outsourcing. MIT Sloan Manage Rev 42(3):60–69

Bauernschuster S, Falck O, Heblich S (2009) Training and innovation. J Hum Cap 3(4):323–353

Becker S, Egger P (forthcoming) Endogenous product versus process innovation and a firms propensity to export. Empir Econ

Bertschek I (1995) Product and process innovation as a response to increasing imports and foreign direct investment. J Ind Econ 63(4):341–357

Bessant J, Rush H (1995) Building bridges for innovation: the role of consultants in technology transfer. Res Pol 24(1):97–114

Cantwell J, Fai F (1999) Firms as the source of innovation and growth: the evolution of technological competence. J Evol Econ 9(3):331–366

Cassiman B, Veugelers R (2006) In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. Manage Sci 52(1):68–82

Cohen W, Levinthal D (1989) Innovation and learning: the two faces of R&D. Econ J 99(397):569–596

Czarnitzki D, Spielkamp A (2003) Business services in Germany: bridges for innovation. Serv Ind J 23(2):1–31

Dibbern J, Goles T, Hirschheim R, Jayatilaka B (2004) Information systems outsourcing: a survey and analysis of the literature. SIGMIS Database 35(4):6–102

Eaton J, Kortum S (2006) Innovation, diffusion, and trade. NBER working paper:12385

Engelstätter B, Sarbu M (2010) Enterprise software and service innovation: standardization versus customization. ZEW discussion paper 10–100

Flaig G, Stadler M (1994) Success breeds success. The bynamics of the innovation process. Empir Econ 19(1):55–68

Freund C, Weinhold D (2002) The internet and international trade in services. Am Econ Rev 92(2):236–240

Geroski PA, Walters CF (1995) Innovative activity over the business cycle. Econo J 105(431):916–928

Gooroochurn N, Hanley A (2007) A tale of two literatures: transaction costs and property rights in innovation outsourcing. Res Pol 36(10):1483–1495

Görg H, Hanley A (2011) Services outsourcing and innovation: an empirical investigation. Econ Inq 49(2):321–333
Griliches Z (1979) Issues in assessing the contribution of research and development to productivity growth. Bell J Econ 10(1):92–116
Grimpe C, Kaiser U (2010) Balancing internal and external knowledge acquisition: the gains and pains from R&D outsourcing. J Manage Stud 47(8):1483–1509
Grossman G, Helpman E (2002) Integration versus outsourcing in industry equilibrium. Q J Econ 117(1):85–120
Grossman G, Helpman E (2005) Outsourcing in a global economy. Rev Econ Stud 72(1):135–159
Han K, Kauffman R, Nault B (2011) Returns to information technology outsourcing. Information Systems Research, 22(4):824–840
Harrigan K (1984) Formulating vertical integration strategies. Acad Manage Rev 9(4):638–652
Hecker A, Kretschmer T (2010) Outsourcing decisions: the effect of scale economies and market structure. Strat Organ 8(2):155–175
Hoffman K, Parejo M, Bessant J, Perren L (1998) Small firms, R&D, technology and innovation in the UK: a literature review. Technovation 18(1):39–55
Howells J (2006) Intermediation and the role of intermediaries in innovation. Res Pol 35(5):715–728
Huang KF, Yu CM (2011) The effect of competitive and non-competitive R&D collaboration on firm innovation. J Technol Trans 36:383–403
Kakabadse A, Kakabadse N (2002) Trends in outsourcing: contrasting USA and Europe. Eur Manage J 20(2):189–198
Kirbach M, Schmiedeberg C (2008) Innovation and export performance: adjustment and remaining differences in East and West German manufacturing. Econ Innov New Technol 17(5):435–457
Klein B, Crawford R, Alchian A (1978) Vertical integration, appropriable rents, and the competitive contracting process. J Law Econ 21(2):297–326
Knittel C, Stango V (2008) The productivity benefits of IT outsourcing. UC Davis working paper
Kogut B, Zander U (1992) Knowledge of the firm, combinative capabilities, and the replication of technology. Organ Sci 3(3):383–397
Kretschmer T, Miravete E, Pernías J (2012) Competitive pressure and the adoption of complementary technologies. American Economic Review, 102(4):1540–1570
Krugman P (1991) Increasing returns and economic geography. J Pol Econ 99(3):483–499
Kumar S, Snavely T (2004) Outsourcing and strategic alliances for product development: a case of banta digital group. Technovation 24(12):1001–1010
Lacity MC, Willcocks LP (2001) Global information technology outsourcing. Wiley, Chichester
Lacity MC, Willcocks LP, Feeny D (2009) Making the outsourcing decision. In: Willcocks LP, Lacity MC (eds) Information systems and outsourcing: studies in theory and practice. Palgrave Macmillan, New York, pp 212–234
Lehmann E, Neuberger D, Räthke S (2004) Lending to small and medium-sized firms: is there an east–west gap in Germany. Small Bus Econ 23:23–39
Lind J, Mehlum H (2010) With or without U? The appropriate rest for a U-shaped relationship. Oxf Bull Econ Stat 72(1):109–118
Loh L, Venkatraman N (1992) Determinants of information technology outsourcing: a cross-sectional analysis. J Manage Inf Syst 9(1):7–24
Miozzo M, Grimshaw D (2005) Modularity and innovation in knowledge-intensive business services: IT outsourcing in Germany and the UK. Res Pol 34(9):1419–1439
Mowery D, Rosenberg N (1979) The Influence of market demand upon innovation: a critical review of some recent empirical studies. Res Pol 8(2):102–153
Muller E, Doloreux D (2009) What we should know about knowledge-intensive business services. Technol Soc 31(1):64–72
Muller E, Zenker A (2001) Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems. Res Pol 30(9):1501–1516

Nonaka I, Takeuchi H (1995) The knowledge-creating company: how Japanese companies create the dynamics of innovation. Oxford University Press, Oxford
Ohnemus J (2007) Does IT-outsourcing increase firm success? An empirical assessment using firm-level-data. ZEW discussion paper 07–087
Overby S (2007) What does it take to get IT outsourcers to innovate. CIO Magazine. http://tinyurl.com/overby07
Overby S (2010) IT outsourcing: 3 reasons your vendor won't innovate. Networkworld. http://tinyurl.com/overby10
Peters B (2009) Persistence of innovation: stylised facts and panel data evidence. J Technol Trans 34:226–243
Peukert C (2011) Switching costs and information technology: the case of IT outsourcing. LMU Munich working paper SSRN ID:1683270
Piga C, Vivarelli M (2004) Internal and external R&D: a sample selection approach. Oxf Bull Econ Stat 66(4):457–482
Rouse AC (2009) Is there an information technology outsourcing paradox? In: Hirschheim R, Heinzl A, Dibbern J (eds) Information systems outsourcing: enduring themes, global challenges, and process opportunities, 3rd edn. Springer, New York, pp 129–146
Scarbrough H (1998) The external acquisition of information systems knowledge. In: Willcocks LP, Lacity MC (eds) Strategic sourcing of information systems. Wiley, Chichester, pp 137–161
ener F, Zhao L (2009) Globalization, R&D and the iPod cycle. J Int Econ 77(1):101–108
Smolny W (2012) Cyclical adjustment, capital-labor substitution and total factor productivity convergence–East Germany after unification. Jahrbücher für Nationalökonomie und Statistik Journal of Economics and Statistics-Jahrbücher für Nationalökonomie und Statistik 232(4): 445–459
Tether BS, Tajar A (2008) Beyond industry-university links: sourcing knowledge for innovation from consultants, private research organizations and the public science base. Res Pol 37(6–7):1079–1095
TPI (2011) The TPI index – global outsourcing market data and insights, Second quarter 2011. 20 July 2011
Weeks MR, Feeny D (2008) Outsourcing: from cost management to innovations and business value. Calif Manage Rev 50(4):127–146
Weigelt C, Sarkar M (2009) Learning from supply-side agents: the impact of technology solution providers' experiential diversity on clients' innovation adoption. Acad Manage J 52(1):37–60
Whitten D, Wakefield R (2006) Measuring switching costs in IT outsourcing services. J Strat Inf Syst 15(3):219–248
Williamson OE (1975) Markets and hierarchies, analysis and antitrust implications. Free Press, New York
Williamson OE (1985) The economic institutions of capitalism. Free Press, New York
Williamson OE (1991) Comparative economic organization: the analysis of discrete structural alternatives. Adm Sci Q 36(2):269–296
Windrum P, Reinstaller A, Bull C (2009) The outsourcing productivity paradox: total outsourcing, organisational innovation, and long run productivity growth. J Evol Econ 19(2):197–229
World Trade Organization (2011) International trade statistics 2011. World Trade Organization, Geneva

Chapter 11
The *Enrollment* in an R&D Subsidy Program for SMEs: Evidence from Southwest Germany

Niclas Rüffer, Detlef Keese, and Michael Woywode

Abstract The literature on R&D subsidy programs has mainly focused on final R&D outcomes and has largely ignored the processes that operate within subsidy programs. The implementation of programs and allocation of funds might have a profound impact on the final economic outcome though.

We discuss the targeting process of R&D subsidy programs and analyze empirically the Enrolment in a particular R&D promotion program. Companies applying for the program we analyze often seem not to have complete knowledge on their projects and project partners when applying for funds. About one out of five companies does not conduct the project it was granted money for. Dropouts are not random; companies that were planning to cooperate with "high quality" R&D institutions in the scope of the project and those from core cities are more likely not to conduct their projects. In line with our expectations we are also able to show that companies which have cooperated with R&D institutions before are more likely to conduct their projects than those without cooperation experience.

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1 Introduction

Innovation promotion in SMEs and especially in newly founded companies is high on the political agenda. Market and system failures have been identified as reasons for underinvestment in innovation. Private returns from R&D are usually smaller than social returns causing underinvestment in R&D (Arrow 1962; Nelson 1959; Mohen 1996). Furthermore, there can be financial constraints for risky R&D projects that stem from imperfect capital markets and information asymmetries (Stiglitz and Weiss 1981), uncertainty in R&D (see Hall 2002 for a survey), or market uncertainty (Czarnitzki and Toole 2006). Knowledge sharing can be insufficient in an innovation system (Lundvall 1992; Nelson 1993) and is therefore addressed by government actions targeting behavioral additionalities (Falk 2005; Heijs 2003). Hence, there are various reasons for policy makers to foster R&D and innovation, especially in small and newly founded companies since they might suffer even more from market or system failures than larger firms.

In the scientific community, a theoretical consensus exists that appropriate innovation policy can bring the market solution closer to the socially optimal solution. The practical implications though are ambivalent. As Jaffe (2002) points out, the political debate has evolved on the targeting of subsidies (i.e., picking winners and losers) and on possible distortions that are caused by political interventions. In theory innovation projects that are socially profitable but would not be conducted without subsidies due to market or system failures should be chosen for subsidization. In a real-world setting, such an allocation is rather difficult though since the implementation of R&D subsidy programs is not conducted by a benevolent social planner with complete knowledge. Instead, it has to go through several steps on which different individuals with incomplete knowledge make decisions according to their preferences. Hence, we argue that for a better understanding of the incentives and results of public innovation promotion programs, one needs a better comprehension of the political and economical processes that are at work during the different steps of the implementation of such programs both in public agencies and in firms. Heckman and Smith (2004) decompose the steps political promotion programs have to go through into five stages, namely, *eligibility, awareness, application, acceptance,* and *enrollment* (in their analysis of a job training program). These complex processes have received little attention in the empirical as well as in the theoretical literature on R&D policies. To address this gap, we are going to discuss the implementation process of public promotion programs theoretically and empirically analyze the stage *enrollment* in a special innovation promotion program targeting small- and medium-sized companies in southwest Germany. We will focus on answering the question which of the firms that are granted funds do conduct the projects and which firms drop out.

The literature on R&D subsidies has mainly focused on final results of R&D programs for instant in terms of additional R&D expenditures by subsidized firms. An in-depth analysis of the incentives and decisions within the targeting process might diminish some of the confusion about the outcomes of subsidy programs since these outcomes might depend crucially on the targeting processes (Koski and

Tuuli 2010). While there is some evidence on the step *acceptance* into R&D subsidy programs, an analysis of the stage *enrollment* or a discussion of the idea that this stage might be relevant for the final outcome of R&D programs is, to our knowledge, completely missing in the area of evaluating innovation promotion programs. Furthermore, an in-depth analysis of the incentive structures of the various steps of the allocation process can give hints to politicians and bureaucrats alike regarding the design of future R&D subsidy programs and to the public to judge over the goals and the effectiveness of decision makers.

In this chapter, we are going to use recent data from a R&D subsidy program in southwest Germany which aims at supporting joint R&D projects of small- and medium-sized companies with public or private R&D providers. We will analyze which of the projects that were accepted into the program were actually conducted. To our knowledge, there is no previous evidence on the stage *enrollment* into an innovation promotion program. There is some literature on the targeting of R&D programs though that we will discuss in Sect. 2 after a theoretical in-depth discussion of the incentive structures on the different steps of the targeting process. Section 3 develops hypotheses regarding the factors influencing the likelihood of *enrollment*. In Sect. 4, we will describe the program under revision and our data set. Section 5 tests our hypotheses. In Sect. 6, we will provide a summary of the results and discuss some main limitations of this work and implications for policy makers and researchers.

2 Theoretical Background and Previous Evidence on the Processes of Government Support Programs

There is a great deal of market and system failures regarding R&D and innovation identified in the literature on R&D and innovation providing theoretical rationales for government interventions. It is, however, relevant whether in a real-world setting R&D public policy can really diminish market and system failures or whether it will

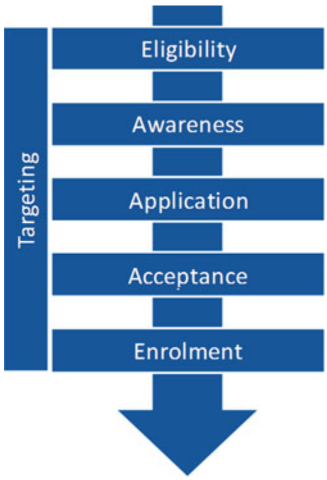

Fig. 11.1 The targeting process (Following Heckman and Smith 2004)

lead to even bigger distortions or is used to promote special interests of politicians or bureaucrats (e.g., due to interventions of lobby groups). In this chapter, we suppose that R&D-related problems of small- and medium-sized companies have been identified appropriately and that R&D support programs have been formulated well. But even in a situation where ex ante the policy is appropriate, allocation processes might be critical in practice for the performance of R&D promotion programs. Each step (following Heckman and Smith 2004, see Fig. 11.1) of the allocation process identified above contains different optimization problems for different parties.

The definition of who is eligible to apply for a support program is mostly carried out by politicians and bureaucrats. These actors might follow economical rationales such as the elimination of market failures by making a group eligible that suffers from those market failures (providing, e.g., equity capital programs to high-risk start-ups). Yet they might also follow political rationales such as defining the target group so narrowly that it is equipollent with the members of some special lobby group to gain political support from this lobby group (e.g., the introduction of agriculture subsidies by parties that have the political support of farmers).

In the second step, relating to the awareness of support programs, the bureaucrats in charge will have to decide how to inform the public about the support program which in turn, together with the company's decision to actively search for a program, will lead to companies being aware of the program or not. Again there is the possibility to dedicate the funds to those companies that are most likely to suffer from market failure, but at the same time, it is possible to choose special groups for other – most likely – political reasons. The program might be communicated mainly in one region instead of informing exhaustively in the relevant geographical space (e.g., by holding information meetings exclusively in the constituency of an important politician involved) or to special interest groups (such as publishing the program through special industrial associations or other lobby groups). However, there will be also a self-selection process going on in the target group which will have an impact on the awareness level regarding R&D support programs. Companies that show no interest in innovation will hardly search for innovation promotion programs. Furthermore, there might be highly active groups searching for public programs to fund their projects. Finally, there might be highly innovative firms that simply show no interest in public help since R&D projects have to be in line with program proposals and firms do not want to lose time and resources by writing proposals and aligning projects with promotion programs' guidelines.

Those firms that are aware of the program will decide if they should apply based on some (but incomplete) knowledge of the success chances within the application process and on a preliminary evaluation of the perceived technical and economical risks of the intended R&D projects. Companies do not have complete knowledge regarding the R&D project and the application process since information is costly (at least in the form of opportunity costs regarding the time needed to gather information). Apart from that, things can change over time because intended R&D projects will not be conducted right away once the application decision is taken but one or several months later (depending on the duration of the decision process).

If companies decide to apply for a support program, the acceptance step into the program is usually carried out by special agencies which often use the help of boards of experts. These experts might follow economical considerations such as their evaluation of whether the proposed projects are socially profitable, their intuition based on their technological knowledge, or their preferences for some type of technology or company. Again in this step, there is the possibility that political incentives of bureaucrats or interests/convictions of the experts involved will influence the final acceptance decision. In practice, the final acceptance decision will be a mixture of different incentives (economical, political, and individual). Since decision makers have limited time and resources to make their decisions, they will frequently rely on heuristics in their decision making (e.g., by rating positively R&D cooperation partners mentioned in the application that are "high-quality" R&D institutions like universities as a signal for the quality of the R&D project). Even if the bureaucratic unit in charge uses "independent" experts, there might be distortions toward members of special groups or industries by choosing experts that are likely to prefer such subgroups of the targeted population. There is often no mechanism that guarantees that only R&D projects will be chosen that would suffer from market or system failure and would not be undertaken without subsides.

In the last step of the process, companies that are accepted into a program will have to decide if they should enroll and hence actually undertake the project. The evaluation of the technical and economical risk will be more detailed, especially if companies are obliged to contribute their own financial funds (which is most common in public R&D support programs) and other resources such as time and manpower. Furthermore, competitors might have announced new R&D-related findings in the time period between application and acceptance rendering the proposed R&D project more or less obsolete. Or the company itself might not have sufficient financial as well as other resources anymore due to unexpected external shocks. Finally, cooperation with a designated partner, which was mandatory in the public support program studied here, might not work out as was expected due to differences in mentality between the parties or the divergence of goals that was not revealed during first contacts while planning the joint R&D project. Another reason for failing to execute a collaborative R&D project which was accepted for public support could be related to the importance of spatial distance between the partners involved in the joint R&D project that might have been underestimated or the prospective partners that might have resource problems themselves.

All the aforementioned five stages in the decision-making process need to be taken into account when evaluating the effectiveness of R&D subsidy programs. However, most studies on the effectiveness of R&D programs try to measure final outcomes of subsidies. Early studies did not even take into account that there are selection processes going on in the allocation of R&D subsidies as David et al. (2000) or Klette et al. (2000) criticize in their literature surveys. Aschhoff (2009) provides a more recent literature survey. She shows that recent studies on R&D subsidies take into account that subsidies are not distributed randomly to companies, e.g., by using matching approaches. But this literature does not take a closer look at the decision processes within the programs (Desmet et al. 2004). In particular, studies on allocation rules in R&D subsidy programs are rare. There are some studies analyzing the allocation without having data on application and enrollment, comparing the participants of programs with the group of eligible firms. One relevant example here is

Blanes and Busom (2004). They compare the allocation of funds between regional and national Spanish agencies, but their data consist only of a data set on firms that were subsidized and such that were not. Hence, there is no way to distinguish between different steps of the allocation process. Aschhoff (2008 and 2009) shows that firms which have been enrolled inside a German or European subsidy program at least once have better chances to receive subsidies from the German project funding (DPF) in the following years. Desmet et al. (2004) analyze if decision criteria used in a Spanish R&D program are in line with the previously announced guidelines and found quite significant deviation. Feldman and Kelley (2006) conducted a telephone survey with subsidized and rejected firms and compared them according to criteria of social profitability. As far as we know, Tanayama (2007 and 2009) was the first to use the Heckman and Smith (2004) framework for a R&D program and to test it with data from Tekes (Finnish Funding Agency for Technology and Innovation). She compares subsidy decisions for R&D projects in Finnish SMEs and large firms showing for both SMEs and larger firms that more challenging and more technologically risky projects are chosen. Firm partners and research partners alter the probability for SMEs of being subsidized. For large firms this is only valid for firm partners. Furthermore, indirect market objectives and the level of technological novelty increase the probability of being subsidized for larger firms. In Tanayama (2009) she analyzes the decision on the size of the subsidy. Technological challenge, technological risk, and technological novelty are related to higher subsidies. A negative relationship to the subsidy exists with commercial risk.

A theoretical or empirical in-depth discussion of the stage enrollment is to our knowledge missing in the literature on R&D programs. There is some work on labor market programs addressing the issue of enrollment though. Heckman and Smith (2004) propose the framework that we are applying here, decomposing the targeting processes as mentioned and analyzing the steps including enrollment in detail.

Some interesting literature exists on the performance of cooperation between firms and R&D institutions. Although this is not exactly the same question that we address, there are clearly similarities: Mora-Valentin et al. (2002) analyze which factors influence the quality of cooperation. Based on a literature review, they develop a couple of hypotheses about organizational and contextual success factors for cooperation. The first organizational factor they identify is commitment of the partners (e.g., the degree of involvement of the partners and the senior executives) which has a positive influence on the quality of cooperation. Furthermore, the development of an appropriate communication system and frequent communication is also relevant for cooperation success as well as interorganizational trust and dependence. Obviously, conflict is not beneficial for the success of cooperations.

Regarding contextual factors, previous cooperation has a positive influence on the quality of cooperation. A clear definition of objectives will also have a positive influence on the success of cooperation, and the same is assumed to be true for institutionalization. Finally, geographical proximity is depicted to be beneficial as well for successful cooperation.

Mora-Valentin et al. (2002) test their hypothesis with two samples of Spanish firms and R&D providers (one questionnaire for R&D institutions and one questionnaire for firms, all involved in cooperation between 1995 and 2000). They do not reject their entire hypotheses except for institutionalization and geographical proximity. Both seem to have no influence on the likelihood of cooperation success.

3 Theoretical Model and Hypotheses Regarding the Enrollment Stage

After being accepted into a R&D support program, it cannot be taken for granted that companies will really conduct the projects. As mentioned above, firms usually have to spend substantial financial resources themselves to cofinance or match the subsidies. There may not have been a complete evaluation of technological and market risk in the *application* step or the financial or market environment may have changed due to external shocks. Contact with the potential R&D provider may have been only preliminary, and while planning the joint project in detail, it may turn out that it is not beneficial for the R&D provider, that the R&D providers' price is too high for the firm, or that simply the partners do not match, e.g., due to different professional backgrounds. We expect that the distribution of support program drop-outs is not random but that it will depend on specific characteristics of the intended R&D projects, the R&D partners, and other criteria. In the following step, we will develop a number of hypotheses on factors that might influence the likelihood of conducting the R&D projects where subsidies were granted for.

Larger firms have more complementary resources than smaller firms regarding human capital, equipment, and financial resources. Furthermore, they can be expected to have more experience in managing complex innovation projects at the organizational level as well as at the level of individual members of the organization. Hence, our first hypothesis is:

H1: *The probability of conducting as planned collaborative R&D projects that were accepted in the scope of the aforementioned R&D support program will increase with the size of the firm applying for the subsidy.*

Younger companies are more vulnerable than older companies to environmental changes. Especially for start-ups (up to 3 years), the relevant environment might change within a couple of months (between the *application* and the *acceptance* into the program). Many companies go out of business within their first years of existence. Those that survive will have survived for good reasons. We suppose that one of the reasons for surviving should be a better ability of planning and conducting innovative projects. Hence, older companies should have both better abilities and more experience regarding innovation projects. In this line, our second hypothesis is:

H2: *The probability of conducting joint R&D projects where the subsidy application was already accepted will increase with increasing age of the applying company.*

"High-quality" R&D institutions such as universities and Fraunhofer centers (Fraunhofer is Europe's largest provider of applied R&D and enjoys a good reputation among businesses) have complex administrative processes in comparison with small private firms that work as R&D providers for other firms. Hence, the organization of a project with a "high-quality" R&D provider should be more difficult, especially for small firms. Furthermore, between "high-quality" R&D providers and small firms, there might be communication problems, e.g., due to mentality differences stemming from a different professional background. Technicians working in the firms might have had vocational training and have no university education. They might be very professional in their field but not used to an academic language which is typically the case when talking to high-reputation research institution. Hence, our third hypothesis is:

H3: *The probability of conducting the R&D projects as planned is lower for companies that planned to work together with "high-quality" R&D institutions.*

A whole body of literature has been written about the importance of spatial proximity for innovation and cooperation (for an overview, see, e.g., Asheim and Gertler 2005). The literature on clusters (Porter 2000) has evolved around the observation that the concentration of interconnected firms in a region with dense networks fostered by spatial proximity often leads to superior performance. Qualitative work within the project suggested that face-to-face contact between R&D service providers and subsidized firms was highly important for conducting the R&D projects. Furthermore, this should be even more true for rather small companies like those that applied for the R&D subsidies since the higher transaction costs of conducting a project with a R&D service provider that is far away should be more important for small companies. Hence, our fourth hypothesis is:

H4: *The larger the geographical distance between the firm and the designated R&D partner, the lower the probability of conducting the projects as planned.*

Geography might also play a role here in the following sense. Companies from rural areas have fewer chances to get in contact with new R&D partners. A social exchange on a formal and especially on an informal basis between members of the small- and medium-sized business and members of the public or private research support organization is easier to organize in urban areas and core cities. In particular, companies from core cities should have advantages in collaborating with research institutions. In line with this argument, our fifth hypothesis is:

H5: *The probability of conducting the intended R&D projects as planned is higher for companies located in core cities compared to companies in all other places.*

Due to learning effects companies that had already previous R&D cooperations with public or private R&D providers know better how to plan and to conduct new cooperations than those without experience in R&D cooperation. Hence, our sixth hypothesis is:

H6: *The probability of conducting the intended R&D projects as planned is higher for companies with experience in R&D cooperation.*

Finally, as a measure of quality of the application and resources invested by the company, we used a simple word count of the application form. We suppose that those companies that write a longer application are more serious in the *application* step and that there might have been a more detailed evaluation of the economical and technical risks of the projects. In line with this argument, our seventh hypothesis is:

H7: *The longer the application sent in by the company, the higher the probability of conducting the intended collaborative R&D project as planned.*

4 Data and Methods

The data set used here contains (1) company level information on 1,361 companies that have applied for a special R&D subsidy program in southwest Germany in 2008 and 2009 (innovation vouchers), and (2) it also contains information on their applications (including a short questionnaire) concerning collaborative R&D projects that involve a R&D service provider. Small firms with less than 100 employees and less than 20 million Euros of turnover were eligible to apply for the financial R&D subsidies. They had to give some basic information on company characteristics and describe the R&D projects they wanted to undertake, the R&D service provider they wanted to cooperate with, and the tasks the R&D provider had to carry out. The maximum subsidy was 7,500€ and companies had to spend some 5,625€ to receive the maximum subsidy. The applications and the R&D projects were reviewed by a board of experts appointed by the bureaucratic unit in charge of the subsidy program. The board consisted of two scientific members, two entrepreneurs and two employees of the chamber of commerce and the chamber of handcrafts.

Out of the 1,361 applications, 1,023 were granted. In 130 cases, applications were granted and companies did not conduct the R&D projects, but the time for conducting the projects was not expired at the time of observation, and hence, the data had to be removed. Another 301 application did not contain all relevant information, e.g., because the companies did not complete the short questionnaire which was not mandatory for receiving the subsidy. 592 applications were accepted and data on all relevant variables were available. The data set consists of data on size, legal form, and other relevant company characteristics. Furthermore, the R&D projects were classified in sectors: *mining, construction, services, company-related services,* and *manufacturing*. The partners for the R&D projects were classified in subgroups: universities, Fraunhofer Society, Steinbeis Society, private R&D institutions, etc. Effects of the length of the application were taken into account by a simple word count.

Most of the companies applying were rather small: 46% had only four or less employees and another 32.4% had five to 19 employees. Applicants were mainly active in manufacturing (62%), company-related services (21%), services (8%), and construction (5%). The industry-specific distribution in our sample is in line with the distribution of industry-specific innovation activity as analyzed in various innovation reports. Some more details about our sample are reported in the following: 76% of the firms in our sample had not received any state subsidies before and 70%

did not cooperate with external R&D service providers. Most R&D providers chosen for the joint R&D projects were private firms (55%), followed by universities (20%), Steinbeis centers (13%), and Fraunhofer institutions (6%).

The probability of enrollment was used as a dependent variable in a logit model (see Table 11.1). Although the fitting criteria of the models are not extremely satisfying, all models except for models 2 and 7 fulfill the necessary statistical criteria. For model 2, the AIC is bigger than the AIC of the basic model (AIC: 579.19). Hence, all models with the exception of model 2 have explanatory power. For model 7, the deviance test is significant.

The estimation models presented in the next section contain the variables needed to test our seven hypotheses developed above: size (operationalized as number of employees), age (operationalized as number of years since founding), type of R&D service provider, previous R&D cooperation, geographical distance between companies and R&D providers, location, and the number of words in the application. Furthermore, we used the sector and previous subsidization as control variables.

5 The Enrollment Stage: Empirical Results

In this section, we are going to present the results of our estimations (see Table 11.1) and test our hypotheses. The parameter estimates are fairly stable across all models. Therefore, it is sufficient to interpret the results of model (1) which is our preferred model.

The size of the company does not have an influence on the likelihood of conducting a project. Hence, we have to reject H1. The assumptions that led to the hypothesis seem to be mistaken (in addition to the categorical results of the variable number of employees displayed in Table 11.1, we tested linear and curvilinear relationships of the continuous scores without any significant results). Small companies might have only one (or rather few) projects. But it seems as if small companies planned the project before applying for subsidies as well as did bigger companies. An alternative explanation could be that the costs of compliance might be relatively higher for smaller companies. If there are, e.g., only two employees in a firm, gathering information on the subsidy scheme and on the chances of the project might be relatively more costly than for a company of 20 employees. Companies would then only gather information and write a proposal if they really meant to undertake the project. This might outweigh the fewer chances to finish the project on later stages due to insufficient resource endowment. This means that there would be some preselection; smaller companies might only apply if they really know that they can finish the project. It also could mean that the coalition of those who want to do a project is more stable in small companies than in large companies. R&D projects cannot get killed so easily.

For *age* of the company, there are no significant results either. Companies were divided into three groups: start-ups, 0–3 years; young companies, 3–7 years; and old companies, older than 7 years. The results were insignificant in all models where

Table 11.1 Probability of conducting the project

Independent variables	Reference group	Model 1			Model 2			Model 3			Model 4		
		Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.
Number of employees	**≥ 20**												
≤ 2		–0.3461	0.707	0.3277	–0.2954	0.744	0.3896						
3–4		–0.2469	0.781	0.5657	–0.1747	0.840	0.6764						
5–9		–0.3900	0.677	0.3111	–0.2591	0.772	0.4857						
10–19		–0.0132	0.987	0.9709	0.0744	1.077	0.8335						
Age	**Start-up (up to 3 years)**												
Young company (3–7 years)		–0.1498	0.861	0.6506	–0.1372	0.872	0.6749	–0.0498	0.951	0.8741			
Old company (older than 7 years)		–0.2380	0.788	0.4294	–0.2603	0.771	0.3738	–0.1016	0.903	0.6925			
Sector	**Company-related services**												
Construction		0.5091	1.664	0.3899									
Mining		0.2289	1.257	0.7099									
Manufacturing		0.0311	1.032	0.9180									
Services		0.6400	1.896	0.2948									
Type of R&D provider	**Private firm**												
Fraunhofer		**–0.9880**	**0.372**	**0.0095**	**–0.8864**	**0.412**	**0.0170**	**–0.8344**	**0.434**	**0.0232**	**–0.8359**	**0.433**	**0.0225**
Steinbeis		–0.1734	0.841	0.6378	–0.0622	0.940	0.8632	–0.0853	0.918	0.8129	–0.0872	0.916	0.8085
Universities		**–0.8408**	**0.431**	**0.0037**	**–0.7603**	**0.468**	**0.0076**	**–0.7298**	**0.482**	**0.0097**	**–0.7280**	**0.483**	**0.0099**
Incorporated society		–0.2224	0.801	0.6585	–0.1644	0.848	0.7402	–0.2013	0.818	0.6811	–0.1961	0.822	0.6887

(continued)

Table 11.1 (continued)

Independent variables	Reference group	Model 1			Model 2			Model 3			Model 4		
		Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.	Koeff	Exp(B)	Sig.
Region	**Rural area**												
Core city		**–0.6184**	**0.539**	**0.0309**	**–0.5985**	**0.550**	**0.0315**	**–0.5835**	**0.558**	**0.0346**	**–0.5748**	**0.563**	**0.0368**
Suburban areas		–0.0751	0.928	0.8420	0.0067	1.007	0.9856	0.0039	1.004	0.9915	0.0042	1.004	0.9910
Urban areas		0.2651	1.304	0.5633	0.1376	1.148	0.7526	0.1548	1.167	0.7215	0.1489	1.161	0.7315
Previous cooperation	**Yes**												
No		**–0.5551**	**0.574**	**0.0466**	**–0.5357**	**0.585**	**0.0496**	**–0.5512**	**0.576**	**0.0428**	**–0.5433**	**0.581**	**0.0453**
Previous subsidies	**Yes**												
No		–0.3651	0.694	0.2104	–0.3297	0.719	0.2430	–0.3600	0.698	0.1975	–0.3577	0.699	0.1991
Distance between company and R&D provider		–0.0009	0.999	0.1323	–0.0008	0.999	0.1869	–0.00076	0.999	0.2105	–0.00076	0.999	0.2097
Number of words in the description of project		0.0013	1.001	0.1551	0.0013	1.001	0.1508	0.00128	1.001	0.1559	0.00133	1.001	0.1368
Constant		**2.9257**	**18.647**	**<,0001**	2.8343	17.018	<,0001	2.6020	13.491	<,0001	2.5203	12.432	<,0001

Criteria of model fitting	Model 1	Model 2	Model 3	Model 4
Deviance test (Pr > ChiSq)	0.7864	0.7620	0.7843	0.7999
AIC	578.175	583.577	577.055	573.216
Hosmer-Lemeshow test (Pr > ChiSq)	0.9560	0.9857	0.5238	0.6779
PseudoR2 (according to Nagelkerke)	0.0915	0.0783	0.0745	0.0741

Independent variables		Model 5			Model 6			Model 7		
Type of R&D provider	**Private firm**									
Fraunhofer		**−0.8145**	**0.443**	**0.0256**	**−0.8098**	**0.445**	**0.0263**	**−0.8464**	**0.429**	**0.0197**
Steinbeis		−0.0377	0.963	0.9159	−0.0468	0.954	0.8953	0.0018	1.002	0.9958
Universities		**−0.7213**	**0.486**	**0.0104**	**−0.7174**	**0.488**	**0.0107**	**−0.6882**	**0.502**	**0.0139**
Incorporated society		−0.2844	0.752	0.5566	−0.2878	0.750	0.5519	−0.2816	0.755	0.5599
Region	**Rural area**									
Core city		**−0.5668**	**0.567**	**0.0391**	**−0.5530**	**0.575**	**0.0436**	**−0.5226**	**0.593**	**0.0554**
Suburban areas		0.0161	1.016	0.9651	0.0157	1.016	0.9659	0.0006	1.001	0.9988
Urban areas		0.1747	1.191	0.6863	0.1778	1.195	0.6807	0.1782	1.195	0.6795
Previous cooperation	**Yes**									
No		**−0.5577**	**0.573**	**0.0399**	**−0.6799**	**0.507**	**0.0071**	**−0.6588**	**0.517**	**0.0090**
Previous subsidies	**Yes**									
No		−0.3276	0.721	0.2372						
Number of words in the description of project		0.00132	1.001	0.1392	0.00133	1.001	0.1369			
Constant		**2.3919**	**10.934**	**<,0001**	**2.2250**	**9.253**	**<,0001**	**2.3890**	**10.903**	**<,0001**

(continued)

Table 11.1 (continued)

Criteria of model fitting	Model 5	Model 6	Model 7
Deviance test (Pr > ChiSq)	0.6663	0.6133	0.0437
AIC	572.730	572.166	572.689
Hosmer-Lemeshow test (Pr > ChiSq)	0.2191	0.3124	0.8745
PseudoR2 (according to Nagelkerke)	0.0702	0.0665	0.0599

age was taken into account (as were all other classifications we used, e.g., other groups further classifying older companies or a continuous variable). Hence, H2 does not hold either. A reason might be that the applicants for an R&D subsidy program are most likely not typical start-ups but more likely highly skilled entrepreneurs. This group might plan the start-up process in great detail and might be rather professional already. They could have significant experience with innovation project already before the inception of the business. Therefore, they are not very likely to kill R&D projects that they have carefully planned without trying out first.

For the *type of R&D provider,* we find significant differences between "high-quality/high-status" R&D providers such as universities and Fraunhofer institutions and private firms that were used as the control group. The coefficients for universities and Fraunhofer institutions are negative and significant at least on a 5% level in all models (those of universities are even significant on a 1% level in three out of six models). Hence, H3 cannot be rejected. This means that projects that were supposed to run with private firms are more likely to be conducted than those that are supposed to run with "high-quality/high-status" research providers. This might be a hint that for the mostly rather small companies in our sample, R&D providers like private design or engineer bureaus are in many cases more adequate than large research centers at universities or Fraunhofer institutions.

The geographical distance between a company and its R&D provider is not significant in any of our estimated models. The coefficient has the expected negative sign but is insignificant in all models. Hence, we reject our hypothesis H4 which stated that with an increase in geographical distance, the likelihood of execution of the collaborative projects should decrease. Interestingly, our result is in line with the findings of Mora-Valentin et al. (2002) though. They found distance not to have an influence on the quality of cooperation.

Furthermore, we find that companies from core cities have a significantly higher probability of dropping out than those from rural areas. This contradicts H5 where we expected that companies from core cities have a higher probability of conducting their projects than those from rural areas. In fact the opposite is true. This result is stable and significant on a 5% level in all but one model (in model 6 it is significant only on a 10% level). We tried to come up with an explanation for this surprising finding. Innovation is about putting new ideas into practice. In core cities life is quicker and gathering new ideas occurs at a faster rate relative to all other places. Exchanging new ideas with other companies and actors is quicker in core cities due to extended networks that are easily accessible. Such was our argument, why companies from core cities should have more cooperation experience than those from rural areas. But this could also lead to an increased number of innovative projects for companies in core cities which in turn could mean that not only more projects are started but that also more ideas are abolished on the way. In other words, there is more competition between innovative ideas and projects which leads to a higher rate of abortion of collaborative innovation projects.

Furthermore, it turns out that companies that did not have previous cooperation experience with R&D providers have a significantly lower probability of conducting the intended projects than those that already cooperated as was expected in H6.

This result corresponds to the result of Mora-Valentin et al. (2002) and might be a good argument in favor of fostering cooperation especially for those firms that did not have any links to R&D institutions before: having conducted an innovation project together with an external R&D provider seems to lead to substantial learning effects, lowers the company's transaction costs in follow-up cooperations, and improves the chances to finish further cooperation projects. The transaction costs of a first time cooperation can be seen as some kind of system failure that rectifies subsidies.

Finally, concerning the number of words in the description of the project, we expected them to have a positive influence on the probability of conducting the project (H7). We interpreted the number of words as the effort that was spent to apply for the subsidy. The coefficient has the expected sign but is not significant in any model. This might be due to the preselection in the *acceptance* stage though. Those with low-quality smaller applications might have been sorted out in the previous step of the targeting process.

The control variables sector and previous subsidization do not have a significant influence on the likelihood of conducting collaborative innovation projects in the multivariate analysis.

6 Conclusion and Limitations

To sum it up, by analyzing the last step of the allocation process (*enrollment*) in a specific R&D promotion program, one can learn about the behavior of small firms in cooperation projects. Dropouts of the program under revision are not random but follow clear lines. The probability of conducting a project is lower when companies did not possess cooperation experience in R&D-related activities before. This is a clear hint on higher transaction costs for companies without cooperation experience. Policies targeting the creation of cooperation hence can be seen as addressing a specific system failure. Furthermore, planned cooperation between small companies and "high-quality" R&D institutions seem to be less likely to work out than cooperations with private R&D service providers. This coincides with the qualitative evidence gathered for this project.

The most obvious limitation of this chapter is that out of the complete allocation process, only the stage *enrollment* was analyzed in this chapter. More research is necessary for a better understanding of all stages of the allocation process of public funds mentioned by Heckman and Smith (2004) (*eligibility, awareness, application, acceptance,* and *enrollment*) and how these stages interact with each other.

For political decision makers, more emphasis might be necessary regarding the selection process of companies being subsidized when designing R&D promotion programs. Politicians have to be clear about different incentives that work within bureaucracies. Even if the selection criteria seem to be open, there could be hidden preferences inside boards, bureaucrats that even board members are not aware of themselves. Bureaucrats have the chance to channel funding to special interest groups or regions by defining who is eligible and by deciding how to communicate the promotion program. Fostering innovation is an important task. But the implementation of such programs might serve other goals as well.

The definition of the criteria for applications that are granted is difficult as well. Politicians and academics call for small application costs. But diminishing the application costs too much might lead to bigger differences between preliminary evaluation of the projects in the step *application* and in-depth evaluation in the step *enrollment*.

Finally, in our opinion, academic work that is done in the area of evaluating R&D promotion programs should put more emphasis on the discussion of the different steps of the allocation process. They might crucially determine the economic outcomes of the entire promotion programs. Finally, we should give some thought on our finding that small companies' projects with R&D institutions that are frequently seen as "high-quality/high-reputation" providers such as universities and Fraunhofer institutes are less likely to work out at the enrollment step compared with private R&D providers. Presumably, the large research institutions are badly equipped to interact with the SME. It might be necessary that the public research institutions develop competences in the area of knowledge transformation and collaboration with small organizations. Having said that, we don't have information about a quality assessment of the collaboration or the success of the collaborative innovation project. Perhaps the picture looks more in favor of the public R&D organizations, but we have first indications that this is not the case.

References

Arrow KJ (1962) Economic welfare and the allocations of resources of invention. In: Nelson R, Nelson RR (eds) The rate and direction of inventive activity: economic and social factors. Princeton University Press, Princeton

Aschhoff B (2008) Who gets the money? The dynamics of R&D project subsidies in Germany. ZEW discussion paper 09–018

Aschhoff B (2009) The effect of R&D project subsidies on R&D revisited. The role of firms subsidy history and subsidy size. Working paper presented at the summer conference 2009 on Copenhagen Business School

Asheim BT, Gertler MS (2005) The geography of innovation – regional innovation systems. In: Fagerberg J et al (eds) The Oxford handbook of innovation. Oxford University Press, Oxford

Blanes JV, Busom I (2004) Who participates in R&D subsidy programs? The case of Spanish manufacturing firms. Res Pol 22:1459–1476

Czarnitzki D, Toole AA (2006) Business R&D and the interplay of R&D subsidies and market uncertainty. ZEW discussion paper 06–055

David PA, Hall BH, Toole AA (2000) Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Res Pol 29(4–5):497–529

Desmet K, Kujal P, Lobo F (2004) Implementing R&D policies: an analysis of Spain´s pharmaceutical research program. Res Pol 33:1493–1507

Falk R (2005) Behavioural additionality effects of R&D subsidies: empirical evidence from Austria. Paper presented at the 32nd conference of the European association of research in industrial economics (EARIE), Porto

Feldman MP, Kelley MR (2006) The ex ante assessment of knowledge spillovers: government R&D policy, economic incentives and private firm behaviour. Res Pol 35:1509–1521
Hall B (2002) The financing of research and development. Oxf Rev Econ Pol 18(1):35–51
Heckman JJ, Smith JA (2004) The determinants of participation in a social program: evidence from a prototypical job training program. J Labor Econ 22(2):243–298
Heijs J (2003) Freerider behaviour and the public finance of R&D activities in enterprises: the case of the Spanish low interest credits for R&D. Res Pol 32(3):225–461
Klette TJ, Moen J, Griliches Z (2000) Do subsidies to commercial R&D reduce market failure? Microeconomic evaluation studies. Res Pol 29:471–495
Koski H, Tuuli J (2010) Business subsidies in Finland: the dynamics of application and acceptance stages. Research Institute of the Finnish Economy, Elinkeinoelämän Tutkimuslaitos, discussion papers, no 1225
Lundvall B-A (1992) National systems of innovation: towards a theory of innovation and interactive learning. Pinter, London
Mohen P (1996) R&D externalities and productivity growth. STI Rev 18:39–66
Mora-Valentin EM, Montoro-Sanchez A, Guerras-Martin L (2002) Determining factors in the success of R&D cooperative agreements between firms and research organizations. In: Peoceedings of 28th EIBA conference, 2002, Athens
Nelson RR (1959) The simple economics of basic scientific research. J Polit Econ 67:297–306
Nelson RR (1993) National systems of innovation: a comparative study. Oxford University Press, Oxford
Porter ME (2000) Location, competition, and economic development: local clusters in a global economy. Econ Dev Quart 14:15–34
Stiglitz JE, Weiss A (1981) Credit rationing in markets with imperfect information. Am Econ Rev 71(3):393–410
Tanayama T (2007) Eligibility, awareness and the application decision: an empirical study of the firm participation in an R&D subsidy program. Helsinki center of economic research discussion paper no 161
Tanayama T (2009) Rationales and reality of R&D subsidies: are SMEs and large firms treated differently? Helsinki center of economic research discussion paper no 280

Part III
Regional Differences

Chapter 12
Productivity Gaps Among European Regions

Claudio Cozza, Raquel Ortega-Argilés, Mariacristina Piva, and Rui Baptista

Abstract How is the R&D-productivity link affected by the environment where firms locate? Are companies located with their registered offices in more R&D favorable environments better able to translate their R&D knowledge into productivity gains? Our paper tries to answer these questions analyzing - in the European context - if R&D performing companies cluster themselves in "higher-order R&D regions", as the Economic Geography theories postulate, inducing a polarisation in terms of labour productivity in comparison with firms located in "lower-order R&D regions".

The proposed microeconometric estimates are based on a unique longitudinal database of publicly-traded companies belonging to manufacturing and service sectors. The final unbalanced sample comprises 626 European companies for a total of 3,431observations, covering the period 1990-2008. Results show that European "higher-order R&D regions" not only invest more in R&D, but also achieve more in terms of productivity gains from their own research activities. Results also show that in the case of "lower-order R&D regions", physical capital stock is still playing a dominant role.

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1 Introduction

This volume on "Technology Transfer in a Global Economy" following a conference on the topic puts together contributions from different business and economics literature strands. Global technology transfer was empirically analysed using different quantitative and qualitative techniques; among other topics the conference presented works based on the link between academy and industrial research; technological growth "external" to the firm, cooperation or technology acquisitions; and sectoral and product value chains.

The volume stresses the important aspect of the geographical level – national or regional – in conducting analysis of the global context. Although we live in a global economy, where technological links have to be analysed on the whole world scenario, the national and subnational patterns still help in explaining the global tendency. Even more than before, the subnational analysis constitutes the building brick to understand how world balances are changing.

This chapter addresses all these issues through a quantitative analysis of the link between R&D and productivity at the regional level. The global economic tendency is analysed looking at the behaviour of the global R&D business performers. The hypothesis on regional technology transfer focuses on how companies located in a favourable environment for R&D can better translate their knowledge capital into productivity gains. For the location, NUTS 1 level classification has been adopted. Additionally, the analyses have taken into consideration the importance of the sectoral belonging, with regard to industrial sectoral breakdown (manufacturing versus services) and the technological intensity of the sector (high-, medium- and low-tech sectors).

Previously applied literature shows that the economic performance of regions (proxied by GDP, GDP per capita or labour productivity) has a higher variability than the one of countries.[1] Indeed, differences in the performance across regions within the same country are often greater than differences between countries (OECD 2009a, b). The main reason is that "localised" factors seem to play a greater role than national factors in determining the performance of regions. Each region is endowed with very different production structure, comparative advantages, location and geographic characteristics, institutions, policies and assets. In Europe, indeed, regions appear to be extremely heterogeneous.

The inequalities between regions are often an outcome of different processes. One of the most significant is the geographical concentration of economic activity. The concentration of economic activity is characterised by the presence, activity and interactions of private and public actors (firms, training institutions, trade unions, universities, public research centres) that chose the region to locate and operate. The peculiarities characterising each region (such as different supply factors) have a direct effect on firms' decisions to locate and, subsequently, might determine firms' performance and growth. In principle, growth opportunities exist

[1] In this publication, region is used to mean a subunit within a country, rather a supranational grouping of countries.

in all regions, but firms tend to locate in regions that might offer a favourable environment to pursue their production and growth targets. This chapter is focused on how companies located with their registered offices in a favourable environment for R&D can better translate their knowledge capital into productivity gains.

Recent empirical works have shown how the endogenous growth can be applied to the regional level, underlining the crucial role of knowledge stock (R&D or patents) and human capital (skilled labour) in explaining the differences in productivity across regions (Gumbau-Albert and Maudos 2006; Dettori et al. 2008; Fischer et al. 2008; Bronzini and Piselli 2009). We analyse this hypothesis for the European case splitting our sample between the so-called higher-order R&D regions and lower-order R&D regions. We want to test if following the localisation logic, R&D-performing companies cluster themselves in "higher-order regions" and get better labour productivity performance in comparison with firms located in "lower-order regions" (Cantwell and Iammarino 2001).

In order to run this exercise, we use firm-level data. The data sample covers the period 1990–2008, depending on the number of years available in each company's history; therefore, the sample used is unbalanced in nature and comprises 626 European companies for a total of 3,431 observations.[2]

Results show that regions investing more in R&D are also characterised by a better ability to translate the R&D investment in an increase in labour productivity both in manufacturing and service sectors. On the other side, results show that in the case of lower-order R&D regions, the physical capital stock is still playing a dominant role.

After this Introduction, the rest of the chapter is organised as follows: Sect. 2 provides a survey of the theories and previous empirical literature on the tendency of firms to agglomerate and polarise in regions and on the different effects that input factors have on firm productivity; in Sect. 3, data, variable construction and methodological issues are discussed; Sect. 4 deals with the empirical results, and finally, Sect. 5 addresses the main conclusions of the work and some policy implications derived from the analysis.

2 Literature Review

2.1 Economic Geography Theories: The Role of Geography

As we indicated in the introduction, firms locate in regions where they might be able to obtain better results from the inputs used for their production process. One of the

[2] In case of multilocated or multinational corporations, data refer to global activities controlled by mother companies from the region of their registered office. In the estimates, therefore, the NUTS (Nomenclature of Territorial Units for Statistics) codes always refer to the regions from where company activities on the whole are owned and controlled.

main issues in this chapter is focused in analysing if the effects on productivity of different production inputs can differ among firms located in different environments. We can illustrate this idea by some concepts from economic geography theories.

Firm creation, performance and growth depend on the conditions of both the environment and the market where firms operate (see the pioneer works: Krugman 1991; Porter 1990, 1998, 2000). The creation of agglomeration patterns in economic activity is centred in various concepts: localisation economies (cluster creation), input–output linkages and technological spillovers.

Localisation economies turn out to be relevant when many firms operating in the same industry locate close to each other. Sources of localisation economies can differ among different industries. In general, the main important sources that can facilitate and encourage the proximity of firms are as follows: benefits from accessing to a pool of labour with the required skilled and abilities, increasing returns to scale in intermediate inputs and relative ease of communication and circulation of innovative ideas. As more firms in same and/or *related industries* (Frenken et al. 2007) cluster together, cost of production may decline significantly.

Input–output linkages are crucial in the creation of agglomeration economies. The accumulation of certain input factors (knowledge, natural, labour resources) in certain locations creates a favourable industrial environment capable to enhance the economic growth by the means of the development of specific industries (Krugman and Venables 1996). Following this line of reasoning, we can say that economic activity will tend, accordingly to their needs, to agglomerate in certain areas producing *regional (and national) specialisation production patterns*.

The positive effect of the accumulation of skills, know-how and knowledge in certain locations in explaining the *creation of clusters* started with the work of Marshall (1890), and the idea has evolved by other authors like Malmberg and Maskell (1997, 2002) or Maskell (2001). Evolutionary economics theories that focus the attention in the historical evolution of the localisation processes of firms introduce other concepts like *industrial relatedness*, *organisational ecology* or *industrial heritage*. The presence of related industries has increased importance where local access to specialised skilled labour force is determinant or knowledge sharing between the actors (Frenken et al. 2007) in firm heritage processes (Klepper 2007) and organisational ecology framework (among others, Hannan et al. 1995; Carroll and Hannan 2000; Audia et al. 2006).

Furthermore, this accumulation effect is conditional on the *absorptive capacity* of firms. As Cohen and Levinthal (1990) have argued, firms can understand, absorb and implement external knowledge only when it is close to their own knowledge base. The potential learning mechanism might be at work horizontally that is from spillovers from other producers and competitors, or vertically, by interacting with upstream suppliers and downstream users, as well as from independent research carried out in the regional, national or international science and technology networks by universities and research institutes. Boshma and Frenken (2009) show that knowledge accumulation tends to operate at the regional level because the mechanisms through which they operate (like spinoff activity, firm diversification, labour mobility or social networking) tend to have a regional bias.

Finally, *technological spillovers* are another source of localisation economies. Technical knowledge and expertise, knowledge spillovers, technological learning, higher R&D returns and other important synergies for the innovation process (von Hippe 1988; Feldman 1994; Baldwin and Forslid 2000; Martin and Ottaviano 2001; Forslid and Wooton 2003; Antonelli 2010) are particularly relevant in a regional framework. In this perspective, the significance of the regional dimension of innovation systems has emerged as the logical consequence of the interactive model (Kline and Rosenberg 1986), which indeed puts the emphasis on the relations with knowledge sources external to the firm. Such relationships – at interfirm level, between firms and the science infrastructure, between the business sector and the institutional environment, etc. – are strongly influenced by spatial proximity mechanisms that favour processes of polarisation and cumulativeness (see, e.g. Lundvall 1988; von Hippe 1988; Cooke et al. 1997).

The theoretical literature explored in the previous part suggests that there are benefits for the firm adopting inputs available in the geographical area where it is located. This could, in turn, be translated into an increase in its performance. However, when the inputs are R&D investments, the cumulative efforts may widely vary across the different environments. Indeed, technological opportunities and appropriability conditions are so different across regions depending on the level of knowledge found in the region and the sectoral composition.

In a sense, the endogenous growth approach (Romer 1986, 1987, 1990; Lucas 1988; Aghion and Howitt 1992)[3] applied at the regional level reflect the crucial role of knowledge stock (proxied by either R&D or patents) and human capital in explaining the differences in performance across regions, such as total factor productivity (see, for instance, Dettori et al. 2008, studying 199 European regions over the period 1985–2006; Fischer et al. 2008, analysing 203 European regions over the period 1997–2002; Gumbau-Albert and Maudos 2006, investigating 17 Spanish regions over the period 1986–96; Bronzini and Piselli 2009, studying 19 Italian regions over the period 1985–2001).

Furthermore, this result might come from the agglomeration patterns creating economies of scale and scope that have a direct influence in the performance and growth of companies located in certain regions. Cantwell and Iammarino's work (1998, 2000, 2001) is centred in the presence of large, mainly of them multinational or global, players, in determining the specialisation patterns of certain regions by the location of their sites. Their works show that the patterns of large players create endogenous patterns to attract other innovative actors in order to create lines of specialisation through intra-firm networks. Their studies show that geographical

[3] Romer (1986) and Lucas (1988) defined a model where the main premises where knowledge was considered an input of production and displayed increasing marginal productivity, increasing returns to scale and decreasing returns in production of new knowledge. Lately, Romer (1987, 1990) and Aghion and Howitt (1992) models introduced the assumption of imperfect competition and the fact that technological change aroused by the international decisions from profit-maximising agents. R&D activities reward firms through monopolistic power, and their effect is higher in environments where competition is higher (in specialised clusters of high-tech firms, higher-order R&D regions in our work).

concentration of large company innovation activity is quite pronounced in most European countries.

Le Bas and Sierra (2002) study the question of the determinants of the foreign location of technological activities of multinational firms. They explore if multinationals locate their knowledge activities as a consequence of their home country advantages or according to host country strengths. The study is based on a panel of 345 multinationals with the greatest patenting activity in Europe. They found that the strategies of multinationals differ among countries of origin and countries of destination. Finally, their results confirm the work by Patel and Vega (1999) based on a sample of 220 high-patenting multinationals. Both works show that more than 70% of the multinationals locate their activities in technological activities where they are already strong at their home country.[4]

Moreover, Iammarino and McCann (2010) provide an explanation for why the strategies of multinational enterprises result in a pattern of "concentrated dispersion" worldwide. They claim that firms' accumulated different competences in time and space have an impact on their incentives to co-locate and tap into complementary knowledge bases in different locations. This shows how single important player might drive and determine sectoral geographical specialisation and innovative strategies.

2.2 The Role of R&D to Enhance Firm Productivity: Firm and Sectoral Evidence

Since Zvi Griliches' (1979) work, the literature devoted to investigate the role of R&D on productivity at the firm and sectoral level has found robust evidence of a positive and significant impact of knowledge capital on firm productivity.

In general, microeconometric literature indicates a significant and positive role of R&D in enhancing productivity at the firm level independently of the proxy for productivity used (labour productivity as the ratio between value added and employment or the ratio between value added and hours worked, total factor productivity, Solow's residual, etc.). Furthermore, sectoral studies clearly suggest a greater positive impact of R&D efforts on firm productivity in high-tech sectors rather than in low-tech ones.

Examples are Griliches and Mairesse (1982) and Cuneo and Mairesse (1983), who performed two companion studies using micro-level data and making a distinction between firms belonging to science-related sectors and firms belonging to other sectors. They found that the impact of R&D on productivity for scientific firms (elasticity equal to 0.20) was significantly greater than for other firms (0.10).

By the same token, Verspagen (1995) tested the impact of R&D expenditures using OECD sectoral-level data on value added, employment, capital expenditures

[4] Defined as the technological fields in which a particular country exhibits a specialisation index greater than unity.

and R&D in a standard production function framework. The author singled out three macro sectors: high-tech, medium-tech and low-tech, according to the OECD classification (Hatzichronoglou 1997). The major finding of his study was that the impact of R&D was significant and positive only in high-tech sectors, while for medium and low-tech sectors, no significant effects could be found.

Using the methodology set up by Hall and Mairesse (1995), Harhoff (1998) studied the R&D/productivity link – using a slightly unbalanced panel of 443 German manufacturing firms over the period 1977–1989 – and found a significant impact ranging from a minimum of 0.068 to a maximum of 0.137, accordingly to the different specifications and the different econometric estimators adopted. Interestingly, the effect of R&D capital was considerably higher for high-technology firms rather than for the residual groups of enterprises. In particular, for the high-tech firms, the R&D elasticity always turned out to be highly significant and ranging from 0.125 to 0.176, while for the remaining firms, the R&D elasticity resulted either not significant (although positive) or lower (ranging from 0.090 to 0.096), according to the different estimation techniques.

More recently, Wakelin (2001) applied a Cobb–Douglas production function where productivity was regressed on R&D expenditures, capital and labour using panel data (170 UK quoted firms during the period 1988–1992). She found that R&D expenditures had a positive and significant role in influencing a firm's productivity growth; however, in firms belonging to sectors defined as "net users of innovations", R&D activities turned out to have a significantly larger impact on productivity.

Rincon and Vecchi (2003) also used a Cobb–Douglas framework in dealing with panel microdata extracted from the Compustat database over the time period 1991–2001. R&D-reporting firms appear to be more productive than their non-R&D-reporting counterparts throughout the entire time period. Sectoral macroeconomic disparities in the R&D productivity link were found in their analysis; the positive impact of R&D expenditures turned out to be statistically significant both in manufacturing and services in the USA, while in the three main European countries (Germany, France and the UK), only a positive effect was found only in manufacturing. Their estimated significant elasticities ranged from 0.15 to 0.20.

Kwon and Inui (2003) analysed 3,830 Japanese firms with no less than 50 employees in the manufacturing sector over the period 1995–1998, also using the methodology set up by Hall and Mairesse (1995). Using three different estimation techniques (within estimates, first difference and 3-year differences), they found a significant impact of R&D on labour productivity, with high-tech firms systematically showing higher and more significant coefficients than medium- and low-tech firms.

Ortega-Argilés et al. (2011) have looked at the top EU R&D investors, using an unbalanced longitudinal database consisting of 577 large European companies over the period 2000–2005, extracted from the UK-DTI Scoreboards. The authors found that the R&D productivity coefficient was significantly different across sectors. In particular, the coefficient increased monotonically moving from the low-tech to the medium-high and high-tech sectors, ranging from a minimum of 0.03/0.05 to a maximum of 0.14/0.17. This outcome has been interpreted as evidence that firms in high-tech sectors are still far ahead in terms of the impact on productivity of their R&D investments, at least as regards top European R&D investors.

With the aim of addressing some conclusions of the comparison of the effect of different types of R&D/innovations on firm productivity between manufacturing and knowledge-intensive services (KIS) companies in the Spanish region of Catalonia, Segarra (2010), using a sample extracted from the CIS4 (2002–2004), concludes that a considerable heterogeneity in firm performances can be found in the comparison of manufacturing and service industries and between high- and low-tech manufacturing firms; results show that especially KIS sectors play a key role in Catalonian economy.

On the whole, previous firm and sectoral empirical studies – using different data sets across different countries – seem to suggest a greater impact of knowledge and R&D investments on firm productivity in the high-tech sectors rather than in the low-tech ones.

3 Data and Method

3.1 The Data

The microdata used in this study were provided by the JRC-IPTS (Joint Research Centre, Institute for Prospective Technological Studies) of the European Commission; the information provided only concerns publicly traded companies and is extracted from a variety of sources, including companies' annual reports, Securities and Exchange Commission (SEC) 10-K and 10-Q reports, daily news services and direct company contacts, using standardised data definitions and collection procedures to assure consistent presentation of data.[5]

Available data includes:

- Company identification, name and address and industry sector (Global Industry Classification Standard (GICS) that can be translated in the standard SIC classification)
- Fundamental financial data including income statements, cash flows, taxes, dividends and earnings, pension funds, property assets and ownership data
- Fundamental economic data, including the crucial information for this study, namely, sales, cost of goods (the difference between the former and the latter allows us to obtain value added), capital formation, R&D expenditures and employment

Given the crucial role assumed by the R&D variable in this study, it is worthwhile to discuss in detail what is intended by R&D in our database. This item represents

[5] The original data source being Compustat Global data set provided by Standard & Poor's, for additional information about the data source, consult: http://be.ncue.edu.tw/compustat/manual/MK-CGDC4-02.pdf.

all costs incurred during the year that relate to the development of new products and services. It is important to notice that this amount is only the company's contribution and excludes amortisation and depreciation of previous investments, so being a genuine flow of current in-house R&D expenditure.[6] On the whole, the adopted definition of R&D is quite restrictive and refers to the genuine flow of current additional resources coming from internal sources and is devoted to the launch and development of entirely new products.

The period covered is 1990–2008; however, the number of years available for each company depends upon the company's history; therefore, the data source is unbalanced in nature and comprises 626 firms for a total of 3,431 observations.

Once we acquired the rough original data from IPTS, we proceeded in the construction of a longitudinal database that would be adequate to run panel estimations for testing the hypotheses discussed in the previous section.

3.2 Construction of the Data Set

The first step was focused on the data extraction. In guiding the extraction of the data from what provided, the following criteria were adopted:

- Selecting only those companies with R&D > 0 in, at least, 1 year of the available time span.
- Selecting only those companies located in the EU 27 countries.
- Extracting information concerning R&D, sales, cost of goods (the difference between sales and cost of goods allowed to obtain value added), capital formation, R&D expenditures and employment. More specifically, this is the list of the available information for each firm included in the obtained workable data set: country of incorporation (location of the headquarter), industry code at 2008, R&D expenses, capital expenditures, net turnover, cost of goods sold and employees.
- All the value data were expressed in the current national currency in millions (for instance, countries which are currently adopting euro have values in euro for the entire examined period).

The second step focused on the deflation of current nominal values. Nominal values were translated into constant price values through GDP deflators (source: IMF) centred in year 2000. For a tiny minority of firms reporting in currencies different from the national ones (viz. 41 British firms, 9 Dutch firms, 4 Irish firms, 2 Luxembourg firms, 1 German and 1 Swedish firms reporting in US dollars and 7 British firms, 2 Danish firms and 1 Estonian firm reporting in euro), we opted for deflating the nominal values through the national GDP deflator, as well.

[6] In particular, the figure excludes the following: customer- or government-sponsored R&D expenditures engineering expenses such as routinised ongoing engineering efforts to define, enrich or improve the qualities and characteristics of the existing products, inventory royalties, market research and testing.

Once we obtained constant 2000 price values, as a third step, all figures were converted into US dollars using the PPP exchange rate at year 2000 (source: OECD).[7] The fourth step was devoted to give format to the data string. The obtained unbalanced database comprises 926 companies, 2 codes (country and sector) and 5 variables (see the bullet points above) over a period of 19 years (1990–2008).

Since one of the purposes of this study is also to distinguish between high-tech and medium/low-tech sectors, a third code was added, labelling as high-tech the following sectors[8]:

- SIC 283: Drugs (ISIC Rev.3, 2423: Pharmaceuticals)
- SIC 357: Computer and office equipment (ISIC Rev.3, 30: Office, accounting and computing machinery)
- SIC 36 (excluding 366): Electronic and other electrical equipment and components, except computer equipment (ISIC Rev.3, 31: Electrical machinery and apparatus)
- SIC 366: Communication equipment (ISIC Rev.3, 32: Radio, TV and communications equipment)
- SIC 372–376: Aircraft and spacecraft (ISIC Rev.3, 353: Aircraft and spacecraft)
- SIC 38: Measuring, analysing and controlling instruments (ISIC Rev. 3, 33: Medical, precision and optical instruments)

As a fifth step, the following computation of the R&D and capital stocks was used. Consistent with the reference literature (see Sect. 2), the methodology adopted in this study requires us to compute the R&D and capital stocks, accordingly with the *perpetual inventory method*. In practice, the following two formulas have to be applied:

$$K_{t0} = \frac{R\&D_{t0}}{(g+\delta)} \text{ and } K_t = K_{t-1}\cdot(1-\delta) + R\&D_t \tag{12.1}$$

where R&D = R&D expenditures

[7] This procedure is consistent with what suggested by the Frascati Manual (OECD 2002) in order to correctly adjust R&D expenditures for differences in price levels over time (i.e. intertemporal differences asking for deflation) and among countries (i.e. interspatial differences asking for a PPP equivalent). In particular, "…the Manual recommends the use of the implicit gross domestic product (GDP) deflator and GDP-PPP (purchasing power parity for GDP), which provide an approximate measure of the average real "opportunity cost" of carrying out the R&D" (ibidem, p. 217). More in detail, nine companies from four countries (Lithuania, Latvia, Malta and Romania) were excluded, due to the unavailability of PPP exchange rates from the OECD. The ten companies reporting in euro but located in non-euro countries (Denmark, Estonia and the UK) were excluded as well, while the 58 companies reporting in US dollars were kept as such.

[8] The standard OECD classification was taken (see Hatzichronoglou 1997) and extended it including the entire electrical and electronic sector 36 (considered as a medium-high-tech sector by the OECD). We opted for this extension taking into account that we just compare the high-tech sectors with all the other ones and that we need an adequate number of observations within the subgroup of the high-tech sectors.

$$C_{t0} = \frac{I_{t0}}{(g+\delta)} \text{ and } C_t = C_{t-1} \cdot (1-\delta) + I_t \quad (12.2)$$

where I = gross investment
where g is generally computed as the ex ante pre-sample compounded average growth rate of the corresponding flow variable and δ is a depreciation rate.

However, our data set spans 19 years and is unbalanced in nature. This means that only a minority of firms display continuous information all over the entire period, while many firms have information only for one or more spans over the 1990–2008 period and these spans may be either very short or even isolated data. In addition, many firms display left-truncated data.

Given the unbalanced structure of the data set, to strictly apply the Formulas 12.1 and 12.2 for computing initial stocks (using – say – the first 3 years to obtain the ex ante growth rates) would have implied the loss of huge amount of information. In the best case – say a firm with a complete set of 19 data over the period – this methodology would have implied the loss of 3 observations out of 19; in the worst case – say a firm characterised by data available only for some spells of 3 years each – this computation would have implied the loss of all the available information for that particular firm.

In order to avoid this severe loss of available data, we adopted the following criteria. First, it was decided to compute a rate of growth using the initial 3 years of a given spell and then apply it to the initial flow and not to the fourth year (that is our t_0 is the very first year of the spell and so g is an "ex post" 3-year compound growth rate). Second, we iteratively applied this methodology to all the available spans of data comprising at least three consecutive years.[9] The combination of these two choices allowed us to keep all the available information, with the only exceptions of either isolated data or pairs of data.

Although departing from the usual procedure, to rely on ex post growth rates appears acceptable in order to save most of the available information in the data set; however, the impact of this choice on the values assumed by the stocks is limited, since they are also affected by the flow values and the depreciation rates. Finally, the chosen growth rate affects only the initial stock, and its impact quickly smoothes out as far as we move away from the starting year.[10]

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[9] This means that for firms characterised by breaks in the data, we computed different initial stocks, one for each available time span, consistent with Hall (2007); however, differently from Hall (2007), we consider the different spans as belonging to the same firm and so we will assign – in the following econometric estimates – a single fixed or random effect to all of the spans belonging to the same company history.

[10] Options for the choice of g – different from the standard one – have been implemented by other authors, as well. For instance, Parisi et al. (2006) assume that the rate of growth in R&D investment at the *firm* level in the years before the first positive observation equals the average growth rate of *industry* of R&D between 1980 and 1991 (the time span antecedent to the longitudinal microdata used in their econometric estimates). In general terms, the choice of a feasible g does not significantly affect the final econometric results of the studies. As clearly stated by Hall and Mairesse (1995, p.270, footnote 9): "In any case, the precise choice of growth rate affects only the initial stock, and declines in importance as time passes".

Therefore – in order to be able to compute R&D and capital stocks according to the procedure described above – only R&D and capital expenditure flows data with at least 3 observations in consecutive years were retained. This implied that 118 companies had to be dropped because they were lacking 3 R&D observations in successive years and 10 additional companies were lacking 3 capital expenditure observations in successive years. Thus, a total of 778 firms were retained at the end of this stage of the cleaning process.

Turning the attention to the depreciation rates (δ), we differentiated both between R&D and capital and between the high-tech sectors and the other sectors, taking into account what is common in the reference literature which assumes $\delta = 6\%$ for computing the capital stock and $\delta = 15\%$ for computing the R&D stock (see Nadiri and Prucha 1996 for the capital stock; Hall and Mairesse 1995 and Hall 2007 for the R&D stock).

Indeed, depreciation rates for the R&D stocks have to be assumed to be higher than the corresponding rates for physical capital, since it is assumed that technological obsolescence is more rapid than the scrapping of physical capital.

However, depreciation rates for the high-tech sectors have to be assumed to be higher than the corresponding rates for medium- and low-tech sectors under the assumption that technological obsolescence – both related to R&D efforts and to the embodied technologies incorporated in physical capital – is faster in high-tech sectors. Specifically, depreciation rates were assumed to be equal to 6% and 7% with regard to physical capital in the low-medium and high-tech sectors, respectively, while the corresponding δ for R&D stocks were assumed equal to 15% and 18%, respectively.

Once computed according to the Formulas (12.1) and (12.2) and the adopted g and δ rates, the resulting stocks were checked and negative ones were dropped.[11] Moreover, we excluded a minority of unreliable data such as those indicating negative sales and cost of goods equal to zero.

After these further removals of data, we ended up with 674 companies, for a total of 3,730 observations.

Finally, the last step was centred in checking for the presence of outliers (i.e. observations that appear to deviate markedly in terms of standard deviations from the relevant mean, possibly implying a bias in the econometric estimates); the Grubbs test (Grubbs 1969) was run on the two critical variables in the analysis: the R&D stock (K) and the physical capital stock (C).

Since the outlier test has to be applied to the variables used in the regression analysis, the test was run on the two normalised stock variables: K/E and C/E (see Eq. 12.3 in Sect. 3.3).

In detail, the Grubbs test – also known as the maximum normed residual test, (Grubbs 1969; Stefansky 1972) – is used to detect outliers in a data set, either creating a new variable or dropping outliers out of the data set. Technically, the Grubbs

[11] The occurrence of negative stocks happens when g turns out to be negative and larger – in absolute value – than δ.

test detects one outlier per iteration[12]: The outlier is expunged from the data set, and the test is iterated until no outliers remain.[13]

After running the Grubbs test, 100 observations turned out to be outliers for the K/E variable and 205 for the C/E variable (6 outliers turned out to be common to both the variables). Therefore, at the end of the process, we ended up with a final data set comprising 626 companies (for a total of 3,431 observations).

3.3 The Econometric Specification and the Regional Subsamples

Consistent with previous literature discussed in Sect. 2, we will test the following augmented production function, obtainable from a standard Cobb–Douglas function in three inputs: physical capital, labour and knowledge capital (see Hall and Mairesse 1995, formulas 12.1, 12.2, 12.3, pp. 268–69)[14]:

$$\ln(VA / E) = \alpha + \beta \ln(K / E) + \gamma \ln(C / E) + \lambda \ln(E) + \varepsilon \qquad (12.3)$$

Our proxy for productivity is labour productivity (value added (VA), over total employment (E); our pivotal impact variables are the R&D stock (K) per employee and the physical capital stock (C) per employee).

As it is common in this type of literature (see Hulten 1990; Jorgenson 1990; Hall and Mairesse 1995; Parisi et al. 2006), stock indicators rather than flows were considered as impact variables; indeed, productivity is affected by the accumulated stocks of capital and R&D expenditures and not only by current or lagged flows.

Moreover, dealing with R&D stocks – rather than flows – has two additional advantages: On the one hand, since stocks incorporate the accumulated R&D investments in the past, the risks of endogeneity are minimised; on the other hand, there is no need to deal with the complex (and often arbitrary) choice of the appropriate lag structure for the R&D regressor.

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[12] The default number of iterations is 16,000.

[13] The Grubbs test is defined under the null hypothesis (H_0) that there are no outliers in the data set; the test statistic is $G = \frac{\max_{i=1,..,N} \left| Y_i - \bar{Y} \right|}{s}$ with $\bar{Y}$ and s denoting the sample mean and standard deviation, respectively. Therefore, the Grubbs test detects the largest absolute deviation from the sample mean in units of the sample standard deviation. With a two-sided test, the null hypothesis of no outliers is rejected if $G > \frac{(N-1)}{\sqrt{N}} \sqrt{\frac{t^2_{(\alpha/(2N),N-2)}}{N-2+t^2_{(\alpha/(2N),N-2)}}}$ with $t^2_{(\alpha/(2N),N-2)}$ denoting the critical value of the t-distribution with $(N-2)$ degrees of freedom and a significance level of $\alpha/(2N)$.

[14] As clearly stated and demonstrated in Hall and Mairesse (1995), the direct production function approach to measure returns to R&D capital is preferred on other possible alternative specifications.

In this framework, R&D and physical capital stocks were computed using the *perpetual inventory method,* according to the Formulas 12.1 and 12.2 reported in the previous section.

Finally, taking per capita values permits both standardisation of our data and elimination of possible size effects (see, e.g. Crépon et al. 1998, p.123). In this framework, total employment (E) is a control variable: If λ turns out to be greater than zero, it indicates increasing returns.

All the variables are taken in natural logarithms.

While *K/E* (R&D stock per employee) captures that portion of technological change which is related to the cumulated R&D investment, *C/E* (physical capital stock per employee) is the result of the cumulated investment, implementing different vintages of technologies. So, this variable encompasses the so-called *embodied technological change*, possibly affecting productivity growth (see Sect. 2).

Table 12.1 reports the correlation matrix of the variables included in Eq. 12.1. As can be seen, a preliminary evidence of the expected positive impacts of both K/E and C/E upon VA/E emerges. Moreover, no evidence of possible serious collinearity problems is evident, since the three relevant correlation coefficients turn out to be less than 0.301 in absolute values.

Besides the overall sample, as discussed in the previous sections, one of the purposes of this study is to investigate possible regional peculiarities in the relationship between R&D and productivity. In order to check for specificities, we decided to split the European regions in two defined groups: "higher-order R&D regions" and "lower-order R&D regions". We adopted the NUTS1 geographical classification to split the sample in these two groups independently from the country regions where they belong to.[15] Regions were split according to their R&D intensity level, measured by the R&D/GDP ratio in 2005, as provided by Eurostat. In order to have two comparable subsamples, we assumed an R&D/GDP (R&D measured as BERD – Business Enterprise Research and Development) ratio equal to 1.8% as a feasible threshold, generating an "innovative group" of 328 firms (1,827 observations) versus a "weakly innovative group" of 298 companies (1,604 observations). In the following Table 12.2, we report the ranking of the regions, their R&D/GDP ratios, the number of firms and the number of observations. In bold are the regions belonging to the higher-order R&D regions.

4 Results

Specification (12.3) was estimated through different estimation techniques. Firstly, pooled ordinary least squared (POLS) regressions were run to provide preliminary reference evidence. Although very basic, these POLS regressions were controlled for heteroscedasticity (we used the Eicker/Huber/White sandwich estimator to compute robust standard errors) and for a complete set of three batteries of dummies,

[15] Final sample (number of firms and observations) by country is reported in Table 12.8 in the Appendix.

Table 12.1 Correlation matrix

	Log(value added per employee)	Log(R&D stock per employee)	Log(physical stock per employee)	Log(employment)
Log(value added per employee)	1			
Log(R&D stock per employee)	0.323	1		
Log(physical stock per employee)	0.282	0.126	1	
Log(employment)	–0.030	–0.202	0.301	1

Note: all correlation coefficients are 1% significant

namely, country (18 countries), time (19 years) and sector (52 two-digit SIC sectors) dummies.

Secondly, fixed effect (FE) regressions were performed in order to take into account the firm-specific unobservable characteristics such as managerial capabilities. The advantage of the FE estimates is that different firms are not pooled together but taken into account individually. The disadvantage is that country and sector dummies are dropped for computational reasons, since they are encompassed by the individual dummies. Thirdly, random effect (RE) regressions were run to provide more complete results, where both individual (randomised) effects are taken into account together with the possibility to retain all the entire batteries of dummies.

In Table 12.3, the benchmark European figures are compared with the estimates coming out from the separate estimates for the group of firms located in higher-order or higher innovative regions versus their counterparts located in the lower-order or lower innovative ones. As can be seen, "more is better"; those regions that invest more in R&D are also characterised by a better ability to translate the R&D investment in an increase in productivity. In more detail, all the three R&D coefficients (uniformly significant) are larger in magnitude when estimated within the group of the innovative regions. In other words, firms located in innovative European regions not only invest more in R&D but also achieve more in terms of productivity gains from their own knowledge investments.

As far as the physical capital stock is concerned, the lower-order innovative European regions seem to be characterised by a dominant role of the embodied technological change, which does not turn out to be crucial in the R&D-intensive regions. If we consider the latter results together with the evidence coming out from Tables 12.6 and 12.7, we come out with a picture where R&D-advanced European regions characterised by high-tech sectors rely on R&D expenditure as the main lever to increase productivity, while lagging regions – specialised in the non-high-tech sectors – rely more on the embodied technological change incorporated in capital formation.

In Table 12.3, it is interesting to notice that the results for the same firms located in higher-order regions show no significant effect of the sectoral composition of the sample on productivity. As can be seen in the fact that the global significance test for the sectoral dummies in the higher-order region' results appears not to be significant, an explanation of that could be found in the fact that innovative regions appear to have a more dynamic environment, with a higher diversification of the sectors in

Table 12.2 European NUTS1 R&D intensities (BERD/GDP) (decreasing order)

NUTS	Code	R&D/GDP	Firms	Observations	NUTS	Code	R&D/GDP	Firms	Observations
Baden-Württemberg	**DE1**	**3.40**	**16**	**96**	Thüringen	DEG	0.95	8	51
Eastern	**UKH**	**3.15**	**30**	**188**	Nord Ovest	ITC	0.93	3	13
Södra Sverige	**SE2**	**3.08**	**25**	**122**	Czech Republic	CZ0	0.91	1	4
Östra Sverige	**SE1**	**2.89**	**35**	**248**	Bremen	DE5	0.91	1	3
Manner-Suomi	**FI1**	**2.48**	**41**	**157**	Est	FR4	0.88	1	8
Zuid-Nederland	**NL4**	**2.39**	**5**	**42**	Norra Sverige	SE3	0.85	1	12
Südösterreich	**AT2**	**2.36**	**3**	**9**	Slovenia	SI0	0.84	1	4
Bayern	**DE2**	**2.30**	**41**	**175**	Ireland	IE0	0.82	8	55
Île de France	**FR1**	**2.10**	**44**	**236**	West Midlands	UKG	0.79	9	38
Hessen	**DE7**	**2.09**	**15**	**112**	Oost-Nederland	NL2	0.76	5	25
Berlin	**DE3**	**1.87**	**9**	**50**	Közép-Magyarország	HU1	0.69	2	10
Denmark	**DK0**	**1.80**	**21**	**152**	West-Nederland	NL3	0.62	15	98
South East	**UKJ**	**1.80**	**43**	**240**	Scotland	UKM	0.60	8	58
Centre-Est	FR7	1.71	8	29	Région de Bruxelles-Capitale	BE1	0.54	6	16
Sud-Ouest	FR6	1.68	1	6	Schleswig-Holstein	DEF	0.52	2	12
Ostösterreich	AT1	1.64	7	20	Wales	UKL	0.52	2	10
North West	UKD	1.59	17	100	Northern Ireland	UKN	0.49	1	3

Westösterreich	AT3	1.52	6	22	Nord Est	ITD	0.47	1	3
Niedersachsen	DE9	1.49	7	40	Estonia	EE0	0.42	1	3
Vlaams Gewest	BE2	1.44	11	52	Centro	ITE	0.41	1	3
Région Wallonne	BE3	1.36	3	14	Yorkshire and the Humber	UKE	0.40	15	88
Luxembourg (Grand-Duché)	LU0	1.35	3	9	North East	UKC	0.39	5	27
East Midlands	UKF	1.32	8	51	Saarland	DEC	0.32	2	12
South West	UKK	1.28	17	111	Attiki	GR3	0.29	8	32
Rheinland-Pfalz	DEB	1.22	5	32	Sur	ES6	0.27	1	2
Hamburg	DE6	1.15	7	31	London	UKI	0.26	59	353
Nordrhein-Westfalen	DEA	1.10	26	133	Alföld és Észak	HU3	0.21	1	2
Sachsen	DED	1.07	1	1	Voreia Ellada	GR1	0.08	1	3
Comunidad de Madrid	ES3	1.04	2	5					

Note: R&D/GDP intensities are computed based on 2005 values (due to missing values, for FR1, FR4, FR6, FR7 2004 values were used; for DK0 2007) (Eurostat).

contrast with the situation in lower-order regions where only certain sectors are relevant to explain their labour productivity.

Macroeconomic conditions effects, explained by the significance of the time and country dummy sets, play a role on labour productivity for the firms operating in higher-order regions. All these conclusions are reinforced from what emerges from the following Tables 12.6 and 12.7, where we replicated the overall estimation reported in the previous Tables 12.4 and 12.5, separately by manufacturing and service sectors (explained in Sect. 4.1.), and where we analyse more in depth the high-tech nature of the manufacturing sectors, differentiating between high-tech and non-high-tech manufacturing sectors (Sect. 4.2).

4.1 Manufacturing Versus Service Sectors

Tables 12.4 and 12.5 show the results for the analysis splitting the sample in manufacturing and service firms located in higher- and lower-order R&D regions, respectively. As can be seen – focusing on the more reliable FE- and RE-estimated coefficients – in both manufacturing and service sectors, the R&D-intensive regions are characterised by larger R&D coefficients in comparison with the other regions. This is a confirmation of the “increasing return” hypothesis. Furthermore, the higher R&D/productivity elasticities are displayed by the firms belonging to the service sectors and located in the high-order R&D regions (0.096 and 0.118).

Turning the attention to capital formation and embodied technological change, an unambiguous outcome clearly merges: In all the economic sectors, the weakly innovative European regions strongly rely on embodied technological change with a capital/productivity elasticity that is always larger than the one estimated within the firms located in the R&D-intensive regions.

4.2 High-Tech Versus Non-high-tech Manufacturing Sectors

In Tables 12.6 and 12.7, the focus is in the differences between high-tech manufacturing firms located in higher-order or lower-order regions and differences between non-high-tech manufacturing firms located in lower-order regions.

Table 12.6 results show what other previous evidence showed, the way R&D investments affect productivity in high-tech industries appears to be affected by the environment where the firm operates. Our results support the hypothesis that firms belonging to manufacturing sectors with higher requirements of investments (high-tech ones) would get more from their investments if they are located in a favourable environment for R&D and innovation. High-tech manufacturing firms, characterised by higher requirements of knowledge capital, get more from their investments in R&D

Table 12.3 Higher-order versus lower-order European NUTS (regional BERD/GDP>= 1.8% is the threshold)

	Whole sample			Higher-order R&D NUTS regions			Lower-order R&D NUTS regions		
	POLS	FE	RE	POLS	FE	RE	POLS	FE	RE
Log(R&D stock per employee)	0.144^{***}	0.057^{***}	0.073^{***}	0.160^{***}	0.072^{***}	0.087^{***}	0.119^{***}	0.044^{***}	0.057^{***}
	(0.013)	(0.011)	(0.009)	(0.020)	(0.016)	(0.014)	(0.019)	(0.015)	(0.013)
Log(physical stock per employee)	0.122^{***}	0.053^{***}	0.079^{***}	0.091^{***}	–0.010	0.031^{***}	0.145^{***}	0.093^{***}	0.111^{***}
	(0.012)	(0.011)	(0.010)	(0.018)	(0.017)	(0.015)	(0.017)	(0.014)	(0.014)
Log(employees)	0.014^{**}	-0.162^{***}	-0.056^{***}	0.037^{***}	-0.174^{***}	-0.054^{***}	–0.002	-0.166^{***}	-0.064^{***}
	(0.007)	(0.017)	(0.011)	(0.011)	(0.024)	(0.017)	(0.010)	(0.023)	(0.016)
Constant	-1.642^{***}	3.751^{***}	–1.151	3.835^{***}	3.637^{***}	3.210^{***}	-1.116^{***}	3.739^{***}	3.777^{***}
	(0.165)	(0.079)	(1.016)	(0.134)	(0.202)	(0.487)	(0.187)	(0.169)	(0.752)
Wald time dummies	1.89^{**}	2.35^{***}	17.34	1.80^{**}	3.04^{***}	25.50^{*}	1.08	0.58	9.37
(p-value)	(0.014)	(0.001)	(0.431)	(0.022)	(0.000)	(0.084)	(0.365)	(0.910)	(0.950)
Wald country dummies	17.38^{***}	–	27.02^{*}	6.52^{***}	–	16.76^{**}	15.36^{***}	–	15.51
(p-value)	(0.000)		(0.057)	(0.000)		(0.019)	(0.000)		(0.415)
Wald sectoral dummies	100.42^{***}	–	88.02^{***}	38.35^{***}	–	40.62	82.94^{***}	–	87.00^{***}
(p-value)	(0.000)		(0.000)	(0.000)		(0.274)	(0.000)		(0.000)
R^2 (overall)	0.28	0.01	0.18	0.26	0.01	0.15	0.38	0.01	0.30
No. of observations	3,431			1,827			1,604		
No. of firms	626			328			298		

Notes: (Robust in POLS) standard errors in parentheses; *significance at 10%, **5%, ***1%

– For time dummies, country dummies and sectoral dummies, Wald test of joint significance are reported

Table 12.4 Higher-order versus lower-order European NUTS: manufacturing sectors

	Whole sample			Higher-order R&D NUTS regions manufacturing sectors			Lower-order R&D NUTS regions manufacturing sectors		
	POLS	FE	RE	POLS	FE	RE	POLS	FE	RE
Log(R&D stock per employee)	0.144***	0.057***	0.073***	0.129***	0.068***	0.084***	0.128***	0.038**	0.053***
	(0.013)	(0.011)	(0.009)	(0.021)	(0.020)	(0.018)	(0.023)	(0.016)	(0.015)
Log(physical stock per employee)	0.122***	0.053***	0.079***	0.115***	0.002	0.044**	0.167***	0.098***	0.120***
	(0.012)	(0.011)	(0.010)	(0.022)	(0.021)	(0.020)	(0.020)	(0.017)	(0.016)
Log(employees)	0.014**	–0.162***	–0.056***	0.056***	–0.149***	–0.008	–0.004	–0.193***	–0.072***
	(0.007)	(0.017)	(0.011)	(0.012)	(0.033)	(0.021)	(0.011)	(0.027)	(0.018)
Constant	–1.642***	3.751***	–1.151	3.685***	3.744***	0.730	2.837***	3.740***	1.208
	(0.165)	(0.079)	(1.016)	(0.220)	(0.223)	(0.776)	(0.251)	(0.104)	(1.053)
Wald time dummies	1.89**	2.35***	17.34	1.37	2.15***	24.27	1.17	0.77	8.88
(p-value)	(0.014)	(0.001)	(0.431)	(0.143)	(0.000)	(0.146)	(0.284)	(0.735)	(0.944)
Wald country dummies	17.38***	–	27.02*	34.02***	–	7.69	21.80***	–	18.34
(p-value)	(0.000)		(0.057)	(0.000)		(0.361)	(0.000)		(0.245)
Wald sectoral dummies	100.42***	–	88.02***	8.21***	–	25.53	13.22***	–	36.43*
(p-value)	(0.000)		(0.000)	(0.000)		(0.489)	(0.000)		(0.065)
R^2 (overall)	0.28	0.01	0.18	0.27	0.01	0.17	0.39	0.02	0.29
No. of observations	3,431			1,358			1,278		
No. of firms	626			238			225		

Notes: (Robust in POLS) standard errors in parentheses; *significance at 10%, **5%, ***1%
– For time dummies, country dummies and sectoral dummies, Wald test of joint significance are reported

Table 12.5 Higher-order versus lower-order European NUTS: service sectors

	Whole sample			Higher-order R&D NUTS regions Service sectors			Lower-order R&D NUTS regions Service sectors		
	POLS	FE	RE	POLS	FE	RE	POLS	FE	RE
Log(R&D stock per employee)	0.144***	0.057***	0.073***	0.207***	0.096***	0.118***	0.059**	0.068	0.056*
	(0.013)	(0.011)	(0.009)	(0.032)	(0.029)	(0.024)	(0.027)	(0.043)	(0.029)
Log(physical stock per employee)	0.122***	0.053***	0.079***	0.056**	–0.007	0.008	0.088***	0.089**	0.098***
	(0.012)	(0.011)	(0.010)	(0.028)	(0.033)	(0.030)	(0.033)	(0.035)	(0.030)
Log(employees)	0.014**	–0.162***	–0.056***	–0.006***	–0.199***	–0.123***	–0.008	–0.081***	–0.024
	(0.007)	(0.017)	(0.011)	(0.023)	(0.040)	(0.029)	(0.022)	(0.051)	(0.031)
Constant	–1.642***	3.751***	–1.151	4.601***	3.706***	3.439***	–0.025	3.469***	2.987***
	(0.165)	(0.079)	(1.016)	(0.336)	(0.204)	(0.700)	(0.346)	(0.426)	(0.859)
Wald time dummies	1.89**	2.35***	17.34	1.40	1.20	17.76	1.94**	0.24	5.28
(p-value)	(0.014)	(0.001)	(0.431)	(0.132)	(0.258)	(0.404)	(0.016)	(0.991)	(0.980)
Wald country dummies	17.38***	–	27.02*	14.42***	–	14.02**	4.43***	–	61.55***
(p-value)	(0.000)		(0.057)	(0.000)		(0.029)	(0.000)		(0.000)
Wald sectoral dummies	100.42***	–	88.02***	10.81***	–	23.22***	67.34***	–	10.86
(p-value)	(0.000)		(0.000)	(0.000)		(0.002)	(0.000)		(0.285)
R^2 (overall)	0.28	0.01	0.18	0.36	0.05	0.26	0.44	0.03	0.41
No. of observations	3,431			469			326		
No. of firms	626			90			73		

Notes: (Robust in POLS) standard errors in parentheses; *significance at 10%, **5%, ***1%
– For time dummies, country dummies and sectoral dummies, Wald test of joint significance are reported

Table 12.6 Higher-order versus lower-order European NUTS: high-tech manufacturing sectors

	Whole sample			Higher-order R&D NUTS regions High-tech manufacturing sectors			Lower-order R&D NUTS regions High-tech manufacturing sectors		
	POLS	FE	RE	POLS	FE	RE	POLS	FE	RE
Log(R&D stock per employee)	0.144***	0.057***	0.073***	0.109***	0.097***	0.095***	0.188***	0.035	0.054***
	(0.013)	(0.011)	(0.009)	(0.034)	(0.033)	(0.030)	(0.051)	(0.023)	(0.022)
Log(physical stock per employee)	0.122***	0.053***	0.079***	0.143***	0.004	0.067**	0.135***	0.050**	0.072***
	(0.012)	(0.011)	(0.010)	(0.036)	(0.037)	(0.032)	(0.036)	(0.024)	(0.024)
Log(employees)	0.014**	–0.162***	–0.056***	0.085***	–0.131***	0.018	0.002	–0.190***	–0.065**
	(0.007)	(0.017)	(0.011)	(0.016)	(0.050)	(0.033)	(0.020)	(0.042)	(0.030)
Constant	–1.642***	3.751***	–1.151	1.802***	3.436***	2.633***	3.780***	3.530***	0.057
	(0.165)	(0.079)	(1.016)	(0.201)	(0.431)	(1.012)	(0.150)	(0.163)	(0.440)
Wald time dummies	1.89**	2.35***	17.34	6.05***	1.03	10.92	2.35***	2.38***	47.71***
(p-value)	(0.014)	(0.001)	(0.431)	(0.000)	(0.423)	(0.860)	(0.001)	(0.001)	(0.000)
Wald country dummies	17.38***	–	27.02*	9.01***	–	4.52	5.37***	–	11.48
(p-value)	(0.000)		(0.057)	(0.000)		(0.718)	(0.000)		(0.404)
Wald sectoral dummies	100.42***	–	88.02***	9.19***	–	9.19	10.17***	–	6.33
(p-value)	(0.000)		(0.000)	(0.000)		(0.163)	(0.000)		(0.275)
R^2 (overall)	0.28	0.01	0.18	0.25	0.01	0.16	0.40	0.01	0.24
No. of observations	3,431			688			529		
No. of firms	626			114			96		

Notes: (Robust in POLS) standard errors in parentheses; *significance at 10%, **5%, ***1%
– For time dummies, country dummies and sectoral dummies, Wald test of joint significance are reported

Table 12.7 Higher-order versus lower-order European NUTS: other manufacturing sectors

	Whole sample			Higher-order R&D NUTS regions Other manufacturing sectors			Lower-order R&D NUTS regions Other manufacturing sectors		
	POLS	FE	RE	POLS	FE	RE	POLS	FE	RE
Log(R&D stock per employee)	0.144***	0.057***	0.073***	0.141***	0.024	0.059***	0.065***	0.040*	0.047**
	(0.013)	(0.011)	(0.009)	(0.019)	(0.021)	(0.019)	(0.020)	(0.022)	(0.020)
Log(physical stock per employee)	0.122***	0.053***	0.079***	0.085***	0.006	0.027	0.203***	0.140***	0.176***
	(0.012)	(0.011)	(0.010)	(0.020)	(0.021)	(0.020)	(0.025)	(0.025)	(0.022)
Log(employees)	0.014**	–0.162***	–0.056***	0.001	–0.166***	–0.043	–0.023	–0.262***	–0.094***
	(0.007)	(0.017)	(0.011)	(0.013)	(0.042)	(0.027)	(0.015)	(0.039)	(0.024)
Constant	–1.642***	3.751***	–1.151	4.311***	3.789***	3.919***	2.784***	3.906***	1.976
	(0.165)	(0.079)	(1.016)	(0.221)	(0.283)	(0.737)	(0.246)	(0.150)	(0.746)
Wald time dummies	1.89**	2.35***	17.34	1.76**	2.60***	28.31**	0.92	0.66	19.08
(p-value)	(0.014)	(0.001)	(0.431)	(0.029)	(0.000)	(0.041)	(0.552)	(0.844)	(0.387)
Wald country dummies	17.38***		27.02*	4.78***		6.38	27.22***		16.67
(p-value)	(0.000)	–	(0.057)	(0.000)	–	(0.496)	(0.000)	–	(0.214)
Wald sectoral dummies	100.42***	–	88.02***	49.73***	–	32.26**	12.85***	–	37.98***
(p-value)	(0.000)		(0.000)	(0.000)		(0.040)	(0.000)		(0.006)
R^2 (overall)	0.28	0.01	0.18	0.39	0.01	0.17	0.45	0.01	0.38
No. of observations	3,431			670			749		
No. of firms	626			124			129		

Notes: (Robust in POLS) standard errors in parentheses; *significance at 10%, **5%, ***1%
– For time dummies, country dummies and sectoral dummies, Wald test of joint significance are reported

if they are located in higher-order regions. Regarding the physical capital returns on firm productivity, they are also positive and significant, showing their importance in high-tech manufacturing firms' productivity. We can conclude that this particular set of firms show, no matter the type of investment, gains on labour productivity.

The results address additional conclusions; high-tech manufacturing sectors operating in lower-order regions obtain higher gains for the physical capital than high-tech manufacturing firms located in higher-order regions.

It is worth noticing that time does not affect the productivity for the high-tech manufacturing firms located in higher-order regions, while for firms that are located in lower-order regions, the macroeconomic conditions of the cycle affect the labour productivity of these particular samples.

Table 12.7 contains the results of the samples of firms belonging to non-high-tech manufacturing sectors and located in higher-order and lower-order R&D regions, respectively. As we can see, non-high-tech firms appear to gain more for their physical capital investments when they are located in a less favourable R&D environment. When firms belonging to a non-high-tech manufacturing sector locate themselves in a more dynamic and innovative environment, the only investment that appears to be determinant is the knowledge capital. Firms that operate in a more competitive environment are forced to maintain higher levels of knowledge investments and higher production of innovation in order to maintain their levels of competitiveness (and survive and grow). In any case, their investments show higher returns in comparison with firms operating in a more hostile environment.

The non-high-tech manufacturing firms show the highest returns from their investments in physical capital when they are operating in non-R&D-intensive regions; embodied technical change is still playing an important role in this set of firms.

For the non-high-tech firms, the sectoral composition of the environment appears to be determinant in explaining the labour productivity differences when they operate in lower-order regions. In general, industrial structure characterising each region might affect the R&D productivity relationship. This issue has not been yet largely analysed in the literature. In the case of non-high-tech manufacturing firms operating in higher-order regions, macroeconomic conditions appear to be more significant in explaining productivity gains.

On the whole, in Europe, productivity growth in medium- and low-tech sectors and in the less innovative regions is still heavily dependent on investment in physical capital (embodied technological change), while knowledge capital or intangibles seem to play a secondary role.

Hence, we can further confirm and specify what has been already discussed commenting on the sectoral results reported in the Tables 12.4 and 12.5. In the EU, the investment in physical capital is significantly linked to productivity gains, confirming the hypothesis advanced in this study that "embodied technological change" is a crucial driver of productivity evolution. While this contribution is similar to the one offered by the R&D expenditures in aggregate, when we only consider either the manufacturing non-high-tech sectors (Table 12.7) or the non-R&D-intensive European regions (Tables 12.3, 12.4, 12.5, 12.6 and 12.7; panel 3, columns 2 and 3), the capital coefficient systematically exceeds the correspondent R&D coefficient.

5 Conclusions and Policy Implications

The results of this study show that the returns of the R&D investments on firm performance are higher for firms located in the European regions with a more favourable innovative environment and, among them, for firms belonging to high-tech sectors.

Our results also emphasise the relevant role in firm productivity of physical capital investments in certain firms. In particular, physical capital is still playing an important role in explaining the productivity gains of manufacturing firms located in lower-order regions or belonging to non-high-tech sectors.

The particular nature of the relationship between R&D and capital formation on the one hand and productivity evolution on the other hand might heavily be affected by the industrial structure which characterises a single region. Thus – according to what discussed above – a region characterised by a large presence of high-tech sectors would probably turn out to be very sensitive to R&D activities in getting productivity gains, while a region characterised by a disproportionate presence of traditional sectors, mainly composed by SMEs, would come out to be particularly responsive to firm capital formation.

In terms of policy implications, a European regional policy targeted to increase the competitiveness and productivity of European countries by means of increasing the R&D investment (with strategies like the Lisbon Agenda or the Innovation Union) should not leave aside the strong heterogeneity across European regions. Therefore, there is no single formula to promote efficient innovation in all regions, but more systematic policy analysis would help policymakers to understand which region-level instruments help firms to generate innovation in increasing their regional competitiveness and growth.

Regional policy of innovation should, in general, focus on emphasising absorption capacity and innovation by adoption. By encouraging and incentivising labour mobility, attracting private capital, improving the accessibility and connectivity and promoting endogenous growth by identifying potential sources of growth, the possibilities of the regions to attract high-tech firms will increase.

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Appendix

Table 12.8 Distribution of firms and observations across countries

Country	Firms	Observations
Austria	16	51
Belgium	20	82
Czech Republic	1	4
Denmark	21	152
Estonia	1	3
Finland	41	157
France	54	279
Germany	141	749
Greece	11	41
Hungary	3	12
Ireland	8	55
Italy	5	19
Luxembourg	3	9
Netherlands	25	165
Slovenia	1	4
Spain	3	7
Sweden	62	386
United Kingdom	223	1,299

References

Aghion P, Howitt P (1992) A model of growth through creative destruction. Econometrica 60(2):232–251

Antonelli C (2010) Pecuniary externalities and the localized generation of technological knowledge. In: Boschma R, Martin R (eds) The handbook of evolutionary economic geography. Edward Elgar, Cheltenham/Northampton

Audia PG, Freeman JH, Reynolds P (2006) Organizational foundings in community context: instruments manufacturers and their interrelationship with other organizations. Admin Sci Quart 51:381–419

Baldwin R, Forslid R (2000) The core-periphery model and endogenous growth: stabilizing and destabilizing integration. Economica 67:307–324

Boshma R, Frenken K (2009) Technological relatedness and regional branching. In: Bathelt H, Feldman M, Kloger D (eds) Dynamic geographies of knowledge creation and innovation. Routledge/Taylor and Francis, London

Bronzini R, Piselli R (2009) Determinants of long-run regional productivity with geographical spillovers: the role of R&D, human capital and public infrastructure. Reg Sci Urban Econ 39:187–199

Cantwell J, Iammarino S (1998) MNCs, technological innovation and regional systems in the EU: some evidence in the Italian case. Int J Econ Bus 5:383–408

Cantwell J, Iammarino S (2000) Multinational corporations and the location of technological innovation in the UK regions. Reg Stud 34:317–322

Cantwell J, Iammarino S (2001) EU regions and multinational corporations: change, stability and strengthening of technological comparative advantages. Ind Corp Change 10:1007–1039

Carroll GR, Hannan MT (2000) The demography of corporations and industries. Princeton University Press, Princeton
Cohen CW, Levinthal DA (1990) Absorptive capacity: a new perspective on learning and innovation. Admin Sci Quart 35:128–152
Cooke P, Gómez Uranga M, Etxebarria G (1997) Regional innovation systems: institutional and organisational dimensions. Res Policy 26:475–491
Crépon B, Duguet E, Mairesse J (1998) Research, innovation, and productivity: an econometric analysis at firm level. Econ Innov New Tech 7:115–158
Cuneo P, Mairesse J (1983) Productivity and R&D at the firm level in French manufacturing. NBER working paper no. 1068
Dettori B, Marrocu E, Paci R (2008) Total factor productivity, intangible assets and spatial dependence in the European regions. CRENOS working paper, 2008/23
Feldman MP (1994) The geography of innovation. Economics of science, technology and innovation. Kluwer, Amsterdam
Fischer M, Scherngell T, Reismann M (2008) Knowledge spillovers and total factor productivity. Mimeo, paper presented at the ERSA conference, Liverpool
Forslid R, Wooton I (2003) Comparative advantage and the location of production. Rev Int Econ 11:588–603
Frenken K, van Oort F, Verburg T (2007) Related variety, unrelated variety and regional economic growth. Reg Stud 41:685–697
Griliches Z (1979) Issues in assessing the contribution of research and development to productivity growth. Bell J Econ 10:92–116
Griliches Z, Mairesse J (1982) Comparing productivity growth: an exploration of French and US industrial and firm data. NBER working paper no. 961
Grubbs F (1969) Procedures for detecting outlying observations in samples. Technometrics 11:1–21
Gumbau-Albert M, Maudos J (2006) Technological activity and productivity in the Spanish regions. Ann Regional Sci 40:55–80
Hall BH (2007) Measuring the returns to R&D: the depreciation problem. NBER working paper no. 13473
Hall BH, Mairesse J (1995) Exploring the relationship between R&D and productivity in French manufacturing firms. J Econometrics 65:263–293
Hannan MT, Carroll GR, Dutton EA, Torres JC (1995) Organizational evolution in a multinational context: entries of automobiles manufacturers in Belgium, Britain, France, Germany and Italy. Am Sociol Rev 60:509–528
Harhoff D (1998) R&D and productivity in German manufacturing firms. Econ Innov New Tech 6:29–49
Hatzichronoglou T (1997) Revision of the high-technology sector and product classification. OECD, Paris
Hulten CR (1990) The measurement of capital. In: Berndt E, Triplett J (eds) Fifty years of economic management. University of Chicago Press, Chicago
Iammarino S, McCann P (2010) The relationship between multinational firms and innovative clusters. In: Boschma B, Martin R (eds) The handbook of evolutionary economic geography. Edward Elgar, Cheltenham
Jorgenson DW (1990) Productivity and economic growth. In: Berndt E, Triplett J (eds) Fifty years of economic management. University of Chicago Press, Chicago
Klepper S (2007) Disagreements, spinoffs, and the evolution of Detroit as the capital of the U.S. automobile industry. Manage Sci 53:616–631
Kline SJ, Rosenberg N (1986) An overview of innovation. In: Landau R, Rosenberg N (eds) The positive sum strategy: harnessing technology for economic growth. National Academy Press, Washington, DC
Krugman P (1991) Increasing returns and economic geography. J Polit Econ 99:483–499
Krugman P, Venables AJ (1996) Integration, specialization, and adjustment. Eur Econ Rev 40:959–967

Kwon HU, Inui T (2003) R&D and productivity growth in Japanese manufacturing firms. ESRI Discussion Paper Series No. 44, Tokyo
Le Bas C, Sierra C (2002) Location versus home country advantages in R&D activities: some further results on multinationals' location strategies. Res Policy 31:589–609
Lucas R (1988) On the mechanics of economic development. J Monetary Econ 22:3–42
Lundvall BA (1988) Innovation as an interactive process: from user-producer interaction to the national system of innovation. In: Dosi G, Freeman C, Nelson R, Silverberg G, Soete L (eds) Technical change and economic theory. Pinter, New York
Malmberg A, Maskell P (1997) Towards an explanation of industry agglomeration and regional specialization. Eur Plann Stud 5:25–41
Malmberg A, Maskell P (2002) The elusive concept of localization economies - towards a knowledge-based theory of spatial clustering. Environ Plann A 34:429–449
Marshall A (1890) Principles of economics. Macmillian, London
Martin P, Ottaviano G (2001) Growth and agglomeration. Int Econ Rev 42:947–968
Maskell P (2001) The firm in economic geography. Econ Geogr 77(4):329–344
Nadiri M, Prucha I (1996) Estimation of the depreciation rate of physical and R&D capital in the US total manufacturing sector. Econ Inq 34:43–56
OECD (2002) Frascati manual - proposed standard practice for surveys on research and experimental development. OECD, Paris
OECD (2009a) Regions matter. Economic recovery, innovation and sustainable growth. OECD, Paris
OECD (2009b) How regions grow. Trends and analysis. OECD, Paris
Ortega-Argilés R, Piva M, Potters L, Vivarelli M (2010) Is corporate R&D investment in high-tech sectors more effective? Contemp Econ Pol 28:353–365
Ortega-Argilés R, Potters L, and M. Vivarelli (2011) R&D and Productivity: Testing Sectoral Peculiarities Using Micro Data. Empirical Economics 41(3):817–839
Parisi M, Schiantarelli F, Sembenelli A (2006) Productivity, innovation creation and absorption, and R&D. Microevidence for Italy. Eur Econ Rev 50:2037–2061
Patel P, Vega M (1999) Patterns of internationalization of corporate technology: location versus home country advantages. Res Policy 28:145–155
Porter M (1990) The competitive advantage of nations. Free Press, New York
Porter M (1998) Clusters and the new economics of competition. Harv Bus Rev 76:77–90
Porter M (2000) Location, competition, and economic development: local clusters in a global economy. Econ Dev Q 14:15–34
Rincon A, Vecchi M (2003) Productivity performance at the company level. In: O'Mahony M, Van Ark B (eds) EU productivity and competitiveness: an industry perspective. Can Europe Resume the Catching-up Process? European Commission, Luxembourg
Romer P (1986) Increasing returns and long-run growth. J Polit Econ 94:1002–1037
Romer P (1987) Growth based on increasing returns due to specialization. Am Econ Rev 77:56–62
Romer P (1990) Endogenous technical change. J Polit Econ 99:72–102
Segarra A (2010) Innovation and productivity in manufacturing and service firms in Catalonia: a regional approach. Econ Innov New Tech 19:233–258
Stefansky W (1972) Rejecting outliers in factorial designs. Technometrics 14:469–479
Verspagen B (1995) R&D and productivity: a broad cross-section cross-country look. J Prod Anal 6:117–135
von Hippe E (1988) The sources of innovation. Oxford University Press, New York
Wakelin K (2001) Productivity growth and R&D expenditure in UK manufacturing firms. Res Policy 30:1079–1090

Chapter 13
The Effect of Regional Characteristics on the Relationship Between University Resources and Knowledge-Based Startup's Performance

Thomas O'Neal, Cameron Ford, Vernet Lasrado, and Stephen Sivo

Abstract There is considerable evidence that regional resource endowments promote the viability of firms within those regions. University resources endowments are often portrayed as especially important to the development and success of firms, especially knowledge-based firms that benefit from faculty expertise, specialized facilities, and intellectual property. Recent research, however, suggests that the contribution of university resources endowments to firm performance and viability is contingent on the presence of complementary regional resource endowments. Thus, firms that draw resources from universities are more likely to realize performance benefits when a regional economy is rich in complementary resources. We propose that for knowledge-based startup firms, in addition to the direct positive effects of regional and university resources endowments on firm performance found in prior research, regional resource endowments availability will moderate the impact of university resources endowments on firm performance. We examine these relationships within the population of university-based incubators in the US and a sample of knowledge-based firms associated with those incubators.

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1 Introduction

Understanding determinants of firm-level performance is one of the primary challenges addressed by management research. One of the most popular theoretical lenses used to address questions related to variations in firm performance is the resource-based view. This perspective argues that a firm's ability to create competitive advantage is based on its ability to organize valuable, available resources (Wernerfelt 1984). To the extent that the way in which a firm organizes resources is hard to imitate or to substitute, a firm may be able to sustain its competitive advantage. One factor that limits imitation thereby creating barriers to competition is the heterogeneity and relative immobility of many resources (Peteraf 1993). Since many resources necessary to organize a new venture are highly localized – expertise, social capital, skilled workers, risk capital, etc. – it is not surprising that there are substantial differences in the number and type of firms established from one regional context to another (Feldman 2001; Porter 1996, 1998).

Considering that resources tend to vary considerably among different locations and that creating competitive advantage is dependent on a firm's access to valuable resources, it follows that one of the most important strategic choices facing a startup venture is where to locate. Recognizing this, firms often locate in geographic locations that offer favorable access to necessary inputs such as high-quality labor, specialized technology, and industry experts (Porter 1998). Two broad considerations related to location decisions include the sheer quantity and diversity of key inputs or resources in a region, such as would be associated with a major city. In regions like these, one would expect to find generally favorable access to facilities, infrastructure, support services, employees, customers, distribution channels, financial capital, and other resources (Feldman 2001). Another consideration that had been the subject of considerable research of late is the proximity of universities to new ventures (Audretsch et al. 2010; Grimaldi et al. 2011). Research on the importance of new venture proximity to universities emphasizes the role of knowledge spillovers from university research and education processes that benefit knowledge-based, innovation-oriented businesses (Audretsch et al. 2005). This suggests that for some startup firms, locating near a university might improve access to important resources necessary for innovation- and knowledge-based capabilities.

To some extent, regional resource endowments and university resource endowments might be viewed as complementary, especially when considering knowledge-based startup firms. Regions are a source of many key resource inputs thought to promote firm performance and regional economic output. Universities play an especially important role in producing new discoveries and training highly specialized employees necessary to create new economic opportunities and motivate new venture formation (Litan and Cook-Deegan 2011). It is interesting to consider that because of the land grant university system that developed in the United States after the Civil War, many outstanding, resource-rich universities are located in relatively remote "college towns" where regional resources are lacking. Thus, in some cases, entrepreneurs may be forced to choose between locating their startup near a prominent public land grant university and locating in a major metropolitan region.

Unfortunately, there are few studies that simultaneously consider the effects of regional resources and university resources on firm survival and performance (Audretsch et al. 2010). This is unfortunate because an improved understanding the joint influence of these sources for new venture resources might inform entrepreneurs' decisions regarding where they locate their firms.

Prior research on the role that universities play in economic development has focused on the USA and Western Europe where research universities are well established and geographically concentrated (Acs and Audretsch 1989; Acs et al. 2009; Amesse and Cohendet 2001; Anderson et al. 2007; Audretsch and Feldman 1996; Audretsch et al. 2005, 2010; Audretsch and Lehmann 2005; Audretsch and Stephan 1999; Bozeman and Crow 1991; Bramwell and Wolfe 2008; Dorf and Worthington 1990; Gulbranson and Audretsch 2008; Harmon et al. 1997; Hülsbeck and Lehmann 2010; Leyden et al. 2008; Markman et al. 2005; Nelsen 2002; Phillips 2002; Premus and Jain 2005; Santoro and Bierly 2006; Sedaitis 2000; Warren et al. 2008; Wright et al. 2004; Wu 2010; Youtie and Shapira 2008). Obviously, data related to the potential impact of universities on regional economies is readily available in these settings. However, it is interesting to consider whether the results of these studies would hold where academic institutions are less mature or where economies are less developed. If university resources are able to bolster firm success directly and in concert with regional economic resources, then university initiatives may be important policy options for accelerating global economic development.

The purpose of this chapter is to contribute to this understanding by investigating a cohort of startup firms that made a strategic choice to join a university incubator when they were founded. We begin by briefly justifying several research propositions related to the independent and joint influences of regional and university resource endowments on incubator startup firm growth. We chose to sample university-based incubator startups because we believe these firms demonstrate a strategic intent to utilize university-based resources related to labor, knowledge, and social factors as well as institutional legitimacy to promote the fortunes of their firms. We then describe how we constructed a unique cohort sample of university incubator startup firms that launched in 2002–2003 time period. We chose to examine a specific cohort of firms starting at approximately the same time to control for differences in economic conditions across different time frames and to control for imprinting effects (Milanov and Fernhaber 2009) that affect subsequent firm development.

2 Analytical Framework

The framework presented here is motivated by the Cobb-Douglas-type production model. However, instead of modeling the macroeconomic production output function (GDP), we focus our attention on modeling the effect of regional and university resource endowments on the performance of nascent knowledge-based firms as shown in Fig. 13.1.

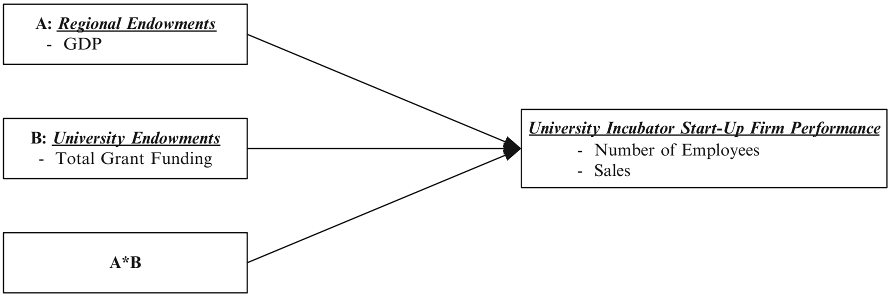

Fig. 13.1 Analytical framework

Prior research shows that regional economies benefit from regional resource endowments. High levels of physical capital, labor capital, knowledge capital, and entrepreneurial capital tend to be associated with large, urban regions where agglomeration has resulted in the development of enriched economies. These different types of capital inputs are considered to be supply-side benefits to specialized agglomeration (McCann and Folta 2008). Also, access to these types of resources is a key factor contributing to the spatial concentration of similar firms (McCann and Folta 2008). Thus, one can assess the effect of the regional resource endowments on the initial performance knowledge-based startup firms, as stated in the proposition below:

P1: *Regional resource endowments will be positively associated with university incubator startup firms' initial employment and sales.*

Likewise, one can assess the effect of the regional resource endowments on the performance knowledge-based startup firms over time, as stated in the proposition below:
P2: *Regional resource endowments will be positively associated with university incubator startup firms' rate of employment growth and rate of sales growth.*

Universities are increasingly viewed as vital to regional economic development, especially with respect to innovation or technology-based firms that tend to grow and create relatively high-wage employment. There is a growing literature on universities and their relationship to entrepreneurship and regional economies, but this literature is rather fragmented. Rothaermel et al. (2007) recently reviewed this research and described findings related to incenting faculty to launch firms, technology transfer office productivity, business incubation, and other university functions. They describe overall "university innovation systems" that encompass technological innovations, technology diffusion via technology transfer or spillovers, and the creation of incubators and research parks that channel university resources more directly to technology-based firms. These processes are thought to enrich local economies and provide more fertile opportunities for technology-based firms to launch, grow, and succeed. Thus, one can assess the effect of the university resource endowments on the initial performance knowledge-based startup firms, as stated in the proposition below:

P3: *University resource endowments will be positively associated with university incubator startup firms' initial employment and sales.*

Likewise, one can assess the effect of the university resource endowments on the performance knowledge-based startup firms over time, as stated in the proposition below:

P4: *University resource endowments will be positively associated with university incubator startup firms' rate of employment growth and rate of sales growth.*

However, a critical review of Rothaermel et al. (2007) provided by Astebro and Bazzazian (2010) finds that there is relatively little empirical support for the argument that universities contribute directly to entrepreneurship and economic development. Further, the review provided by Rothaermel et al. (2007) found little with respect to how regional contexts or economic resources affect university efforts to promote entrepreneurship and economic development. A study by Warren et al. (2008), however, supports the notion that the effects of university resources on knowledge-based firms are contingent on other locally available resources. Their study found that technology transfer (a form of knowledge transfer) was ineffective in geographically remote (relatively impoverished) regions. They conclude that knowledge resources created by a "remote" university are less valuable than if those resources resided in an enriched "entrepreneurial transaction environment" more like Boston or the Silicon Valley, thereby implying an interaction between the effect of the university resource endowments and the region. Prior research provides countervailing conclusions regarding the contributions of universities to the vitality of knowledge-based firms. These unstable findings may suggest that the contributions of universities are contingent on other factors. For example, regional resource endowments may be a necessary contributor to firm performance that moderates the effects of university resources on firm performance. Unfortunately, little research speaks directly to this issue; hence, we propose:

P5: *The associations between university resource endowments and university incubator startup firms' performance will be positively moderated by regional resources.*

The propositions stated are motivated by the primary research questions guiding the development of this study – to what extent, and in what fashion, do regional resource endowments, university resource endowments, and the interaction between regional and university resource endowments affect knowledge-based startup firm performance? Also, do regional resource endowments moderate the effect of university resource endowments on the performance of the knowledge-based startup firms?

3 Data and Methods

This section will describe the variables in the research model, the method used to build the cohort of knowledge-based university incubator startup firms representing the dataset to be analyzed, and finally present a description of the method of analysis upon which the research model is built. We analyze a cohort of firms that formed around the 2002–2003 period for the years 2003 through 2007, a 5-year analysis.

3.1 Variables in the Research Model

The dependent variables used in the proposed research model represent the performance of the firm. As mentioned earlier, the focus of this research is analyze the effect of external factors on the performance of a firm; a firm that strategically chooses to be part of an university incubator. The independent variables in this proposed research model are the regional resource endowments, the university resource endowments, and the interaction between the regional and university resource endowments.

3.1.1 Firm Performance

There is a vast body of work that uses sales and number of employees as performance measures for a firm. The number of employees can be used to measure the rate of growth of the firm when paneled data is used. The sales data provides insight on economic output of a firm in a particular year. The data for the startup firms is retrieved from the National Establishment Time Series (NETS) database. The NETS database is constructed on a yearly basis by taking annual snapshots of all available firms on the Dun and Bradstreet (D&B) database (Walls 2010). We are working with the 2009 NETS database, i.e., firms start period ranging from January 01, 1989 (all companies starting prior to January 1, 1989, are assigned 1989 as the start year), to January 01, 2009. It should be noted that some of the sales values in the NETS database are imputed values developed by multiplying the number of employees by the industry averages.

3.1.2 Regional Resource Endowments

Past research has used many measurements to capture the regional resource endowments, viz., entrepreneurship capital (Audretsch and Keilbach 2004a, b), knowledge capital (Audretsch and Feldman 2004; Griliches 1979, 1992, 1994), and labor capital (as part of the classical Cobb-Douglas-type production model.) In this study, we model the regional resource endowments using the gross domestic product (GDP) of the region. Neoclassical discussions of regional economies have for long used the economic output of the region (GDP) to represent regional performance (Acs and Plummer 2005). It is our contention that GDP will adequately reflect the fertility of the entrepreneurial ecosystem on a particular region.

3.1.3 University Resource Endowments

For the university resource endowments, we compute the total federal, state, local, institutional, and private grants received by a university as its total grant funding (financial capital). We compute the total number of Masters and PhD students graduating in a particular year from a university as its labor capital. We compute the total number of tenured and tenure track professors in a particular year from a university as its knowledge capital. All university-related data is retrieved from the integrated postsecondary education data system (IPEDS) database.

It should be noted that the university resource endowments were highly correlated with each other. Hence, for this study, we choose the total grant funding of the university as the university resource endowment as point of interest among policy-makers on the effective allocation of these resources.

3.2 Cohort of Knowledge-Based University Incubator Startup Firms

A cohort of knowledge-based startup firms has been carefully crafted to be analyzed by the method as presented in § 3.3. We analyze a cohort of firms that formed around the 2002–2003 period that had the most direct exposure to university resource endowments. Hence, we choose to analyze knowledge-based startup firms in university incubator programs, as these firms have the most direct exposure to the university resource endowments. A list of all the known incubators in the USA is presented on the National Business Incubation Association Web site. From this list of incubators, the university incubators can be isolated.

3.2.1 Retrieving the University Incubator Firms

For each university incubator, all the current and graduated (sometimes not listed) client/firm names are retrieved from the university incubator Web site. Once all the university incubator Web sites are visited and the firm names are retrieved, the set of university incubator firms representing the population of US-based university incubator firms is now complete. For each firm in the set of university incubator firms, the DUNS number (a unique 9-digit identification number provided by Dun & Bradstreet) is retrieved from the D&B Web site. Then the DUNS numbers for all the incubated firms are searched for in the NETS database. The NETS database contains rich firm-level data such as year of birth, year of death, first-year metropolitan statistical area (MSA) code, current zip code, NAICS (North American Industry Classification System) code, number of employees, and sales as described in Walls (2010) for US firms from January 01, 1989, to January 01, 2009.

A sweep through 152 US-based university incubator Web sites yielded 5,841 firms. Of these 5,841 firms, a search through the D&B Web site yielded the DUNS numbers for 4,739 firms. Of the 4,739 firms, large national corporations (184 firms) are excluded from the study. Of the 4,555 firms, a search through the NETS 2009 database yielded firm-level data for 3,102 firms. It may seem as though many of the firms are not found, but it is important to realize the NETS database extends untill January 01, 2009, and the data collected is current (2011). Also, if a firm has a DUNS number, it will be found in the NETS database. Hence, it is safe to infer that all firms with DUNS numbers not found in the current NETS 2009 database search will show up in the NETS 2011 database (when it is published). Of the 3,102 firms, 322 firms started around the 2002–2003 period. Of the 322 firms, 201 firms are classified as knowledge-based firms per the NAICS classifications as prescribed by DeVol et al. (2009).

3.2.2 Retrieving the Regional Resource Endowments

The GDP at the MSA level in the USA for 2003 is used for the analysis. It is important to note that the MSA classifications change over time; for the analysis performed, the 2007 MSA classifications are used. In essence, each MSA is composed of a single or multiple counties. Hence, for the year 2003, the GDP for a particular MSA is derived from 2003 GDP by county data by aggregating the GDP for the counties associated with the particular MSA. In this manner, a regional resource endowments dataset representing values of the GDP for all the MSA codes is developed.

3.2.3 Retrieving the University Resource Endowments

Each university incubator is associated with one or more universities. For every firm in a particular university incubator, the university resource endowment is the aggregate of the total grant funding of university or universities associated with the particular university incubator. In this manner, a university resource endowments dataset of representing values of the total grant funding for all university incubators is developed.

3.2.4 Compiling the Cohort of Knowledge-Based University Incubator Startup Firms

For each of the 201 knowledge-based startup firms, the GDP is retrieved for the MSA code of the firm from the regional resource endowments dataset. Next, for each of the 201 knowledge-based startup firms, the total grant funding is retrieved for the university incubator associated with the firm from the university resource endowments dataset. In this manner, a dataset for the cohort of knowledge-based startup firms is developed.

3.3 Method of Analysis

Latent curve analysis within the context of structural equation modeling while incorporating an ARMA process to correct for autocorrelation (Sivo et al. 2005) is used to analyze the research model as presented in Fig. 13.2.

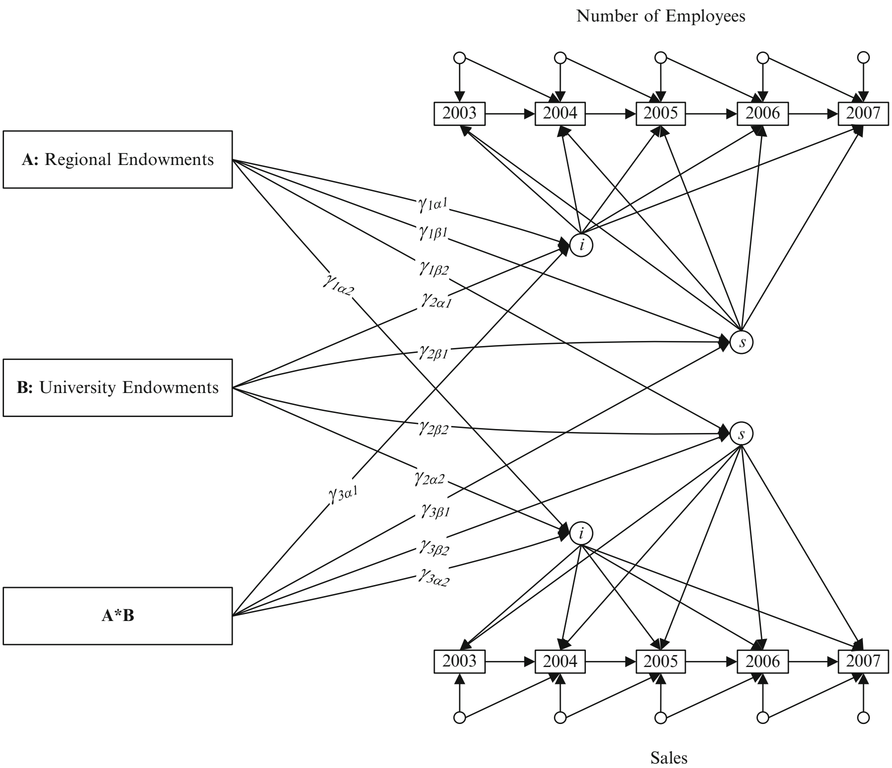

Fig. 13.2 Research model

Latent curve models (LCMs) offer an important advantage over either repeated measures ANOVA or hierarchical linear modeling in that LCMs are more flexible in testing various research hypotheses about longitudinal panel trends (Duncan et al. 2006; McArdle and Bell 2000). In studying nascent firm growth or decline, key parameter estimates are of interest when using LCM. In this study, the researchers desired to model firm change over time by examining the initial status of firm employment and sales numbers (α_i) as well as the rate of change over time (β_i) in both figures. In terms of the latent curve model, these parameters are tested in the context of the two components central to a latent curve model: the *within-person sub-model* and the *between-person sub-model*. With five repeated measurements of both firm size and sales ($t=5$) for some number of firms (i), the *within-person sub-model* is presented as

$$Y_{ti} = \alpha_i + \beta_i \lambda_t + \varepsilon_i \tag{13.1}$$

In this case, the λ_t (known as base parameters) represents the consecutive measurement time points, and ε_i represents the modeling residual for an individual. Latent curve models for five occasions assume base parameters (0, 1, 2, 3, 4) for nascent firms when the change over time begins on the first occasion and a steady linear and positive pattern of growth follows. Other base parameters may be considered for a decline in firm size or revenue. Moreover, quadratic and other nonlinear patterns may be tested as well according to the proposed theories tested (as rival hypotheses). The base parameters a researcher uses in the model specification will affect the results, so this matter should be considered carefully. It should be pointed out that employee numbers (count data) can be modeled as Poisson distributed in this context.

So, the first half of the overall latent curve model allows a researcher studying entrepreneurship to determine the initial status (α_i) of *i* firms as well as their rate of change over time (β_i) with respect to the reading measure used on four occasions (λ_t). Notice that, according to Eq. 13.1, an initial status (α_i) and a rate of improvement (β_i) are represented for each (*i*) of firms considered. This implies that we have yet to calculate the *average* initial status and rate of improvement. Moreover, we have yet to calculate the *variability* (the variance) that exists among initial firm employee and sales numbers, as well as the rate of change in employee and sales numbers. The *between-person sub-model* completes the basic latent curve model by modeling firm employee and sales intercepts (α) and slopes (β) as random variables represented by these equations:

$$\alpha_i = \mu_\alpha + \xi_{\alpha i} \quad (13.2)$$

$$\beta_i = \mu_\beta + \xi_{\beta i} \quad (13.3)$$

The individual model parameters are used to represent group mean intercept (μ_α) and group mean slope (μ_β) plus individual variation ($\xi_{\alpha i}$, $\xi_{\beta i}$). The *between-person sub-model* allows a researcher studying entrepreneurship to study the effect of regional and university resources on incubator firm performance to answer four essential questions regarding firm progress. The intercepts and rates of change in both firm size and sales over time can be studied as outcomes with respect to any theoretically meaningful factors.

Longitudinal panel data are known to evidence often a nuisance condition known as autocorrelation (e.g., Joreskog 1979, 1981; Joreskog and Sorbom 1977, 1989; Marsh 1993; Marsh and Grayson 1994; Sivo 1997, 2001; Sivo and Willson 1998, 2000). To correct for this biasing effects of autocorrelation, we incorporated an ARMA process into our models (Sivo et al. 2005).

4 Results

Data concerning the performance of nascent, knowledge-based firms associated with university incubators during their first 5 years of growth from 2003 to 2007 are analyzed using MPLUS software. Parameters in the proposed latent curve model (see Fig. 13.2) are estimated using maximum likelihood. Overall, the latent curve model fitted the data ($n=201$) well according to the fit indices (RMSEA=0.09, CFI=0.954, SRMR=0.04) with $\chi^2=1,555.642$ (df=75).

A review of the parameter estimates obtained will be discussed in terms of the five propositions previously advanced. Results produced in conjunction with the model fit suggest that regional resource endowments have no statistically significant influence on the initial status of either firm size ($\gamma_{1\alpha 1}=-0.165$, $p=0.14$) or firm sales ($\gamma_{1\alpha 2}=-0.004$, $p=0.495$). Likewise, university resources have no statistically significant influence on the initial status of either firm size ($\gamma_{2\alpha 1}=0.22$, $p=0.423$) or firm sales ($\gamma_{2\alpha 2}=-0.013$, $p=0.498$). Moreover, regional and university resources do not interact to affect initial firm sizes ($\gamma_{3\alpha 1}=0.199$, $p=0.43$) and sales ($\gamma_{3\alpha 2}=-0.13$, $p=0.477$). So, variability in the initial number of employees and initial sales across knowledge-based firms in incubators cannot be attributed to either regional or university resources during the 2003–2007 period. Taken together, these findings suggest that neither Proposition 1 nor Proposition 3 is supported by the data.

Statistically significant findings are associated growth in firm size for incubator knowledge-based firms. University resources ($\gamma_{2\beta 1}=0.22$, $p=0.423$) and the interaction between regional and university resources ($\gamma_{3\beta 1}=0.22$, $p=0.423$) both had a statistically significant influence on employees numbers from 2003 to 2007. According to these results, knowledge-based firms associated with universities possessing greater financial resources grow in number of employees at a faster rate, and this is much more the case when overall regional resources are higher in an area. So, regional resources moderate the effect of university resources on employee growth for nascent, knowledge-based firms in incubators during their first 5 years (specifically, from 2003 to 2007). Strictly speaking, regional resources do not have a statistically significant direct effect on employee growth, although the probability should be reported ($\gamma_{1\beta 1}=-0.18$, $p=0.056$).

By comparison, regional and university resources do not influence the increase in firm sales over time to a statistically significant degree (respectively, $\gamma_{1\beta 2}=0.291$, $p=0.267$; and $\gamma_{2\beta 2}=-1.965$, $p=0.315$). Nor is a statistically significant interaction effect between regional and university resources found on sales growth ($\gamma_{3\beta 2}=-1{,}921$, $p=0.3125$). A summary of the results for latent curve with ARMA Model for number of employees and sales is as presented in Tables 13.1 and 13.2, respectively.

In the analysis, we use GDP as a continuous variable; however, we noticed the negative coefficient for the effect of regional resources on the growth rate of the number of employees. This negative coefficient does not imply there is a negative relationship between regional resource endowments and the growth in the number of employees, but rather, it implies that areas with lower GDPs generally had higher number of employees. We characterized GDP as a dichotomous variable where low GDP implies a value below the average GDP for the sample and high GDP otherwise. The correlations between the new GDP variable and the other variables are the same as before.

The growth of the firms for the years 2003–2007 for number of employees as shown for high GDP versus low GDP versus all locations is shown in Fig. 13.3.

The growth of the firms for the years 2003–2007 for sales as shown for high GDP versus low GDP versus all locations is shown in Fig. 13.4.

Table 13.1 Results for latent curve with ARMA Model for number of employees

	Knowledge-based firms		
Item	Estimate	S. E.	*P value*
Intercept mean	7.858	1.277	*<.001*
Intercept variance	359.728	170.334	0.0175
Slope mean	0.151	0.099	*0.062*
Slope variance	4.491	3.346	*0.09*
Intercept on			
Regional resources ($\gamma_{1\alpha l}$)	−0.165	0.152	0.14
University resources ($\gamma_{2\alpha l}$)	0.22	1.136	0.423
Interaction ($\gamma_{3\alpha l}$)	0.199	1.122	0.43
Slope on			
Regional resources ($\gamma_{1\beta l}$)	−0.18	0.114	0.056
University resources ($\gamma_{2\beta l}$)	2.064	1.166	0.039
Interaction ($\gamma_{3\beta l}$)	1.962	1.123	0.04

Table 13.2 Results for latent curve with ARMA Model for sales

	Knowledge-based firms		
Item	Estimate	S. E.	*P value*
Intercept mean	0.006	0.076	*0.469*
Intercept variance	1.032	0.172	<.001
Slope mean	−0.005	0.014	*0.358*
Slope variance	0.019	0.006	*0.001*
Intercept on			
Regional resources ($\gamma_{1\alpha l}$)	−0.004	0.264	0.495
University resources ($\gamma_{2\alpha l}$)	−0.013	2.312	0.498
Interaction ($\gamma_{3\alpha l}$)	−0.13	2.255	0.477
Slope on			
Regional resources ($\gamma_{1\beta l}$)	0.291	0.466	0.267
University resources ($\gamma_{2\beta l}$)	−1.965	4.073	0.315
Interaction ($\gamma_{2\beta l}$)	−1.921	3.931	0.3125

5 Discussion

The primary question explored in this study is to what extent, and in what fashion, do regional resource endowments, university resource endowments, and the interaction between regional and university resource endowments affect the performance of knowledge-based startup firms located in university incubators. This study provides some interesting results that warrant further examination.

We proposed that regional resource endowments, university resource endowments, and their interaction would be positively associated with university incubator startup firms' initial employment and sales; our findings do not support these propositions.

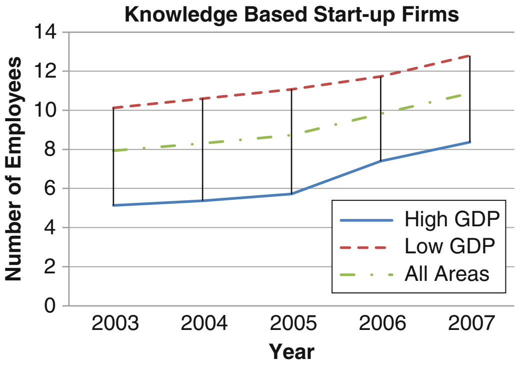

Fig. 13.3 Growth of knowledge-based startup firms in university incubators

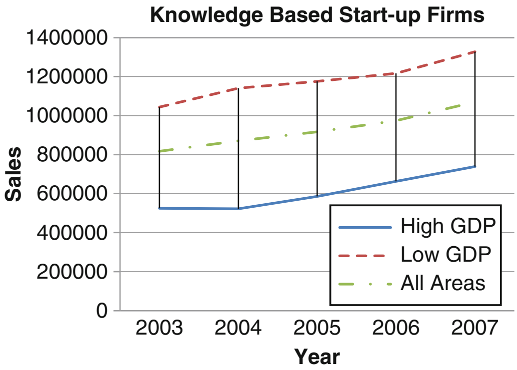

Fig. 13.4 Growth of knowledge-based startup firms in university incubators

Next, we proposed that regional resource endowments would be positively associated with university incubator startup firms' rate of employment growth and rate of sales growth. At the 95% confidence level (the significance level tested), the effect of regional resource endowments is not significant on the performance of knowledge-based startup firms. However, on relaxing the level to 90% confidence, it can be observed that region has an effect on the performance of the firm. It is interesting to observe that while all knowledge-based startup firms in university incubators experienced growth over time in regions of low or high GDP, knowledge-based startup firms in university incubators in lower GDP areas exhibited higher initial growth than knowledge-based startup firms in university incubators in higher GDP areas as shown in Figs. 13.3 and 13.4. Possible reasons for this observance could include the higher cost of labor, increased competition for their products or services, and a more diverse set of substitutes in higher GDP areas. An alternative explanation could be that in lower GDP areas (areas with lower regional endowments), the incubation program may give a competitive advantage to knowledge-based startup firms by filling in gaps not present in higher GDP areas. This observation should be examined further to see if it is limited to the cohort data set in this study or if it applies to the entire population of knowledge-based startup firms.

Next, we proposed that university resource endowments would be positively associated with university incubator startup firms' rate of employment growth and rate of sales growth; our findings support this claim only for number of employees (i.e., job creation) but not in sales growth. This may be attributed to the reliability of the sales data in the NETS database; this data is often imputed by using industry average sales per employees to determine the overall sales of a firm (in the event the data is not submitted by the firm).

Finally, we proposed that the associations between university resource endowments and university incubator startup firms' performance would be positively moderated by regional resources; our observations support this proposition. At the level tested, the effect of regional resource endowments is not significant; however, the effect of university resource endowments and the interaction between regional and university resource endowments are significant. It is this very relationship between the variables that circumscribes the moderating effect of regional resource endowments on the associations between university resource endowments and university incubator startup firms' performance. In other words, the impact of university resources is greater on knowledge-based startup firm performance in university incubators in regions with higher GDP. This supports the notion that areas with higher GDP are better positioned to leverage university resources to help knowledge-based startup firms mature as part of a larger more robust innovation ecosystem.

Efforts are made to control for as much of the variation in boundary conditions as possible to simply determine if one group of companies performed differently in different environments and how the different environment influenced each other.

6 Conclusion

The practical application of this research to policymakers and universities contemplating investments to spur economic development in an innovation-based economy warrants consideration. The knowledge-based startup firms located in university incubators in this study created jobs. Hence, if creating jobs is one of the top priorities of economic development programs, all areas can benefit from university-based incubation programs that support knowledge-based spin-out companies.

As mentioned previously, existing empirical studies examining how university resources influence regional economic outcomes have focused on US and Western European samples that enjoy access to established, relatively concentrated research universities. Consistent with these prior efforts, our sample is drawn from business incubators associated with US research universities because data for these firms is relatively plentiful and accessible. However, this sampling frame may limit the extent to which findings from our study can be generalized to other global regions with less developed universities, incubation programs, or regional economies.

Our results suggest that universities offer direct benefits to knowledge-based startup ventures and amplify the impact of available regional resources. If these relationships prove to be robust, it would suggest that universities could play an important role in promoting innovation and economic empowerment in both industrial and developing economies. Much of the university systems in developing economies are set up to add to the workforce, whereas in developed economies, universities play an active role in the innovation process by actively enabling the technology transfer process. Furthermore, research suggests that a case could be made for increasing the funding for universities in developing economies as long as these funds can be directed toward research (Birdsall 1996). Also, studies suggest that socioeconomic benefits of higher level (university) academic research are not just limited to published information but more importantly a consistent supply of skilled and trained individuals with scientific and technological expertise that add to the technological accumulation of the respective economies (Bell and Albu 1999; Bell and Pavitt 1997; Birdsall 1996; Faulkner et al. 1995; Gibbons and Johnston 1974; Levin et al. 1987; Nelsen 2002; Rosenberg and Nelson 1994; Senker et al. 1998). This might help university initiatives to gain priority as a means of improving a variety of global economic development outcomes such as increased employment, innovation, wealth creation, and wage growth. We encourage others to examine the ways in which universities may serve as important catalysts of global progress and well-being.

References

Acs Z, Audretsch D (1989) Patents as a measure of innovative activity. Kyklos 42:171

Acs Z, Plummer L (2005) Penetrating the "knowledge filter" in regional economies. Ann Reg Sci 39:439–456

Acs Z, Braunerhjelm P, Audretsch D, Carlsson B (2009) The knowledge spillover theory of entrepreneurship. Small Bus Econ 32:15–30

Amesse F, Cohendet P (2001) Technology transfer revisited from the perspective of the knowledge-based economy. Res Policy 30:1459–1478

Anderson T, Daim T, Lavoie F (2007) Measuring the efficiency of university technology transfer. Technovation 27:306–318

Astebro T, Bazzazian N (2010). Universities, Entrepreneurship and Local Economic Development. In M. Fritsch (Ed.), Handbook of Research on Entrepreneurship and regional development. Northhampton, MA, USA: Edward Edgar

Audretsch D, Feldman M (1996) R&D spillovers and the geography of innovation and production. Am Econ Rev 86:630–640

Audretsch D, Feldman M (2004) Chapter 61: Knowledge spillovers and the geography of innovation. In: Henderson JV, Thisse JF (eds) Handbook of regional and urban economics. Elsevier, New York, pp 2713–2739

Audretsch D, Keilbach M (2004a) Entrepreneurship capital and economic performance. Reg Stud 38:949–959

Audretsch D, Keilbach M (2004b) Does entrepreneurship capital matter? Entrep Theory Pract 28:419–429

Audretsch D, Lehmann E (2005) Does the knowledge spillover theory of entrepreneurship hold for regions? Res Policy 34:1191–1202

Audretsch D, Stephan P (1999) Knowledge spillovers in biotechnology: sources and incentives. J Evol Econ 9:97–107

Audretsch D, Lehmann E, Warning S (2005) University spillovers and new firm location. Res policy 34:1113–1122

Audretsch D, Hülsbeck M, Lehmann E (2010) Regional competitiveness, university spillovers, and entrepreneurial activity. Unternehmensfuhrung und Organisation working paper no. 02-10

Bell M, Albu M (1999) Knowledge systems and technological dynamism in industrial clusters in developing countries. World Dev 27:1715–1734

Bell M, Pavitt K (1997) Technological accumulation and industrial growth: contrasts between developed and developing countries. In: Technology, globalisation and economic performance. Cambridge University Press, New York, pp 83–137

Birdsall N (1996) Public spending on higher education in developing countries: too much or too little? Econ Educ Rev 15:407–419

Bozeman B, Crow M (1991) Technology transfer from U.S. government and university R&D laboratories. Technovation 11:231–246

Bramwell A, Wolfe D (2008) Universities and regional economic development: the entrepreneurial University of Waterloo. Res Policy 37:1175–1187

DeVol R, Klowden K, Bedroussian A, Yeo B (2009) North America's High-Tech Economy: The Geography of Knowledge-Based Industries. Milken Institute Research Reports. Retrieved from http://www.milkeninstitute.org/publications/publications.taf?function=detail&ID=38801198&cat=resrep

Dorf R, Worthington K (1990) Technology transfer from universities and research laboratories. Technol Forecast Soc Change 37:251–266

Duncan T, Duncan S, Strycker L (2006) An introduction to latent variable growth curve modeling: concepts, issues, and applications. Lawrence Erlbaum, Mahwah

Faulkner W, Senker J, Velho L (1995) Knowledge frontiers: public sector research and industrial innovation in biotechnology, engineering ceramics, and parallel computing. Clarendon, Oxford

Feldman M (2001) The entrepreneurial event revisited: firm formation in a regional context. Ind Corp Change 10:861

Gibbons M, Johnston R (1974) The roles of science in technological innovation. Res Policy 3:220–242

Griliches Z (1979) Issues in assessing the contribution of research and development to productivity growth. Bell J Econ 10:92–116

Griliches Z (1992) The search for R&D spillovers. Scand J Econ 94:29–47

Griliches Z (1994) Productivity, R&D, and the data constraint. Am Econ Rev 84:1–23

Grimaldi R, Kenney M, Siegel DS, Wright M (2011) 30 years after Bayh-Dole: reassessing academic entrepreneurship. Res Policy 40:1045–1057

Gulbranson C, Audretsch D (2008) Proof of concept centers: accelerating the commercialization of university innovation. J Technol Transfer 33:249–258

Harmon B, Ardishvili A, Cardozo R et al (1997) Mapping the university technology transfer process. J Bus Ventur 12:423–434

Hülsbeck M, Lehmann E (2010) The role of regional knowledge production in university technology transfer: isolating coevolutionary effects. Unternehmensfuhrung und Organisation working paper no. 01-10

Joreskog K (1979) Statistical estimation of structural models in longitudinal developmental investigations. In: Nesselroade J, Baltes P (eds) Longitudinal research in the study of behavior and development. Academic, New York, pp 303–351

Joreskog K (1981) Statistical models for longitudinal studies. In: Schulsinger F, Mednick S, Knop J (eds) Longitudinal research: methods and uses in behavioral science. Nijhoff Publishing, Hingham, pp 118–124

Joreskog K, Sorbom D (1977) Statistical models and methods for analysis of longitudinal data. In: Aigner D, Goldberger A (eds) Latent variables in socioeconomic models. North-Holland Publishing, New York, pp 285–325

Joreskog K, Sorbom D (1989) LISREL 7: a guide to the program and applications. SPSS Inc., Chicago

Levin R, Klevorick A, Nelson R et al (1987) Appropriating the returns from industrial research and development. Brookings Pap Econ Activ 1987:783–831

Leyden D, Link A, Siegel D (2008) A theoretical and empirical analysis of the decision to locate on a university research park. IEEE Trans Eng Manage 55:23–28

Litan R, Cook-Deegan R (2011). Universities and Economic Growth: The Importance of Academic Entrepreneurship. Kauffman, State of Entrepreneurship. Kansas City, MO, USA: Ewing Marion Kauffman Foundation

Markman G, Phan P, Balkin D, Gianiodis P (2005) Entrepreneurship and university-based technology transfer. J Bus Ventur 20:241–263

Marsh H (1993) Stability of individual differences in multiwave panel studies: comparison of simplex models and one factor models. J Educ Meas 30:157–183

Marsh H, Grayson D (1994) Longitudinal confirmatory factor analysis: common, time specific, item specific, and residual error components of variance. Struct Equ Model Multidiscip J 1:116–145

McArdle J, Bell R (2000) An introduction to latent growth models for developmental data analysis. In: Little T, Schnabel K, Baumert J (eds) Modeling longitudinal and multilevel data: practical issues, applied approaches, and specific examples. Lawrence Erlbaum Associates, Mahwah

McCann B, Folta T (2008) Location matters: where we have been and where we might go in agglomeration research. J Manage 34:532–565

Milanov H, Fernhaber S (2009) The impact of early imprinting on the evolution of new venture networks. J Bus Ventur 24:46–61

Nelsen L (2002) Role of university technology transfer operations in assuring access to medicines and vaccines in developing countries. Yale J Health Policy Law Ethics 3:301

Peteraf M (1993) The cornerstones of competitive advantage: a resource-based view. Strateg Manage J 14:179–191

Phillips R (2002) Technology business incubators: how effective as technology transfer mechanisms? Technol Soc 24:299–316

Porter M (1996) Competitive advantage, agglomeration economies, and regional policy. Int Reg Sci Rev 19:85

Porter M (1998) The competitive advantage of nations: with a new introduction. The Free Press, New York

Premus R, Jain R (2005) Technology transfer and regional economic growth issues. Int J Technol Transfer Commer 4:302–317. doi:10.1504/IJTTC.2005.006362

Rosenberg N, Nelson R (1994) American universities and technical advance in industry. Res Policy 23:323–348

Rothaermel F, Agung S, Jiang L (2007) University entrepreneurship: a taxonomy of the literature. Ind Corp Change 16:691–791

Santoro M, Bierly P (2006) Facilitators of knowledge transfer in university-industry collaborations: a knowledge-based perspective. IEEE Trans Eng Manage 53:495–507

Sedaitis J (2000) Technology transfer in transitional economies: a test of market, state and organizational models. Res Policy 29:135–147

Senker J, Faulkner W, Velho L (1998) Science and technology knowledge flows between industrial and academic research: a comparative study. In: Capitalizing knowledge. SUNY Press, New York, pp 111–132

Sivo S (1997) Modeling causal error structures in longitudinal data. (Unpublished doctoral dissertation). Retrieved from 58, 04B. (University Microfilms No. AAG9729271)

Sivo S (2001) Multiple indicator stationary time series models. Struct Equ Model 8:599–612

Sivo S, Willson V (1998) Is parsimony always desirable? Identifying the correct model for a longitudinal panel data set. J Exp Educ 66:249–255

Sivo S, Willson V (2000) Modeling causal error structures in longitudinal panel data: a Monte Carlo study. Struct Equ Model 7:174–205

Sivo S, Fan X, Witta L (2005) The biasing effects of unmodeled ARMA time series processes on latent growth curve model estimates. Struct Equ Model 12:215–231

Walls D (2010) National Establishment Time-Series (NETS) Database: 2009 Database Description. Walls & Associates. Retrieved from http://youreconomy.org/pages/walls.lasso

Warren A, Hanke R, Trotzer D (2008) Models for university technology transfer: resolving conflicts between mission and methods and the dependency on geographic location. Camb J Reg Econ Soc 1:219–232

Wernerfelt B (1984) A resource-based view of the firm. Strateg Manage J 5:171–180

Wright M, Birley S, Mosey S (2004) Entrepreneurship and university technology transfer. J Technol Transfer 29:235–246

Wu W (2010) Managing and incentivizing research commercialization in Chinese universities. J Technol Transfer 35:203–224

Youtie J, Shapira P (2008) Building an innovation hub: a case study of the transformation of university roles in regional technological and economic development. Res Policy 37:1188–1204

Part IV
Innovation Business Models

Chapter 14
Learning from Failure: Case Insights into a UK-India Technology Transfer Project

Alexander Brem and Deependra Moitra

Abstract The success of firms in emerging economies like India and China can be generally attributed to their low-cost R&D and manufacturing capabilities, scalable resource pool, and rapidly growing domestic demand. However, in recent times, emerging economy firms have been employing new innovation strategies to morph into higher orbits and drive profitable business growth. Increasingly, many emerging economy firms are deploying their earnings to invest in R&D and to acquire advanced technologies from developed country firms to boost their innovative capability and to drive their global business competitiveness. Drawing on recent literature on international technology transfer, this paper presents a case study of an Indian MNC to provide theoretical and practical insights into the dynamics and process of technology transfer. Lacking strategic orientation is identified as a main missing factor in recent literature.

1 Introduction and Background

Range Rover Evoque – that is the brand new car of the Indian Tata Group, which is investing about 1.5 billion Euros in new product development of Jaguar Land Rover (FAZ 2011).

Before the background of globalization as well as increasing intensity and speed of innovation processes, there has been a substantial shift in the global innovation landscape to international dispersion of innovation activities (Gerybadze and Reger

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1999; Kumar 1997). Multinationals from developed economies are increasingly globalizing their R&D activities and are developing an “open innovation” model to source innovations from outside the firm, including from emerging economies such as those in Asia (Brem 2008a; Singhal 2011): Multinational corporations (MNCs) answered to the question of their preferred prospective international R&D location, China (62%), the United States (41%), and India (29%) (UNCTAD 2005).

Emerging economy firms, which traditionally have played a secondary role in the global innovation landscape, have now begun to catch up in developing their own innovative capabilities (Brem 2008b). As a result, the number of innovations developed in emerging economies increased dramatically, especially by subsidiaries of MNCs (Zeschky et al. 2011). Firms in the emerging economies can learn from and catch up with investing multinationals, but to do so, they need to develop their own innovative capabilities and move from a process to a product focus and from imitation to innovation (Li and Kozhikode 2009). With this new strategy approach, many emerging economy firms are deploying their earnings to invest in R&D as well as to acquire firms overseas to gain access to sophisticated technological capabilities.

The traditional technology transfer models were heavily based on the domestic economy; there was little international transfer of innovative technology to emerging economies. The emerging countries experienced the technology transfer in a form called as “exnovation,” which is the reverse of innovation. It follows a bottom-up approach deriving technology transfer through reverse engineering of distributed products from industrialized economies. Thus, instead of moving from research to distribution, technology in emerging economies moves in the reverse direction, from distribution to production to development to research (Gardner 2002). A main result of these trends is called “frugal innovation,” which refers to products having extremely high cost advantages compared to existing solutions. They typically do not have sophisticated technological features but meet the basic needs at a low-cost level by comparably high value for the customer (Zeschky et al. 2011). Hence, this kind of innovation is not just about redesigning existing products but rethinking the whole product development process from the scratch, especially for MNCs (Economist 2010).

At the same time, there is a growing trend of companies from developing countries which invest their earned money from the last decades into joint ventures and acquisitions in companies of developed countries. Well-known examples are Chinese companies: Huawei joint ventures with 3Com (2003), Siemens (2004) and Symantec (2007) (Huawei 2011) and Lenovo with the acquisitions of IBM’s personal computing division (2005) and Medion (2011) (Lenovo 2011).

But also Indian companies are investing in western companies, like Tata with the acquisition of Jaguar and Land Rover (2008) (Tata 2011) or Motherson Sumi with the acquisition of Schefenacker (2009) and Peguform (2011). On the one hand, foreign companies invested in 2006 about 11.1 billion USD in India, on the other hand, Indian companies spent about 23.1 billion USD for 168 acquisition in foreign countries (Rybak 2007). However, India is not in the list of most-favored locations of the top 100 locations for MNCs (UNCTAD 2006). These numbers show the growing importance of technology transfer issues, which will be the focus of our research approach.

In summary, there is a techno-cultural shift from the traditional models for technology transfer. There are not just European and American MNCs which have worldwide activities, but more and more Asian MNCs as well. Hence, especially MNCs from Western countries must prepare for this trend, for which our case example may give some valuable insights.

2 Literature Review and Conceptual Framework

2.1 Terms and Definitions

To ensure a common understanding of terms, some definitions will be introduced at the beginning.

In general, technology may be seen "as the information necessary to achieve a certain production outcome from a particular means of combining or processing selected inputs" (Maskus 2004, p. 9). In a wider sense, "technology is commonly understood to mean the stock of knowledge which permits the introduction of new and improved machinery and equipment, products, processes and services. In a wider sense it includes additional elements, such as management and marketing skills" (UNCTC 1988, p. 176). With this definition, a distinction is made between two components of technology, hardware and software (Herzog 1994): for example, machines and production tools, as well as blueprints and instructions. Further detailed, technology has four elements: process, product, management, and quality control (UNCTC 1988). Hence, technology is not just technical knowledge, but human made (Levin 1997). Especially tacit knowledge must be considered, as it can be transferred by individuals, by groups, as well as inter- and intra-firm (Howells 1996).

Hence, these modes of technology transfer can be considered:

– New production facilities as well as expansion and restructuring of existing companies
– Strategic alliances and joint ventures between international and local companies
– Acquisitions and other forms of foreign direct investments
– Granting of patents, licenses, etc.
– Trade of capital goods
– Transfer of other tacit knowledge

Contingent on the organizational interdependence, a further classification of cooperation modes can be made (see Fig. 14.1).

The first two cases typically interact with the last two ones, depending on the specific country and the companies involved. However, technology transfer is not just about hardware, but software as well. Transfer of human skills, know-how, and culture is much more difficult and must be part of a complex organizational learning process (Levin 1997). Channels of technology transfer can be differentiated between formal and informal channels, depending on the nature of the information trade

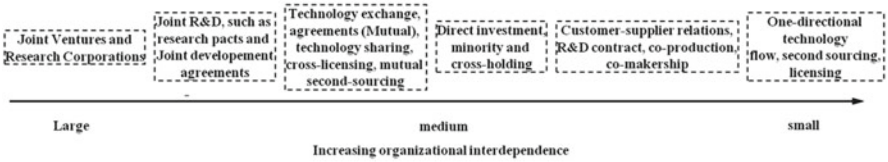

Fig. 14.1 Classification of modes of cooperative agreements and their organizational interdependence (Hagedoorn 1990)

(Maskus 2004). Within MNCs, an internal technology transfer is preferred; as such an approach is less costly – in terms of financial and personal resources. In the case of an external transfer from resp. to an independent firm, these savings cannot be reached unless there is a long history in joint projects (Robinson 1988). The focus of our study is on multinational corporations, which conduct the bulk of industrial R&D worldwide (UNCTAD 2005).

2.2 Literature Review

Most of the technology transfer literature is based on a policy level and is focused on technology transfer from developed to emerging economies. The focus of this chapter is on the company level, specifically on the technology importation to support indigenous innovation capabilities, as mentioned in the introduction. For this, our research question is how Indian MNCs deal with international technology transfer between developed and emerging economies. This research direction is supported by a report which states a clear need for international analysis on the technology transfer to developing countries, especially on lessons learned from successful examples (Ockwell et al. 2007).

In the era of globalization, MNCs must develop competitive strategies for all markets worldwide at the same time. For this, literature suggests two alternative strategic options especially for Asian MNCs: development of strong manufacturing or innovation capabilities (Gao et al. 2006). The first case means technology transfer in its primal meaning, that is, buying machines. The second one refers to nurturing innovation capabilities and developing specific technologies through own R&D, which must be created or acquired. Typically, MNCs have subsidiaries of their R&D all over the world, but at the same time, they tend to keep most of their (critical) R&D near their home base. Hence, the current concentration of corporate R&D activities leads to a strong divergence of worldwide technological development (Freemann and Haagedorn 1995), with a tendency of emerging markets to climb the R&D value chain (Economist 2004). In addition, actions to internationalize corporations and especially R&D activities are still increasing (UNCTAD 2005), with an organization of multiple centers with one dominant coordination center (Gerybadze and Reger 1999). Hence, from the perspective of growing economies, the only chance to gather influential R&D activities within their countries is either to develop

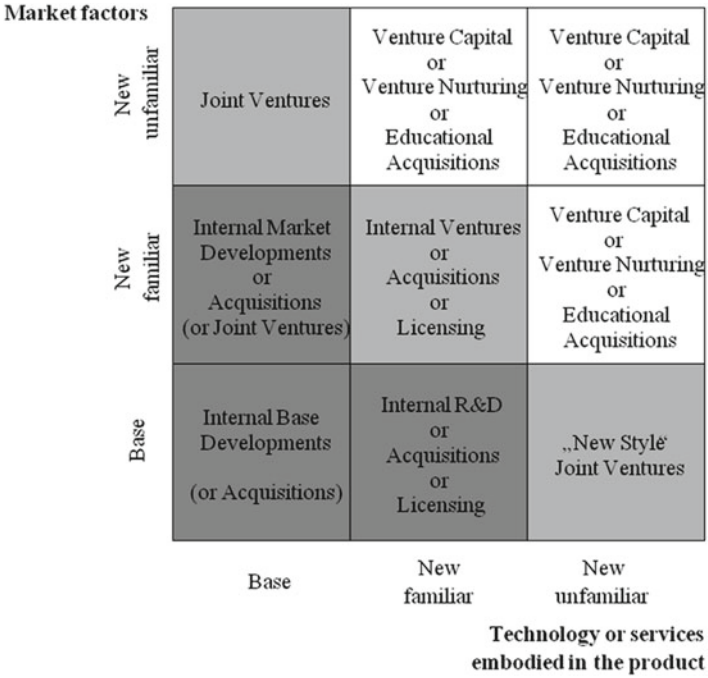

Fig. 14.2 The familiarity matrix (Roberts and Berry 1984)

own research centers or to encourage local companies to look for international mergers and acquisitions of technology.

From a strategic point of view, a decision which kind of technology transfer mode is appropriate must be derived. For transferring technologies across borders, Roberts and Berry (1985) identified different organizational models that can support such a decision (see Fig. 14.2).

The three categories are explained by the familiarity of the company with the specific technology and market. "Base" technologies are already used by the company in other products; a base market is already occupied. Within the "new familiar" category, the technology or market is new to the company, but there is already a connection to known markets or technologies. Finally, the last category describes markets or technologies which are totally new to the company (Roberts and Berry 1984). The model allows discrete strategic proposals although these are not explicit as some fields propose more than just one strategy. Hence, further situational information is needed to make a clear statement on that. In addition to that, there is no possibility to directly rate the variables.

Regarding motivation for technology sourcing, statistics show that there is a plethora of factors for international M&As: financial market boom, economic growth, pressures to merge, strategic choices, and new investors (UNCTAD 2006). Two concepts named "barriers to appropriability" and "opportunities for improvement" offer a conceptual explanation basis (Gao et al. 2006). Barriers to appropriability arise when there are factors that constrain MNCs' ability to use their superior technological resources to gain access to new markets.

Companies are faced with host or home country government regulations, information barriers through relative unfamiliarity with a host country's business environment, coordination barriers based on the internal complexity of coordinating activities, and commitment barriers based on low commitment to a host country market.

Opportunities for improvement may arise from the development of emerging or mature technologies. In the first case, based on the nature of emerging technologies, several opportunities for local companies can be identified:

– Learning opportunities: entry barriers are usually low.
– Cultural opportunities: knowing and applying the local culture.
– Incentive opportunities: cannibalizing the existing businesses may hinder other companies to invest.
– Organizational opportunities: other companies may be locked into existing organizational routines and existing value networks.

In the case of mature technologies, local companies often have to reinvent mature technologies as other companies are unwilling to sell their mature technology or when costs involved are too high. Moreover, technology may be adapted and modified to fit in a specific context or environment, even if it is already mature in other markets. In this context, "reverse technology transfer" is an upcoming phenomenon, for example, the extent to which technology is transferred from foreign R&D to the home base. In a sample of MNCs, about one half of the units were already actively engaged in such transfers (Håkanson and Nobel 2001).

An (international) technology transfer process typically begins with the point of a commitment to a specific technology and concludes when the technology is fully and satisfactorily implemented (Tatikonda and Stock 2003). Such processes are seldom continuous or linear. They strongly depend on situational factors, such as type of technology, location and size of companies involved, and industry backgrounds.

However, some scholars suggest dividing transfer processes into acquisition, adaption, and improvement, or more detailed into the following stages (Cusumano and Elenkov 1994):

– Identification and evaluation of technological options or related R&D areas.
– Acquisition of selected technologies.
– Integration of new technologies into current operations.
– Implementation of technologies in specific products and processes.
– In this context, in-house R&D holds a strong role as a precondition for absorbing externally acquired technologies (Hu et al. 2005).

By improving links between R&D, design, engineering, manufacturing, and marketing technology transfer time may be reduced (Cusumano and Elenkov 1994), as well as corresponding resource costs involved in transferring technologies (Teece 1977). However, such reductions have natural limits, as technology transfer includes many different feedback loops within the processes (Johnson et al. 1997).

Table 14.1 Views of buyer and supplier (Kumar et al. 2006)

Supplier power	
Proprietary technology	Proprietary technology and know-how possessed by a seller creates an entry barrier in the technology market
Reputation	Reputation of the supplier is important, as the buyer will feel more comfortable in associating its name with a reputed seller. Buying technology from a reputed seller also guarantee the future performance
Quasi-monopoly	In many instances, number of reliable suppliers of large-scale technology is quite limited and hence the sellers enjoy a quasi-monopolistic position
Stage of technology	Bargaining power of the seller also depends on the position of the technology in the technology life cycle
Buyer power	
Financial strength	Financial strength of a buyer often dictates a negotiation process as it gives more flexibility in selecting a technology supplier
Network with suppliers	In this information age, it has become quite easier for a buyer to maintain a broad network with all potential suppliers and get useful information on competitive offer
Future business potential	Once there is a successful technology transfer, the technology transferee often turns to the supplier for future collaboration
Spillover effect	A successful technology transfer from a seller in a country would generate interests among other potential buyers and thus may lead to a spillover effect

In order to leverage the acquired technology, several factors influencing a successful technology transfer must be considered (Reddy and Zhao 1990): amount of commercial experience in another country, degree of technological competition based on the technology strategy among supplier companies, willingness and ability to transfer technical knowledge, supplier firm's organizational structure, absorptive capacity of the recipient firm and level of technological development of the host country, characteristics of the host country to be a major factor, mode of transfer, relationship between interacting countries and companies, and training. On the corporate level, it is crucial to bear in mind the relative power of both sides, which determines the negotiation position before and after the transfer (see Table 14.1).

2.3 Conceptual Framework

Literature on conceptual technology transfer frameworks at the company's level is very sparse; however, some remarkable models can be identified. A selection of such models will be introduced in the following. For another overview, the paper of the United Nations Economic and Social Commission for Asia and Pacific is recommended (Ramanathan 2008).

A wide-ranging model from 1971 divides the technology transfer process into the stages search, adaption, implementation, and maintenance (Bar-Zakay 1971). All activities which need to be carried out are detailed and specific, as it shows both perspectives (seller/buyer). However, the model has limited relevance as it based on the setting of that time, when buyers of technology were mainly passive and dependently on aid programs. For example, the paper uses the term “donor” instead of seller.

A very common approach is from 1981, which is based on the experience of rapidly industrializing countries in Asia (Dahlman and Westphal 1981). It consists of nine phases, is hence very detailed, and has an emphasis on transferee involvement. Though, it pays little attention on the negotiation and implementation process.

An improved concept based on Dahlman and Westphal (1981) contains five phases, which are in detail (Chantramonklasri 1990):

– Pre-investment economic and technical feasibility study
– Engineering specification and design
– Capital goods production
– Installation, testing, commissioning, start-up
– Production

This concept is easy to understand, but it strongly focused on a product development process. Moreover, important cultural constraints are not considered (Kedia and Bhagat 1988).

Another technology transfer model from 1999 is based on three categories: developmental stage, implementation process, and diffusion (Walumbwa 1999). This approach is based on the idea that technology transfer is rather a cycle with interdependencies than a linear process, which is interesting. In the context of product development and supply chain management, another approach was introduced in 2003 (Tatikonda and Stock 2003). However, both offer no detailed operationalization of the variables and no Asian-specific context.

Before the background of large-scale technology transfer projects, Kumar et al. (2006) suggest a goal-oriented technology transfer model. This simple model emphasizes supportive capabilities, which must be considered throughout the whole process (Kumar et al. 2006).

All of the shortly introduced frameworks do not fit into our India-specific context. Finally, we identified a concept which fits into our scope of research; this concept was developed with information from the demand and the supply side equally, which did not happen in the other publications before. Moreover, it takes the developments of recent years into account, as it was written in 2002 in the context of climate change. Finally, it has an Indian specific background (Kathuria 2002). The model will be introduced in detail in the following.

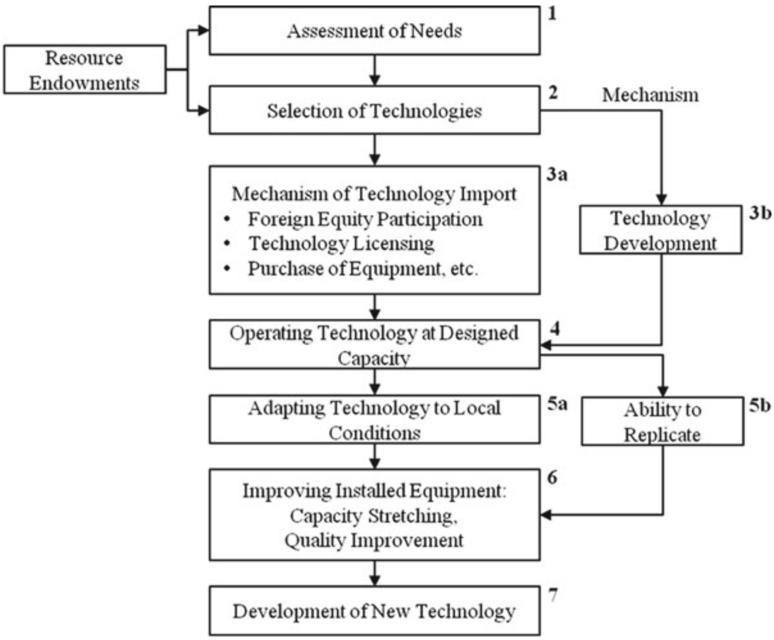

Fig. 14.3 Steps to various levels of technology transfer (Kathuria 2002)

Therefore, the intensity of contact between the supplier and the recipient as well as the strategic orientation of the recipients' company are determine the extent to which technology transfer contributes to technological capabilities.

The various steps of this approach are need assessment, technology selection, technology transfer, exploiting technology to its intended performance, adjusting technology to specific conditions, improving technology further than its designed performance, and the development of new technologies (see Fig. 14.3).

The assessment of needs is the most important step, as it refers to the idea of sustainability. Therefore, a local consumer demand is more favorable than a "supply push." The selection of technologies is influenced by an "information paradox," for example, the company not only acquires the technology but the knowledge embodied into it. So this decision goes along with highly imperfect information. Modes for technology import are depending on the specific situation of the company; the alternative is an own technology development – hence a typical make-or-buy decision (Brem 2007). Operating technology at designed capacity refers to the efficiency of utilization. Once installed, it is necessary to adapt it to location conditions or to procedure it to location conditions, even for managerial processes. Another option is to adapt inputs of skills or information, drawing on the experience to other local companies. After finishing the adaption, a continuous improvement is obligatory, for example, with quality or material improvements. Any technology transfer must have as one of its goals to move to the development of new products, where domestic value added is supposed to be the highest – at least in specific niches.

3 Case Study

3.1 Methodology

Our research employed an interpretive case study to generate understanding of and insights into the process and dynamics of technology transfer in an international context. Interpretive case studies focus on context, content, structure, and processes, and help build understanding and explanation of contemporary phenomena in their real-life context by capturing multiple realities (Yin 2008; Stake 1995; Lincoln and Guba 1985). Given our focus on analysis of practice and because of the lack of public discourse on the focal aspects of this inquiry, an interpretive case study was a particularly appropriate research approach for this study. Based on perusal of publically available information, we selected an exemplary case with a technology licensing agreement as the unit of analysis (Yin 2008). The technology licensing agreement defined a relationship dyad and involved technology transfer between two parties in two different countries.

In keeping with the tenets of the interpretive research paradigm, semi-structured, open-ended interviews were used as the primary method for data collection (Lincoln and Guba 1985). Two different interview questionnaires constructed around the main dimensions of inquiry were used for interviewing informants on each side of the dyad. Informants directly associated with the technology licensing engagement were selected from across the organizational hierarchy to gather diverse and holistic perspectives about the technology licensing agreement and the process of technology transfer (see overview of interviews in Table 14.2). All the interviews were done face-to-face, were recorded using a digital recorder, and later transcribed verbatim by us (Walsham 1995; Lincoln and Guba 1985).

Data analysis took place simultaneously with data collection, although the formal data analysis began only after all the interviews were completed. The formal data analysis involved two levels. In the first level, subjective understanding about the phenomenon and its focal aspects was built by analyzing perspectives obtained from individual informants through interviews. In the next level, our own interpretive understanding about the phenomenon and its focal aspect was built by aggregating informants' perspectives in the given context and mediated by our own understanding and experience (Stake 1995). For the second level, thematic analysis was employed as the tool (Miles and Huberman 1994).

In order to ascertain research quality and validity, we adopted several measures. In order to ensure credibility, all transcribed interviews were sent for review by the informants, thus achieving member checking. Also, dyadic perspectives were obtained from multiple informants from across the organizational hierarchy to

Table 14.2 Details of interviews at ExcelCo and TeleCo

Sr. no.	Position/role of the interviewee	Location of the interview	Date of interview	Duration of the interview (min)
1	Chief Operating Officer, ExcelCo	India	23 August 2010	80
2	Vice President (R&D), ExcelCo	India	27 August 2010	110
3	Principal Tech Architect, ExcelCo	India		
4	Senior Project Manager, ExcelCo	India	29 August 2010	95
5	Senior Software Engineer, ExcelCo	India	6 September 2010	75
6	Chief Technologist, TeleCo	Europe	18 September 2010	105
7	Vice President, R&D and Venturing, TeleCo	Europe	23 September 2010	85
8	Manager, IP Licensing, TeleCo	Europe	29 September 2010	70
9	R&D Manager, TeleCo	Europe	3 October 2010	90
10	R&D Engineer, TeleCo	Europe	9 October 2010	65

achieve triangulation of data. Likewise, to achieve dependability, a case study database based was built that archived all interview notes, transcriptions, documents, and interview guides, providing an end-to-end audit trail. For confirmability, in addition to peer debriefing and informant feedback, theoretical perspectives and multiple informant interviews were employed. Finally, in order to ensure transferability, we have provided thick case description to facilitate comparison with other contexts. In addition, we have also sought to achieve congruence with prior theories and extant literature to aid transferability (Lincoln and Guba 1985). The researched companies and their suitability will be presented in the next section.

3.2 Researched Case

This case study is about a technology licensing engagement between TeleCo, a European company, and ExcelCo, an Indian company. The case study provides dyadic perspectives on the process and dynamics associated with the transfer of an intelligent resource management software technology from TeleCo to ExcelCo. The selected case is unique for three reasons: First, it provides a rare instance of international technology transfer sought by a developing country multinational, signifying an emerging phenomenon. Second, it involves three different modes of technology transfer – technology licensing, joint product development, and joint commercialization – all as parts of a single international cooperation agreement. Third, it presents the collaborative aspects of the technology transfer process unlike most other situations that entail one-way transfer of technology.

TeleCo is one of the largest integrated telecom services companies headquartered in Europe, having sales and R&D operations spread across the world. In the financial year 2010, TeleCo achieved revenue in excess of €20 billion and spent more than €1,200 million in R&D. The company has more than 100,000 employees, of which nearly 5,000 people are devoted to R&D. TeleCo possesses a vast reservoir of intellectual property spanning several technology domains.

ExcelCo is one of India's largest IT consulting and services companies with annual revenue in excess of 3.8 billion USD in 2010. ExcelCo has more than 100,000 employees located in various parts of the world, comprising the company's global delivery and sales network. ExcelCo has 800 R&D engineers and spent approximately 10 million USD on R&D in 2010.

TeleCo's revenue has declined over the years due to intensifying competition and weakening monopoly position that it once enjoyed. Therefore, as part of its business strategy to drive revenue growth, TeleCo, among other things, actively looks for opportunities to license its technology to companies around the world. ExcelCo has been growing at Compound Annual Growth Rate (CAGR) of 30% over the last 5 years, but its business model based on linear growth is beginning to show signs of saturation. Therefore, it is imperative for ExcelCo to develop new and differentiated offerings with a view to achieve nonlinear growth as well.

TeleCo has been a client of ExcelCo since 2000, outsourcing a range of IT services to it. In 2008, the two companies entered into a strategic technology licensing agreement under which TeleCo licensed its intelligent resource management technology to ExcelCo with a view to collaboratively explore new revenue opportunities.

We interviewed people at both TeleCo and ExcelCo (see Table 14.2) during August–October 2010 to understand the technology licensing engagement between the two companies and to acquire an in-depth perspective on the process and dynamics of technology transfer from TeleCo to ExcelCo.

In general, the UK is the number one country for cross-border M&As; communications and information technology is one of the main branches for such deals (UNCTAD 2006). To date, the UK is number two in the list of most-favored locations of the top 100 locations for MNCs (UNCTAD 2006). The branch of Software and IT Services is one of the main globalized sectors with a high concentration of industrial R&D expenditures, in terms of percent of revenues, number two after pharmaceutical, biotechnology, and health (Gerybadze and Reger 1999). Hence, we found this industry background very suitable for such a case research.

3.3 Findings

3.3.1 Motivations for Technology Licensing

The genesis of the technology licensing engagement between TeleCo and ExcelCo is very interesting and rather atypical. TeleCo considers it to be strategically important to leverage its intellectual property assets to maximize return on its R&D investments. However, TeleCo's ability to commercialize its technological assets is constrained by budget as well as outreach. Because of this, TeleCo seeks to license its technologies to interested companies to generate additional revenues and to develop commercialization partnerships with companies to improve its outreach. TeleCo's Manager for Intellectual Property made the following observations during our interview with him:

> We have a valuable repository of intellectual property assets. However, our ability to commercialize them is limited by both a lack of systematic organizational thrust and budget. That's why I am trying to license our technologies to companies around the globe and use our relationship with them to commercialize our technologies. We have done quite a few deals involving technology licensing and joint commercialization. It's a win-win for both the parties. It helps us overcome our budgetary limitations and improves our outreach. As far as our licensing partners are concerned, they gain access to new technologies that they can leverage to create new market opportunities for themselves.

However, the technology licensing agreement between TeleCo and ExcelCo was signed under very different circumstances. As an IT solutions and services vendor, ExcelCo is always keen to deepen its relationship with TeleCo. The interviews suggest that TeleCo exploited this relational dimension to "arm twist" ExcelCo into signing a technology licensing deal with it. ExcelCo's Vice President for R&D provided insights into the genesis of the deal:

> We have had a long-term relationship with TeleCo, and obviously we want to grow our revenues from that account. TeleCo strategically exploited this situation and came to us proposing a technology licensing and commercialization deal that we could not refuse to consider because of the sensitivities involved in our relationship. We were neither aware of TeleCo's technologies and nor we were looking to license any technology in the particular area of intelligent resource management. TeleCo approached our top leadership with the proposal and we were left with no choice than to accept the proposal. We had no clue as to what was the strength and value of that technology.

Interestingly, the Chief Operating Officer of ExcelCo provided a slightly different perspective:

> Honestly, we were not really looking to license any technology in the area of resource management. However, when the TeleCo proposal came, we thought we could leverage their technology to create new offerings for our clients. We are anyway striving to create new technology-based business solutions for our clients in various industry verticals as part of our non-linear growth strategy, and the TeleCo proposal fitted well with our new scheme of things. I thought there was a merit in experimenting with their proposal, although we had not done this kind of thing before. Of course, there are risks, but we are in a position to absorb them if things don't work out.

TeleCo's Vice President for R&D and Venturing provided additional perspectives on the motivations behind the technology licensing engagement:

> We have been working with ExcelCo for several years now, and our relationship is well established. We understand each other well and our technology licensing engagement with them is mutually beneficial. Leveraging their excellent and low cost development capabilities, we could productize our intellectual property and speed-up commercialization. And, they could gain access to our award-winning technology that they could deploy in their offerings to enhance their value proposition to their clients. That, in turn, would improve the outreach of our technology and generate new revenues for both the companies. It's a win-win situation, you see.

The technology licensing agreement between TeleCo and ExcelCo began in September 2008 and continues to be alive. ExcelCo decision-makers felt that TeleCo's intelligent resource management technology could possibly be incorporated in business solutions across industry verticals including telecom, healthcare, logistics, and airline, and it is with that hope that ExcelCo finally signed the agreement with TeleCo. The following section provides the details of the agreement structure.

3.3.2 Structure of the Technology Licensing Agreement

The technology licensing engagement between TeleCo and ExcelCo appears to be unique in the sense that it not only involves technology transfer but also productization and commercialization of intellectual property. Under the agreement, TeleCo licensed its intelligent resource management technology to ExcelCo on a perpetual basis at a certain rate with royalty terms specified as percentage of sales arising from offerings embedding the said technology or its components. The deal also included a 3-year software development contract, wherein ExcelCo would be responsible to productize TeleCo's technology with a view to commercially exploit it.

The productized technology would be available to both the parties for individual as well as joint commercialization, and ExcelCo would be free to adapt the technology in any which way it deemed fit for its own business interests. Moreover, the deal agreement stated that the background intellectual property would always belong to TeleCo, although ExcelCo could own any foreground intellectual property it generates. However, it was not clear to us from the interviews if all the elements of the licensed technology were protected through patents, but an analysis of the agreement revealed that TeleCo did not indemnify ExcelCo from any litigation that might arise from the use of the technology.

Commenting on the structure of the deal, the Chief Technologist of TeleCo observed:

> It is a one of a kind deal, structured to leverage the assets and capabilities of two leaders in their respective businesses. The deal allows ExcelCo to have access to our innovative technology at a low price and gives us the ability to productize our technology for our own use at a low cost. The deal also gives an opportunity to the two market leaders to join hands in commercially exploiting our innovative technology in a mutually beneficial manner.

However, the people at the operating level did not quite seem to appreciate the strategic intent behind the deal, as is evident from the following remarks of ExcelCo's Senior Technical Architect involved with the engagement:

> It's a one-sided deal, and I am not sure how we could derive any significant gain out of this agreement. We do not know what's the value or strength of their technology, and we cannot solely go with their claims. I feel that we signed the agreement because we had to. TeleCo will get their technology productized at a very low cost because of our efficient development capability, but we really have to stretch ourselves to see how we might utilize their IP for our own offerings. Unless we fully productize their technology and see its value, we cannot say much. But, that means we have to wait until the end of the three-year period after which TeleCo is expected to deploy the product in their environment. If results from that trial are encouraging, we could at least approach other telcos with the offering.

3.3.3 Technology Transfer Process

The transfer of technology under the technology licensing agreement was organized in three phases, as shown in Table 14.3.

Phase I: In this phase, which lasted 6 months, a project manager and a senior technical architect from ExcelCo visited TeleCo's R&D facility in Europe to understand the technology and its applications as well as to initiate the development activity for productization. Because the technology concerned is a software technology, technology transfer involved significant amount of knowledge transfer.

Phase II: This phase involved software development activity for productization of technology for TeleCo and was carried out in India by a fully staffed team. Phase II,

Table 14.3 Phases of technology transfer

Phase	Duration (months)	Organization, focus, and activities
Phase 1	6	Key members of TeleCo and ExcelCo teams collocated at TeleCo R&D facility in Europe to initiate the technology transfer process as well as productization of technology
Phase 2	12	Continuation of the technology transfer process and productization activity at ExcelCo's site in India; planned visits by TeleCo personnel to aid the process
Phase 3	18	Completion of technology transfer and software product development and customization with remote support from TeleCo

originally planned to be executed over a 1-year duration, overshot by nearly 2 months due to integration issues between various elements of the intelligent resource management technology. During this phase, TeleCo's Chief Technologist and two senior R&D engineers visited India three times to interact with the ExcelCo team, to clarify aspects related to the technology, to review progress of the development activity, and to explore external commercialization prospects with business development teams at ExcelCo.

Phase III: This phase, to be executed over the last 18 months, was meant for implementing all the features of the product, for customizing the product for TeleCo's own use, and to deploy the product in TeleCo's environment. This phase is currently nearing its completion, although TeleCo still has not been able to secure agreement with its internal users for deploying the product for trial.

The process of technology transfer progressed more or less as planned, although it was characterized by its own dynamics. The technology licensing engagement kicked off on a positive note with the TeleCo managers and engineers appreciating the quality and commitment of the ExcelCo team. However, as the technology transfer process progressed, tension began to develop between the two organizations. First, during the course of technology transfer, the ExcelCo team realized that the TeleCo technology was not as valuable as it was portrayed to be, and that the technology by itself would not be market relevant unless it was complemented with other technological elements. The ExcelCo team found out that TeleCo possessed the other necessary technological elements with them, but those were not part of the licensing agreement. This meant that ExcelCo would need to develop the technological elements on its own or invest additional money to license it from TeleCo to be able to actually exploit the acquired technology for its own business objectives. ExcelCo's Principal Technical Architect remarked:

> During the first six months itself, while we were in TeleCo's R&D facility in Europe, we realized that the technology we have licensed has several limitations and by itself it is not of much value. I think the TeleCo team understood that we understood, and from that point

> onwards they began to speak in very fuzzy terms. In fact, we really had to equip ourselves with detailed knowledge on intelligent resource management, extensively compare their technology with other technologies and products available in the market, and ask several probing questions to get a fuller understanding of their technology. Of course, during the course of technology transfer, we learnt a lot and developed new ideas on how we might be able to commercialize the acquired technology on our own.

Second, the technology transfer process was also affected because of the issues surrounding transfer of knowledge. The TeleCo team felt that the ExcelCo team was not really proficient in the particular technological domain and that they were placing unnecessary demand on their time, raising questions and seeking clarifications. On the other hand, the ExcelCo team felt that the TeleCo team was deliberately avoiding providing clear answers because of the inherent weaknesses in their technology. Third, it appeared from our interviews with the TeleCo people that during the course of technology transfer, ExcelCo kept rotating its staff on the engagement, which affected the flow of technology as well as knowledge transfer. TeleCo's R&D Manager responsible for technology transfer commented:

> The problem is that the ExcelCo team members ask too many questions and every three months I see a new face in the team. This affects learning and continuity of technology transfer. Moreover, we have not budgeted for so much of our time to spend with the ExcelCo team. I fully understand that effective transfer of technology and knowledge is vital for our own success. However, we assume certain level of knowledge and competency.

When we asked the ExcelCo Project Manager about staff rotation, he noted:

> Yes, we have rotated staff on this engagement, but no key member has been moved. We have only replaced a few developers on the productization team. Our business model requires that we optimize resource mix on projects, and provide career advancement opportunities to our staff. Why would we rotate our staff in such a way that the technology transfer process would be impacted? After all, ensuring effectiveness of technology transfer is in our own interest. And, if we knew all about the intelligent resource management technology ourselves, why would we pay to license the technology from outside?

At the time we conducted interviews for this case study, a little more than 2 years had elapsed since the time the technology licensing engagement between TeleCo and ExcelCo began. The technology productization was well on its way to completion as per the specifications provided by TeleCo, and the technology transfer to ExcelCo was over. However, despite a few attempts, ExcelCo had not succeeded in finding avenues to incorporate the acquired technology in its offerings, although theoretically, many opportunities existed. According to people at ExcelCo, the acquired technology did not have any stand-alone value proposition and that it needed to be further developed to be of any relevant to the market. Moreover, since TeleCo itself had still not deployed the productized technology in their business environment, a clear use case was not readily apparent to ExcelCo.

However, according to TeleCo team members, the inability of ExcelCo to leverage the acquired technology was due to their limited vision and inability of their sales force to effectively position the technology to their clients. During our conversation, the Chief Technologies of TeleCo mentioned:

> Our technology has won several prestigious awards and we have obtained several patents for the various elements of our technology. We have envisioned a strong value proposition involving our technology for our own business units, and I know we will be very successful once the productized technology is deployed. Likewise, ExcelCo needs to invest effort in discovering and creating opportunities for themselves using our technology. I have a feeling that ExcelCo is limited by their vision, and their sales teams are not geared to sell such advanced technology based solutions.

The ExcelCo team does not subscribe to TeleCo's observation about lack of vision, as is illustrated by the remarks of their Vice President of R&D:

> Our technology licensing agreement with TeleCo has provision for joint go-to-market to create and exploit new market opportunities. So, what prevents them from collaborating with us in developing a strong vision and develop ideas for new offerings? After all, if we succeed, they stand to gain, too, given the way the agreement is structured.

4 Discussion

The case of technology licensing engagement between TeleCo and ExcelCo is an exemplary and unique case that enfolds three different modes of international technology transfer, viz., technology licensing, joint development, and joint commercialization, under one single agreement. Hence, it is located in the group of customer-supplier relations with relative small organizational interdependences between the two companies (Hagedoorn 1990). TeleCo had "barriers to appropriability" as they could not get access to new markets on their own. ExcelCo saw "opportunities for improvement" because they know the Indian market and culture very well, there was no cannibalizing effect with their existing business, and they were looking for new business opportunities (Gao et al. 2006).

The case offers several interesting insights into the process of technology transfer and decision-making regarding technology acquisitions.

First, the findings from the case suggest that ExcelCo's decision to acquire the intelligent resource management technology from TeleCo was emergent than deliberate and was influenced by relational considerations than driven by any strategic considerations. Thus, the case highlights the need for a strategic decision-making framework for technology acquisitions to boost a company's R&D and innovative capabilities. The findings suggest that it is absolutely vital for companies to develop a structured process for technology evaluation before entering into any technology licensing agreements.

This finding is consistent with the recommendations made by other scholars, who emphasize the need for a strategic decision-making process for technology acquisition (Roberts and Berry 1984; Tatikonda and Stock 2003). However, the extant literature largely concerns selection of the technology acquisition mode or motivation for technology acquisition rather than presenting a normative model for strategic decision-making. Existing literature is often very functional oriented, for example, typical stages start with identification and evaluation of technologies, not with the strategic intent behind it (Cusumano and Elenkov 1994).

Second, the case highlights the existence of strong motivation on part of both parties as a necessary condition for successful and effective transfer. Technology transfer is a dyadic process whose success depends on the willingness, abilities, and committed participation of both the parties (Reddy and Zhao 1990). In the case of the studied engagement, interviews suggest that both willingness and committed participation were lacking on the part of both the constituents, which leads to high resource costs (Teece 1977). Especially in supplier-customer relationships, this could be critical as the whole cooperation of both companies may be damaged. Bearing the different "powers" in mind may help to identify such constraints in advance (Kumar et al. 2006).

Third, the case reinforces the need for strong absorptive capacity on the part of the acquirer as a key determinant for successful technology transfer. This is consistent with the observations made by other scholars (Hu et al. 2005).

Fourth, the case suggests that without an up-front, clear, and compelling vision, technology acquisition could prove to be wasteful exercise, even if technology transfer was successfully completed. Moreover, the findings also suggest that if there was a strong management support behind the strategic intent with which the technology licensing and cooperation agreement was signed, the results could have been more favorable to both the companies involved. Obviously, these points strongly interact with the strategic decision-making in advance of the technology transfer.

Finally, the findings from the case also suggest that the emerging economy firms need to improve their breadth and depth of technological knowledge to be able to identify relevant and valuable technologies and effectively acquire them to be able to enhance their innovative capability. Arguably, had ExcelCo had the necessary technological background, it would have been able to evaluate the merits of TeleCo's technology, assessed its fit with its own business and innovation strategy, and ensured more effective, rapid, and smooth knowledge transfer, besides being able to conceptualize ways to leverage the acquired technology. This factor is still missing in recent literature, though this could be due to the fact that high-tech technology transfers from Europe-based MNCs to Asian-based MNCs are not very common yet. Hence, Asian companies lack of experience in such situations.

5 Implications for Theory and Practice

While the technology acquisition and transfer process in the studied case showed several points of correspondence with our original conceptual framework by Kathuria (2002), which provided scaffolding for our empirical inquiry, the case also revealed several points of differences that merit mention. The most noteworthy point of departure has to do with the type of technology that is being acquired and transferred. Our adopted conceptual framework is hardware and manufacturing technologies oriented, and does not account of the unique characteristics of software technologies. Software systems are primarily conceptual entities and encompass tacit knowledge, which is sticky and hence difficult to transfer. This is also true for other technology transfer process frameworks (e.g., Chantramonklasri 1990;

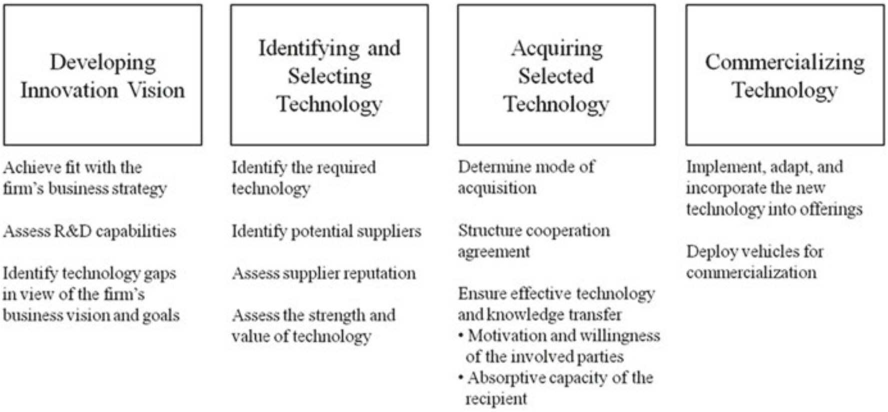

Fig. 14.4 Technology transfer process for knowledge industries

Cusumano and Elenkov 1994) which almost all do not account for the strategic fit of the acquired technology with a firm's business and innovation vision. Hence, we suggest adding a prior stage to all frameworks which is dealing with the company's business strategy and vision as well as their capabilities. In the case of our chosen framework, there would be a stage 0 named "alignment of business strategies and capabilities," followed by the rather technical steps "assessment of needs" and "selection of technologies" (Kathuria 2002).

Juxtaposing prior work with insights derived from our studied case, we propose four areas (see Fig. 14.4) for technology acquisition and transfer which are particularly relevant for software or other knowledge-based technologies.

Our research makes several important contributions to the literature on technology transfer. First, while the extant literature largely addresses the topic of technology transfer from a policy point of view, our work is among the very few studies that investigate technology transfer at the level of the firm. Second, while there are several frameworks that provide guidance on strategic decision-making for technology transfer (e.g., Cusumano and Elenkov 1994; Reddy and Zhao 1990), there are very few studies that offer insights into the process and dynamics of technology transfer and discuss its determinants. The present study makes an attempt in that direction and advances a practical and integrative framework for technology transfer at the level of the firm.

Third, most of the extant literature either concerns technology transfer between developed countries or between two firms in a developed economy. This chapter focuses on the emerging phenomenon of transnational technology transfer from a developed country firm to an emerging economy firm. Interestingly, the chapter highlights the growing propensity of emerging economy firms to acquire technologies from abroad to boost their innovative capabilities in their quest to boost their global competitiveness. Moreover, we present a unique case that involves three different modes of technology transfer – technology licensing, joint product development, and joint commercialization – all parts of a single international cooperation agreement (Hagedoorn 1990). We are not aware of any prior publication that has examined such a broad-based strategic cooperation between two firms located in two different countries. Furthermore, the researched case is particularly noteworthy because it presents the collaborative aspects of the technology transfer process unlike most other situations that entail one-way transfer of technology.

Finally, our case concerns international transfer of software technology involving transfer of tacit knowledge, which is difficult to achieve. Prior publications on technology transfer have mostly investigated instances of transfer of hardware and manufacturing technologies that are relatively easier to codify and hence transfer.

6 Limitations and Further Research

Notwithstanding a robust research design leading to noteworthy contributions, the present study is not without limitations. First of all, although our contributions will likely resonate well with other similar instances of technology transfer, our findings are nevertheless based on a single case study. Therefore, there is a clear need to further the present work with multiple case studies to examine diverse contexts and to achieve wider resonance. Second, our empirical inquiry focused on a case of software technology transfer, and it is plausible that the process and dynamics associated with the transfer of hardware technologies could significantly vary from what we have been able to capture. Thus, studying a diverse set of technology transfer cases involving different technologies offers a promising avenue for future research.

Third, it is conceivable that in the particular context of international technology transfer, cultural context will exert influence on the process of technology transfer, and future research could investigate this dimension in a focused manner. Next, the present study or extended qualitative studies could be complemented with large-scale quantitative surveys to test findings and propositions as well as to improve generalizability. Finally, we did not focus on assessing the link between technology transfer and firm performance – an important dimension of inquiry future studies could examine. Moreover, we suggest further research on strategic decision-making for completion of existing technology transfer models, which should be aligned with existing frameworks. Another interesting topic is a retrospective view on such international technology transfers, and which critical factors for success may be identified through that research.

References

Bar-Zakay SN (1971) A technology transfer mode. Technol Forecast Soc Change 2(3–4):32–1337

Brem A (2007) Make-or-buy Entscheidungen im strategischen Technologie management. VDM, Saarbrücken

Brem A (2008a) The boundaries of innovation and entrepreneurship – conceptual background and essays on selected theoretical and empirical aspects. Gabler, Wiesbaden

Brem A (2008b) The China information technology handbook. In: Ordóñez De Pablos P, Lytras MD (eds) The China information technology handbook. Springer, Heidelberg, p 433
Chantramonklasri N (1990) The development of technological and managerial capability in the developing countries. In: Chatterji M (ed) Technology transfer in the developing countries. Macmillan Press, London
Cusumano MA, Elenkov D (1994) Linking international technology transfer with strategy and management: a literature commentary. Res Policy 23(2):195–215
Dahlman CJ, Westphal LE (1981) The managing of technological mastery in relation to transfer of technology. Ann Am Acad Polit Soc Sci 458:12–26
Economist (2004) Scattering the seeds of invention – the globalisation of research and development. Economist, London
Economist (2010) First break all the rules (cover story). Economist 395(8678):6–8
FAZ (2011) Tata Motors greift mit Jaguar Land Rover den deutschen Rivalen BMW an. Frankfurter Allgemeine Zeitung. September 18th 2011 http://www.seiten.faz-archiv.de/faz/20110810/fd2201108103194943.html
Freemann C, Haagedorn J (1995) Convergence and divergence in the internationalization of technology.pdf
Gao X, Zhang P, Liu X (2006) Competing with MNEs: developing manufacturing capabilities or innovation capabilities. J Technol Transfer 32(1–2):87–107
Gardner PL (2002) The globalization of R&D and international technology transfer in the 21st century. In: The International Conference on Management of Innovation and Technology Proceedings (ICMIT'02 & ISMOT'02), Oct. 18-20, 2002, Hangzhou City, China
Gerybadze A, Reger G (1999) Globalization of R&D: recent changes in the management of innovation in transnational corporations. Res Policy 28(2–3):251–274
Hagedoorn J (1990) Organizational modes of inter-firm co-operation and technology transfer. Technovation 10(1):17–30
Håkanson L, Nobel R (2001) Organizational characteristics and reverse technology transfer. Manage Int 41(4):395–420
Herzog I-K (1994) Wachstumswirkungen des internationalen Technologietransfers. Verlag Dr. Kovac, Hamburg
Howells J (1996) Tacit knowledge, innovation and technology transfer. Technol Anal Strateg Manage 8(2):91–106
Hu AGZ, Jefferson GH, Jinchang Q (2005) R&D and technology transfer: firm-level evidence from Chinese industry. Rev Econ Stat 87(4):780–786
Huawei (2011): http://www.huawei.com/en/about-huawei/corporate-info/index.htm
Johnson SD, Gatz EF, Hicks D (1997) Expanding the content base of technology education: technology transfer as a topic of study. J Technol Educ 8(2):35–49
Kathuria V (2002) Technology transfer for GHG reduction: a framework with application to India. Technol Forecast Soc Change 69(4):405–430
Kedia BL, Bhagat RS (1988) Cultural constraints on transfer of technology across nations: implications for research in international and comparative management. Acad Manage Rev 13(4):559
Kumar (1997) Technology generation and technology transfers in the world economy: recent trends and implications for developing countries, September
Kumar U et al (2006) State sponsored large scale technology transfer projects in a developing country context. J Technol Transfer 32(6):629–644
Lenovo (2011) Lenovo website. September 18th 2011 http://www.lenovo.com/lenovo/us/en/history.html
Levin M (1997) Technology transfer is organizational development. Int J Technol Manage 14(2/3/4):297–308
Li J, Kozhikode RK (2009) Developing new innovation models: shifts in the innovation landscapes in emerging economies and implications for global R&D management. J Int Manage 15(3):328–339

Lincoln YS, Guba EG (1985) Naturalistic inquiry. Sage. Newbury Park, California September 18th 2011
Maskus BKE (2004) Encouraging international technology transfer. UNCTAD-ICTSD project on IPRs and sustainable development (7). UNCTAD-ICTSD, Geneva
Miles MB, Huberman AM (1994) Qualitative data analysis: an expanded sourcebook. Sage. Newbury Park, California, Second Edition September 18th 2011
Ockwell D et al (2007) UK – India collaboration to identify the barriers to the transfer of low carbon energy technology. September 18th 2011 http://www.defra.gov.uk
Ramanathan K (2008) An overview of technology transfer and technology transfer models. September 18th 2011 http://www.business-asia.net/Pdf_Pages/Guidebook on Technology Transfer Mechanisms/An overview of TT and TT Models.pdf
Reddy NM, Zhao L (1990) International technology transfer: a review. Res Policy 19(4):285–307
Roberts EB, Berry CA (1984) Entering new businesses – selecting strategies for success. Working paper Sloan School of Management 14928384 26(3):3–17. http://dspace.mit.edu/bitstream/handle/1721.1/47449/enteringnewbusin00robe.pdf?sequence=1
Roberts EB, Berry CA (1985) Entering New Business: Selecting Strategies for Success, in: Sloan Management Review, 26:3–17
Robinson RD (1988) The international transfer of technology. Ballinger, Cambridge
Rybak A (2007) Indische Welteroberer, Financial Times Deutschland, 03.04.2007
Singhal V (2011) The impact of emerging economies innovative new models of global growth and vitality are emerging. Visions 35(2):12–14
Stake RE (1995) The art of case study research, Sage. Thousand Oaks, California. September 18th 2011
Tata (2011): http://www.tata.com/aboutus/sub_index.aspx?sectid=8hOk5Qq3EfQ
Tatikonda MV, Stock GN (2003) Product technology transfer in the upstream supply chain. J Prod Innov Manage 20(6):444–467
Teece DJ (1977) Technology transfer by multinational firms: the resource cost of transferring technological know-how. Econ J 87(346):242–261
UNCTAD (2005) World investment report – transnational corporations and the internationalization of R&D. UNCTAD, New York
UNCTAD (2006) World investment report 2006 – FDI from developing and transition economies. UNCTAD, New York
UNCTC (1988) Transnational corporations in world development. UNCTC, New York
Walsham G (1995) Interpretive case studies in IS research: nature and method. Eur J Inf Syst 4(2):74–81
Walumbwa FO (1999) Rethinking the issues of international technology transfer. J Technol Stud 25(Summer/Fall):51–54
Yin RK (2008) Case study research: design and methods. Sage. Thousand Oaks, California. September 18th 2011
Zeschky M, Widenmayer B, Gassmann O (2011) Frugal Innovation in emerging markets: the case of mettler. Res Technol Manage 54(4):38–45

Chapter 15
The Emerging Properties of Business Models: A Systemic Approach

Andrea Cocchi

Abstract Aim of this paper is to explore the emerging properties of business models design processes in complex contexts such as a traditional manufacturing cluster. To do we distinguish between a static and dynamic perspective on business models, profiting from a critical analysis of the recent literature. Then we define the service orientation landscape for manufacturing sectors, approaching different strands of analysis. On this canvass, we present our case scenario based on an ongoing project for the design and delivery of new business model concept for the machine tool sector, based on renting and leasing. The analysis of this case will allow us to draft some conclusions about the emerging properties of business models design processes in context different form the one traditionally used to this kind of activities: a cluster of Italian SMEs. The interesting aspects accruing form this analysis lies on the different roles played by public and semi public institutions in participating to this pilot project. Moreover, the business models' systemic impact and strategic dimensions will be explored, showing how this tool can be considered as a systemic instrument for the governance of the innovative processes.

1 Introduction

In the last 10 years, business models mobilised the discourse among scholars and practitioners for their role in explaining the inner functioning of a firm as well as to streamline the evolution of their strategies (Demil and Lecocq 2010; George and Bock 2011; Zott and Amit 2008). Although this discussion is still in its formative phase, different schools and orientations can be distinguished here, proposing this concept as a useful tool to understand the evolutionary behaviours of firms,

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highlighting their entrepreneurial attitude in coping with increasing competitive conditions (Magretta 2002; Chesbrough and Rosenbloom 2002; Chesbrough and Schwartz 2007).

The aim of this chapter is to explore the emerging properties role of new business models (NBMs) for the evolution of a traditional cluster towards a service-oriented perspective. To do so, we will justify the similarities between business models and systemic instruments, highlighting their specificity and uniqueness. The focus here is on specific infrastructures created by the Emilia-Romagna government as part of its renewal strategy. These intermediary organisations are Applied Research Laboratories (LABS) established in the Emilia-Romagna Region. Created in 2004, LABS are composed by universities, local firms and other local stakeholders (chamber of commerce, employers associations, provinces and municipalities). Their aim is to organise, match and steer the regional R&D activities under the coordination of the regional R&D agency (ASTER). More recently, these laboratories gained the administrative and organisational independence by universities and other prominent stakeholders as basic condition for the access to the regional funding programmes (Bianchi and Bellini 1991; Bianchi and Labory 2011). The assumption we further here is that these intermediaries develop specific strategies, and then a specific business model, to fulfil their specific tasks. The unintended (and potential) outcome here is the realisation of a systemic impact on the dynamics and strategies of a traditional cluster, and on their path of revitalisation (Winch and Courtney 2007; Cocchi 2011; Howells 2006; Kirkels and Duysters 2010).

This paper is organised in three main parts. Firstly, in Sects. 2 and 3, we structure a critical review of the literature on innovation intermediaries and business model research. We conclude proposing of an analytical framework for the definition of the dynamics and impact of business models' deployment. Secondly, Sect. 4 deals with the presentation and discussion of a case study regarding the design process for the development of new business models for the machine tool sector. Finally, in Sects. 5 and 6, some conclusion will be offered in order to highlight the possible definition of business models as systemic instruments for the evolution of traditional clusters.

2 Business Models: Review and Classification

Business models (BMs) are a quite recent concept in the field of business and economics. Their appearance in the public domain begins with the rise of the "dot.com" era, as a buzzword in use among investors, financial analysts and other professional to summarise the "way of doing things" specific to a business. Since then, several scholars tried to define BMs according to their own perspective (Makinen and Seppanen 2007; Morris et al. 2005). Recently, the focus shifted to a critical analysis of the literature produced in order to converge on common points such as definition, functions and roles. Here, the literature is divided between academic and practitioners' perspective. For both communities, BMs express the capability to enact a commercial opportunity (Chesbrough and Rosenbloom 2002; Magretta 2002b). While academic debate struggles to reach a common definition, practitioners seem to be less fragmented on BM. Here, three main common rationales seem to emerge: (a) importance of the resource specificities and their organisation, (b) the relational/contractual dimension as enabling factor and (c) the BM as a precursor for sense making (George and Bock 2011). Another critical point is the discourse on the legitimisation of BM among academics, pivoting around the relationship between firms and environment. BMs are seen as a tool leading the evolution and adaptation of businesses to their context (Demil and Lecocq 2010; McGrath 2010), as a system of relations channelling feedbacks and connecting the strategic and the tactical levels (Casadesus-Masanell and Ricart 2010), influencing then the process of structural change and proposing new actors and agencies (Teece 2010; Gambardella and McGahan 2010). The contribution of Doganova and Eyquem-Renaul tries to make sense of the complex set of the intrinsic knowledge dynamics related to the emergence of BMs as a market device (Doganova and Eyquem-Renault 2009). This contributes to expand the generalisation of BM construct, moving away from their static representation according to structures, systems of relationships and "meta-frameworks" (Osterwalder et al. 2005; Conte 2008), towards a more dynamic, democratic and open posture (Mason and Spring 2011; Baden-Fuller and Morgan 2010).

Besides the practice and the diffusion among business and practitioners, this phenomenon relies on common routes. Teece proposes a list of drivers related to this topic: (a) the emerging of the knowledge economy, (b) the importance of ICT in the creation and delivering of value to customers, (c) the reorganisation of the industrial production by outsourcing and offshoring strategies and (d) the rise of services accompanying the industrial's structural change (Teece 2010:4). Baden-Fuller and Morgan offer an interesting perspective in questioning the usefulness of BM generalisations. They observe how BMs operate at an "intermediate level" between description and abstraction, assuming an intermediary role between theoretical and applied landscapes: "as practical models of technology that are ready for copying, but also open for variation and innovation" (Baden-Fuller and Morgan 2010:157). This conclusion seems to be supported by the literature produced. If we think at BMs as structural/organisational models, the example proposed by Oswelander regarding the "meta BM", defined as "an abstract concept that allows describing what a business does for a living", seems to "fit the bill" (Osterwalder et al. 2005:10). On the other hand, this idea indirectly refers to other interesting topics such as the issue of routine inheritance and replication dynamics in their relationship with firms' performance and organisational dimensions (Winter and Szulanski 2001). Finally, Demil and Lecocq summarise this position as a "transformational approach, where the BM is considered as a concept or a tool to address change and focus on innovation, either in the organization, or in the BM itself" (Demil and Lecocq 2010:228). This perspective highlights the importance of the successful adaptation to a specific (dynamic) environment and the systemic interdependence between different actors and governance levels. The entry points for this kind of analysis are different such as the construction of the value proposition (Teece 2010; Chesbrough and Rosenbloom 2002), the learning dynamics induced by the

KNOW. STRUCT → KNOW. NATURE ↓	**One-dimensional (post-Polyanyi)** Rationale*: Specialisation, Organisation*	**Complex (Post-Polanyi)** Rationale*: Translation, Meaning*
Normative *Reality is immutable Science reflects this structure.*	**ESSENTIALIST PERSPECTIVE** Theory Based – Mode 1 BM as Blueprint (intelligent design)	**PRAGMATIC PERSPECTIVE** Object Based - ANT BM is a By-Product
Discursive *Reality is complex (institutionalisation)*	**FUNCTIONALIST PERSPECTIVE** Practice/Output based – Mode 2 BM embodies set of relationships	**SYSTEMIC PERSPECTIVE** Process Based – Discursive BM is a systemic tool

Fig. 15.1 Business model classification (Our adaptation from Callon (1989), Doganova and Eyquem-Renault (2009), Polanyi (1958), Polanyi (2000))

adaptation process (McGrath 2010), the boundary spanning and translational role of BM's related processes (Zott and Amit 2008b; Doganova and Eyquem-Renault 2009).

In Fig. 15.1, we try to summarise the different perspectives on BMs according to an epistemological classification proposed by Callon (1989). On the columns, we have the passage towards a multidimensional and social dimension in the development of knowledge (Polanyi 1958). On the rows, we represent the different uses of the knowledge produced. In the table, we present a classification of the different perspectives introduced by Doganova and Eyquem-Renault (2009) to which we add a systemic perspective, branding BM as systemic instruments (or tools). Here, we have four different dynamics:

1. Essentialist tries to define the phenomenon according to a specific theoretical base.
2. Functionalist perspective: the ends and functions define the phenomenon.
3. Pragmatic is an output-based perspective in which the phenomenon is defined by its end.
4. Systemic: the phenomenon is defined by its recursive and reflexive dynamic.

This classification stresses a trend already appreciable in the literature discussed up to now. BM studies progress from a close to an open perspective, in which the BM knowledge (regarding their nature, meaning and components) is contested between different branches of science (essentialist perspective) or among an enlarged community of users/practitioners (as in the case of market devices). The outcome of the essentialist and pragmatic perspectives is normative in nature; the aim is to produce "standards" regulating specific typologies of exchanges (i.e. mertonian and market norms). On the other hand, we highlight the emergence of another dynamic where knowledge is contested and a closure is agreed among different epistemic communities. Callon talks about "networks of extended translations" where knowledge is produced in a circular and discursive manner (Callon 1989:52). Common statements are agreed among network participants in order to regulate the production of scientific statements and therefore grant a steady, although temporary, reproduction of knowledge. The difference between functionalist and systemic perspective here is the nature of the participating actors and the permeability of the networks established. According to the functionalist logic, these aspects are agreed at the beginning (i.e. business models can be produced in specific contexts by a selected population). Otherwise, in the systemic logic, the context and initial conditions play a central role in defining who and according to which logic a business model can be produced, and where the business models can be applied and understood is a matter of understanding. So while the former (functionalistic) perspective focuses on the efficiency of resources allocation and organization (i.e. market exchanges between firms, resources allocation and ownership), the latter (systemic) highlights the learning processes and the creation of a body of knowledge leading to structural change.

3 Business Models as Systemic Instruments

Systemic instruments are a topic relatively new to the policy innovation arena, although relying on a strong tradition in policy studies (Howlett 2009; Talbot 2005; Kuhlmann et al. 1999). They emerged as a common field of interest to design, manage and pace the evolution of systemic contexts (Howlett 2000; Smits and Kuhlmann 2004). Smits and Kuhlman introduced systemic instruments in the discourse on the governance of innovation systems, with the aim to define new ways to maximise the impact of public policies on complex systems. The rationale for the adoption of a systemic perspective is organised according to three major trends characterising the evolution of innovation processes and systems: (a) the interconnected nature of the innovation processes, (b) the rise of systemic approaches in the innovation theory and (c) the importance of intelligence and learning practices in designing and assessing specific innovation strategies (Smits and Kuhlmann 2004). The application of systemic instruments in the fields of sustainability and regional innovation furthered the evolution of this concept. Here, systemic instruments can be defined as "methods and mechanisms used by governments, political parties, businesses or individuals to organise, coordinate and direct innovation systems" (Wieczorek et al. 2010:16). What distinguishes this approach from the traditional one is the focus on the emergence of new technologies (and technological paradigms), while traditionally, this aspect has been overseen by the traditional approaches, mainly concerned about the application and diffusion of technological knowledge. These aspects highlight the important role played by business models as systemic instruments in the process of emergence (and structuration) and diffusion of specific populations, which could be defined as organised expression of agency (cfr. Dopfer and Potts 2008, Chap. 2; Dopfer et al. 2004).

According to Elidas, Hill and Howlett, systemic instruments are specific and unique. Specificity implies that systemic tools aim to solve particular issues, while uniqueness implies not substitutability between instruments (McDonald 2005; Eliadis et al. 2005; Howlett 2000). We argue that business models, according to their systemic perspective, can be defined as systemic tools because they display specific and unique features towards the governance of territorial subsystem of innovation (i.e. clusters). This is because they represent the processes followed, the structure of relationships and resource employed by private firms in their activity. The specificity of business models is characterised according to three points: (1) they can be considered as a constitutive characteristic of innovation system ontology (or polity); (2) they render the dynamic specialisation process for specific problem-solving networks, (3) they contribute to trace the emergence of common rules and routines between micro and meso dimensions. The role of systemic instruments in an innovation system is to solve a problem of coordination and specialisation between system's agents; they can be defined by "a organised system of relationships connecting one or more typology of agents and aiming at steer the division of labour by mutual learning practices". This definition stresses the generative role of knowledge dynamics in steering the system's structural change, attained by a progressive generation, circulation and consumption of knowledge.

As mentioned in the previous section, business models address an important role at firm level, guiding the process of learning, discovery and specialisation (Demil and Lecocq 2010). This feature is particularly important in the understanding of innovation systems' dynamics. Traditionally, the literature on this topic emphasised the concept of interdependency and collective effort prioritising the systemic traits (in term of fixtures) over the dynamic concept related to innovativeness. Innovation systems have been considered as a collection of biotypes of different institutions (Smits and Kuhlmann 2004:9), at work in a specific ecosystem. Here, learning was primarily related to the translation of knowledge from scientific to the industrial context, the networking aimed at facilitates the access to specific information and the systemic functions assured by the intensiveness of cooperation between actors. Actually, this rationale is not far from the traditional linear model of innovation (Godin 2006, 2010; Balconi et al. 2010). A recent contribution stresses the knowledge and structural dynamics implied in the innovation process (Metcalfe et al. 2005), where "innovations result from a process of accumulation of knowledge that unfolds stepwise in a largely path-dependent fashion within a design space defined by the perception of the problem at hand" (Consoli and Mina 2009:310). Problem-solving here is an open-ended process that, in turn, contributes to the solution of specific problems and challenges the borders of specific knowledge networks (David and Metcalfe 2008; Metcalfe et al. 2011). Business models here can be defined a system of relationships characterised by internal and external consistency. With internal consistency, we refer to the translation of strategies into tactics. With external consistency, we refer to the way in which the actor is able to define, select and coordinate the different sets of stakeholder, functional to the realisation of its aims (Teece 2010; Doganova and Eyquem-Renault 2009).

The development of a common understanding and its contextual nature represents the conceptual basis for discussing the potential role of business models from a policy perspective. We argue here that the potential value of specific business models, according to their structural, systemic and strategic perspective, can be used as systemic instrument enhancing the learning capabilities of public actors. With particular regard to the field of innovation policies, the topic of policy learning has been tackled according to specific evaluation tools (Georghiou and Roessner 2000; Georghiou 1998). With the aim to provide useful insights and appropriate information for the formulation and delivery of proper policy intervention, the issue of systemic intelligence come to the forefront, reflecting the increasing complexity of the systems in object (Kuhlmann et al. 1999; Kuhlmann 2001). More recently, the establishment of cluster policies as an important concept for public intervention on innovation and industrial contexts introduced the issue of evaluation (Schmiedeberg 2011). The specificity of business models can be seen here according to their specific representation of ongoing processes and as emerging ontological dimension. This perspective highlights the importance of meso level as specific context for comparing and scrutinising the evolution of socio-technical systems and networks (Elsner 2008). On the other hand, the topic that business models could contribute to is the innovation in public policymaking and the possibility to experimentation and learning (Elsner 2010; Potts 2009). In this perspective, the role of business models developed by a specific group of firms and other connected organisations (i.e. innovation intermediaries) could provide a useful insight on the ongoing system's innovation processes (Niosi 2002). Moreover, this kind of analysis can help to unravel the value of entrepreneurial actions according to its multilevel and multiactor nature (Breslin 2008) and in appreciating the impact of these activities under different lights and theoretical perspectives (Cuervo et al. 2007).

In Fig. 15.2, we try to summarise the concept of BM as systemic instrument. The logic here is organised according to the nature of BM (columns) and their possible impact on firms and systems (rows). On the left column, we conceptualise a BM as a static object. Here the behavior of a firm is represented by its structure, by specific solutions for the organization, coordination and ownership of its resources. According to George and Bock, this perspective deals with the measurement (or appreciation) dynamics relating to firm's performance (George and Bock 2011). On the other hand, the dynamic and evolutionary perspective (right column) focuses on the learning processes involved in the system of exchange and relationships needed to attain a specific objective. This stance builds on the idea of BM as a tool leading the firms' adaptation process (Demil and Lecocq 2010; McGrath 2010), as a process translating strategic aims in actions (Casadesus-Masanell and Ricart 2010). Moreover, as a complement to the static definition on BM, these dynamics highlight the emergence of new agents and agencies in a complex system (Dopfer and Potts 2008). An interesting point here is the relationship between an important stream of literature on entrepreneurship, according to a process perspective (Morris and Lewis 1994) and the recent literature on the evolutionary nature of this phenomenon (Veciana 2007; Breslin 2008; Metcalfe and Ramlogan 2005). Summarising, con-

		BM REPRESENTATION	
		OBJECT	PROCESS
IMPACT	BUSINESS	Structure and Organisation Knowledge Base Product Architecture	Relationships and Contracts Boundary Spanning Routinisation
	SYSTEM	Value and Performances Strategic Partnerships	Sense making Legitimisation Systemic Intelligence

Fig. 15.2 Business models impact matrix (Our elaboration on George and Bock (2011), Vargo and Lusch (2008), Kwan and Soe-Tsyr (2011))

ceiving BM as systemic instruments could be an interesting perspective for three main reasons: (a) exploring the entrepreneurial phenomenon from an evolutionary perspective; (b) modelling the behaviours of specific agents highlighting the topic of agency; (c) gain a better understanding about the social and knowledge dynamics commanding the ongoing division of knowledge.

4 New Business Models Design for the Manufacturing Sector

Profiting from a real case study, regarding the design process of innovative business models for manufacturing SMEs (Cocchi 2011), our contribution will try to highlight the *emerging properties* of business models in order to explore the possible strategic outcomes for private and public contexts according to a systemic perspective. The case in object relates to a pilot experiment aiming at designing a new business concept for a local manufacturing cluster (machine tool). As the project is still in its prime, we can offer only preliminary conclusions based on the first part of the process.

4.1 New Business Models in Manufacturing

In the last two decades, new business models (NBM) in manufacturing sectors and related product processes have been introduced according to a product service system (PSS) perspective. Defined as “a marketable set of products and services capable of jointly fulfilling a user’s needs” (Goedkoop et al. 1999:111), PSS represents the main organisational and operative framework adopted by manufacturers to define, design and implement a unique value proposition. The logic underpinning this prerogative is known as hybrid value creation (HVC) defined as *the process of generating additional value by innovatively combining products (tangible component) and services (intangible component)* (Velamuri et al. 2011:4). The impact of PSS on manufacturing processes can be appreciated by the variety of terms adopted to describe it: soft products, total offers, through life solutions and service 2.0. According to the literature, four main drivers fuelled the rise of PSS in manufacturing (Isaksson et al. 2001): (1) the introduction of new regulations, specifying limits and standards on users and suppliers along all the products' life cycle; (2) the increasing competition induces producers and suppliers to differentiate their offerings; (3) the progressive adoption of total cost of ownership and total life-cycle costs as standards for the products' selection; and (4) the increased variability of demand induces the adopt hybrid solutions to manage markets' discontinuity. The outcome is the growing service orientation of traditional sectors based on the dyadic relationship between artefacts' technological contents and the role of knowledge dynamics in consumption processes (Vargo and Lusch 2004, 2008). The value proposition here is evolving according to a network logic for the exploration and exploitation of business opportunities (Vladimirova et al. 2011; Biege et al. 2011; Jacob and Ulaga 2008).

The impact of services on manufacturing can be appreciated according to three major perspectives (Xu and Wang 2011). Firstly, we have the perspective that sees products and services as the same: *Everything as a Service (EaaS)*. Market activities here are focused on the transferring of rights of usage, the access to a specific offering in terms of use and results obtained. This trend is based on the concept of information and property rights. Examples here are the offering of specific bundles of services. An example could be the "power by the hour" strategy from Rolls-Royce or the contract signed by Alstom Transport with the London Underground that ensures a certain availability of trains (i.e. transportation capability) each day of the year (Bessant and Davies 2007). Secondly, we have the *Service Outsourcing Logic*, commanded by an increased division of labour between different actors. This leads to the transfer of specific activities up to whole business functions to external (specialised) providers. This is a very common practice among financial services (i.e. web security, document management and storage) and industries as well. Finally, we have the *Service Mash-Up* where single specialised agents joined in common service platform, combining their efforts in developing new service propositions. Examples can be found in business-to-business (B2B) marketplaces offering disparate services' bundling.

In Fig. 15.3, we try to classify the main PSS configurations according to their expected outcomes. Other authors prefer to use the definition Service and Good Dominant Logic (S-D and G-D) (Vargo and Lusch 2008). The good-centred perspective (G-D) defines services according to their relationship with specific products, functions or technological processes. The outcomes are then evaluated according to their level of product affinity, technological and functional compatibility (i.e. efficiency in terms of time, costs and resource savings, organisational integra-

	Value in Products	TANGIBLE		INTANGIBLE	Value in Services
	Pure Product	Product Oriented	Use Oriented	Results Oriented	Pure Service
	Property rights on Goods	Product related services Consultancy	Product Pooling Product Lease	Activity management and Outsourcing. Pay per Service	Fulfilment of customers needs
EaaS Accessibility to product/services		++	++	+++	++
Outsourcing Division of labour based on technology and specialisation		+	++	+++	+
Mash-Up Division of labour based on common goals		++	+	+++	++

Fig. 15.3 PSS classification (Adapted from Tukker (2004), Biege et al. (2009), Kobler et al. (2009), Xu and Wang (2011))

tion). This of course go hand in hand with a neoclassical vision of the product service relationship, defined by the level of specialisation of infrastructures and organisations commanded by the characteristics of the technology adopted (Vargo and Lusch 2008; Spohrer and Maglio 2010). Examples are the insurance contracts complementing the good's offering. For instance, we have contracts about the mean time between repair (MTBR) and failure (MTBF), reliability improvement warranties (RIW) or economic/operative insurances about total cost of ownership (TCO) or maintenance total cost of ownership (M-TCO) (Lanza et al. 2011; Biege et al. 2009; Greenough and Grubic 2011). On the other hand, the S-D logic shifts the focus on customers. In this perspective, services are defined as the "application of specialized competences (skills and knowledge), through deeds, processes, and performances for the benefit of another entity or the entity itself (self-service)" (Vargo and Lusch 2004:326). Here, the division of knowledge, developing along a recursive and reflexive learning process, substitutes the division of labour and its organisational/technological paradigm. Business models here were mainly conceived as networks of resources and activities leading to a coherent balance between offerings and value proposition. If the G-D logic sees services as the product of a process, the S-D perspective services are seen as specific processes by which services are exchanged between actors, accruing a mutual economic benefit.

Although a review of the massive quantity of publications and material produced is well beyond the scope of this work, we think there is a lock-in action here, confining the discourse on NBM in a technological-financial culture. It is like a box of references and practices with very clear and robust borders that complement, or at most, the traditional perspectives on manufacturing (e.g. manucentric approach to service systems). This model has not been challenged by the current research projects, conducted mainly at European level, dominated by specific topics such as energy consumption, the introduction of new materials and the sustainability of production processes (environmentally and operatively). On the other hand, big firms, associations and thematic platforms dominate the demand and supply side of applied research at national and international level. Their need to prioritise and select themes and actors to access to European funding constitutes a very powerful socio-technical system. This, in turn, facilitates the cooperation with industrial partners (normally big firms) but imposes some limitation on the scope and variety of the solutions proposed.

The development of NBM according to the PSS framework is mainly based on the development of products' implicit technologies and properties. Furthering the tradition of PSS design, the NBS rationale is centred on the evolution of the supply chain structure and management. The pre-eminence of a strict vertical/sectoral dimension justifies the adoption of NBM for the rationalisation of production processes, the related decrease of energy consumption and finally the financial benefits accruing from the new capital structure (Kang and Wimmer 2008). However, this perspective is challenged by recent contributions trying to shift the focus from a product- to a client-centred perspective (Kobler et al. 2009; Biege et al. 2009; Vargo and Lusch 2008; Kwan and Soe-Tsyr 2011).

4.2 The Intermediary Organisation

MUSP is an applied research laboratory pertaining to the technological district on manufacturing and located in the Piacenza's technopole. It has been founded in 2005 as joint initiative between universities (Polytechnic of Milan and Catholic University of Milan), local manufacturing firms, a sectoral association (UCIMU, the national association of machine tool and equipments producers) and local institutions (a bank foundation, province and city governments, local employers association). In 2008, MUSP strengthen its technology transfer capabilities by the establishment of an innovation division (Innovation MUSP – i-MUSP), following the incorporation of a local innovation centre (the actual organisational and governance structure is showed here below – Fig. 15.4).

MUSP is an example of the research laboratories recently established with the support of the regional government, with the aim to integrate the regional industrial and research systems towards a regional innovation system. In this respect, MUSP constitutes an interesting case of analysis, as its legal and operative autonomy endure since its foundation. It is a consortium with independent legal status, ruled by industrial partners according to private logics and expectations. The managing director is a full professor in mechanical engineering with relevant professional and industrial vision, thanks to its professional experience as manager in an important manufacturing company.

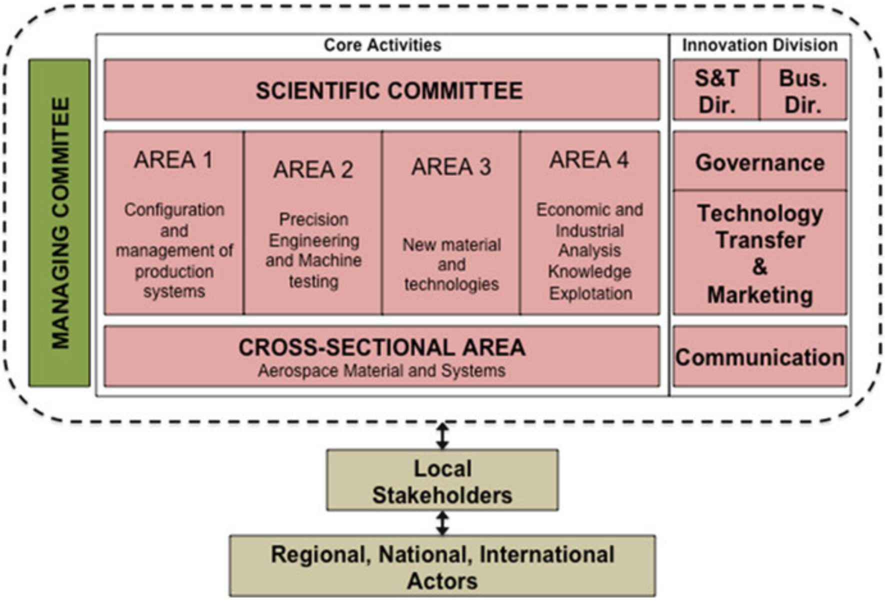

Fig. 15.4 MUSP lab.: Organisational and governance structure

4.3 The Opportunity

The opportunity for this service innovation has been introduced by the disruptive effect of the economic downturn on manufacturing sector. This forced firms and researchers to focus on different key factors, other than the superior performances granted by the technological edge of Italian firms. On the other hand, the effectiveness of traditional strategies (relationship with clients) is partially countered by financial pinch and credit restriction (the demand is only potential or not existent). In this context, MUSP decided to start an internal, independent project aiming at exploring the feasibility of NBM based on renting and leasing. The idea was to propose solutions ready to use, easy to adopt and understand from SMEs. The rationale for this project was based on some simple assumptions: (a) the potential value accruing from the technological content of modern machinery was actually underestimated, (b) other engineering intensive sectors already introduced leasing and renting in their business models (i.e. power generation, oil and gas industry) and (c) the technical life of machine tool is actually longer than the commercial one. On the other hand, the research centre was actually interested in analysing the technical problems associated to the passage from a traditional to a service-centred orientation. It is widely accepted that the introduction of PSS in firms' manufacturing strategies implies a revision of the traditional architecture of the products. This problem however is normally tackled from a technological perspective and not starting from the final service (or service system) (Biege et al. 2011).

The idea to propose renting and leasing as key elements for this business model was initially advanced by the director of the newly born innovation division. He is an external consultant with relevant experience in the field of applied research and development. The idea came from the simple observation of how renting and leasing were diffused and common practices in different manufacturing sectors. Moreover, given the result of the 2006 European Manufacturing Survey, 25% of firms not adopting NBM due to limited technical or commercial capabilities and the 63% that do not understand the applicability have been actually interpreted as a positive element here. We read these results as lacking of absorption capabilities from firms, combined with a weak relational capability from research and consultancy organisations. Conversely, this was an opportunity to explore, in order to propose new solutions for a quite conservative environment like the tooling machine sector. A point of view that seems to be comforted by recent studies on manufacturing challenges on his way to servicisation (Vladimirova et al. 2011).

4.4 The Innovation Proposed

The innovation proposed could be defined as an architectural one, a bundling of contracts and practices that are innovative for the market/sector, but at the same time familiar for producers and consumers. This model highlights the importance of networks and system of relationships in structuring and delivering its value proposition, on the rapid adaptation of contractual and procedural schemes already existing and, finally, on the redefinition of service's role in the strategy of the firm. Our aim is to propose an effective, simply understandable model aiming at exploiting the massive use of ancillary technologies in the modern tooling machines as well as tapping in the growing market of retrofitting and second-hand machinery (e.g. ICT, MEMS, RFDI sensors and accelerometers) (AAVV 2011; Conti 2007). The basic idea is to introduce the practice of renting and leasing in the sector of tooling machines, thanks to an adaptation of the contractual and functioning mechanisms. This should mitigate the problems (and limits) manifested by producers and clients in understanding and exploiting the new business models. In order to ease the design, communication and delivery processes, it has been necessary to expand the traditional system of partnerships adding, to the usual vertical dimension, a horizontal one (Lay et al. 2009). There is a bank with experience on renting and leasing contracts, a rental association with experience in the management of the contracts and the logistics of the renting and leasing processes for industrial machinery and a research centre able to select, manage and adapt specific technologies for renting and leasing purposes.

In Fig. 15.5 above, we compare the two business models proposed. The first "manucentric" is focused on the specific product. This refers to the traditional business model adopted by the SMEs in this sector. The value proposition is characterised by the level of personalisation of the product (machine tool) and by the ancillary nature of the services introduced. This strategy, already known in service studies as

Fig. 15.5 Traditional and new business models (Our adaptation from Miles 2009) (MANUCENTRIC – "assuming that the models and logic of manufacturing industry, or parts thereof (typically high-tech sectors), apply with very little qualification to the service activities that are found in service sectors and more widely across the economy" (Miles 2009, http://knowledgeintensiveservices.blogspot.com/2009_12_01_archive.html. Last accessed 18 Feb 2011))

"encapsulation" (Howells 2004), represents the dominant heuristic in manufacturing business model and has been classified by Tukker among the product-oriented strategies (Tukker 2004, cfr. Fig. 15.3). According to this model, the tool machine (product) is designed to solve specific problems faced by the target market, and the profitability is highly connected to the after-sale services as well as maintenance and other specific functions proposed by the supplier. This close relationship with customers allows the producers to constantly monitor critical market and technological trends but, on the other hand, overlooks the possibilities given by the introduction of ICT (e.g. interoperability and remote management of the process). On the other hand, the transfer of property rights from supplier to customer highlights the intrinsic value of the machine in a specific moment, neglecting the strategic value related to the life span of the machine. Then, we defined this concept as manucentric as related to a culture based on physical product, where engineering (in particular mechanical engineering) defines the main terms of reference. Here, services still have an ancillary position, while the design is mainly focused on the deployment of functional characteristics of products and technologies (Meier and Völker 2008; Meyer-Kramer 1996).

The aim of this new business model is to explore the possibilities offered by contracts and practices extensively used in other sectors for the provision of services along all the life cycle of the machine. The feasibility of the concept has been explored in two consecutive meetings with academics, consultants and representatives of the machine tool sector. The tool utilised to explain the possible model's architectures and explore related issues has been the "morphological box", a scheme introduced during the last part of the 1960s and widely used in the field of PSS modelling (Lay et al. 2009). To introduce the topic of new business models, we produced a presentation highlighting the difficult economic condition and the structural change this would have produced in manufacturing related sectors. On the other hand, we justified the introduction of the "renting hypothesis" as an interesting perspective, even if not the only one. However, our proposal was underpinned by very simple examples proposed in the European Renting Association (ERA) annual report, carefully selected

Characteristic Features		Options			
Ownership	During phase of use	Equipment producer	Leasing Bank	Joint Venture	Customer
	After phase of use	Equipment producer	Leasing Bank	Joint Venture	Customer
After phase of use	Manufacturing	Equipment producer	Operating joint venture	Customer	
	Maintenance	Equipment producer	Operating joint venture	Customer	
Location of operation		Equipment producer's establishment	Establishment "fence to fence" to the customer	Customer's establishment	
Single / multiple customer operation		In parallel operation for multiple customers	Operation for a single customer		
Payment model		Pay per Unit	Pay for Availability	Fixed Rate	Pay for Equipment

Fig. 15.6 Morphological box for NBM on renting (Adapted from Lay et al. (2009))

to reflect the manufacturing and industrial nature of this sector: oil and energy was then selected (ERA 2009). The purpose here was to question the anchoring effect of product and technology (mainly mechanical engineering and material science) as main component in the value proposition. On the other hand, this representation allowed members from different professional and scientific backgrounds to interact purposefully following a problem-solving perspective. Notice how engineers recognised this modular scheme very useful to define (and explain) the concept of reconfigurable manufacturing systems (RMS), while economists were able to associate to RMS, concepts as economies of scale and scope, as well as the resource base view of the firm. However, all these information lacked of consistency: a narrative or discursive path has to be introduced (Fig. 15.6).

An interesting aspect emerged from the meetings with academics (mainly engineers and economists) as well as consultants, bankers and other professional operators. The business model proposed was used by the different actors as a "learning tool" in order to make sense of the possible applications, highlighting problems and opportunities and shaping, at the end, a common understanding. So instead of an architectural model, this has been proved to be a "marked device" by which members for different communities progressively shaped their minds, allowing them to appraise (from the economic, technological and legal perspective) opportunities and threats. In Fig. 15.7, we offer a classification of possible business models obtained from the elaboration and synthesis of the group's discussions. In order to facilitate the understanding of the NBM proposed, we offer a functional model here below in Fig. 15.8. We hypnotised the creation of a new organisation (New Co.) with the aim to coordinate the activities between the different actors involved and in charge of the management of contracts and revenue system related to the renting of machinery.

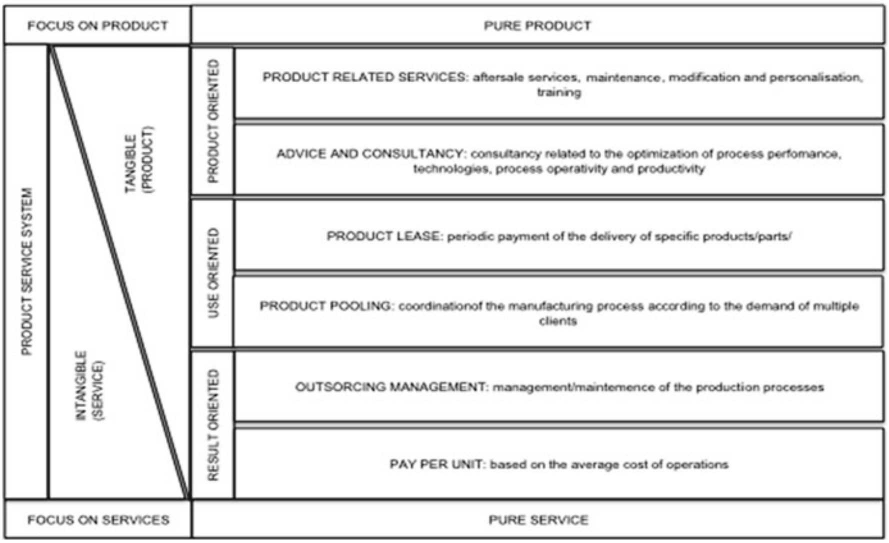

Fig. 15.7 Classification of possible BM (Adapted from Kobler et al. (2009), Tukker (2004))

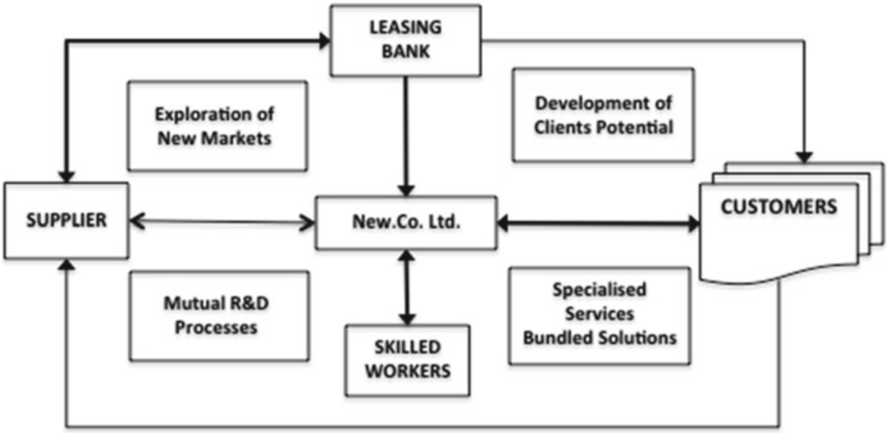

Fig. 15.8 Functional representation of NBM

However, the model is still in its prime, and one of the main issues to tackle for its implementation is the definition of specific market niches to be targeted and the inherent modification of machinery's structure. For this reason, in 2011–2012, MUSP decided to establish a working group focusing on this problem. The product adaptation, on the other hand, is one of the relevant problems to be faced for the delivery of NBM according to a PSS Perspective. A recent publication articulate this issue in six main points (Biege et al. 2011): (1) define and implement the monitoring system, (2) standardisation of the components, (3) design of the production system according to a (4) modular perspective, (5) identify products with long life cycles and (6) design the product to be easily assembled ad disassembled. Besides the technical aspects, this project poses specific challenges related to the organisation of the logistics' flow, as well as security and pricing procedures. However, these issues can be solved profiting from the experiences accruing from other complex product systems such as power generation, oil and gas and aerospace (Nordin and Kowalkowski 2010; ERA 2009; Hesselbach and Herrmann 2011).

5 Discussion

The business model proposed is meant to help local SMEs cluster to upgrade their relationship with market characterised by a highly volatility of demand and geographical distance. It builds on the PSS framework profiting from already available technologies, contracts and experiences from similar sectors. The main hypotheses on which this model is based are coherent with the trends manifested in manufacturing sector at large. We have considered the increasing service orientation of clients and markets, the specific capabilities introduced by sensors and other technological components already in use in the design of machine tool and considered the geographical and strategic importance of emerging markets. The specificity of the model proposed can be summarised in the variety of partners involved in the design and deployment of the model, the importance of skilled workers and the strategic and economic potential of the information generated by the exchange of goods and services. On the other hand, we realised the importance of the design process in defining a common understanding between the different (potential) partners in order to formulate specific and doable solutions. In this perspective, we recognised the potential use of NBM design as systemic instruments for the evolution of traditional clusters.

In Fig. 15.9, we try to put our model in context, highlighting the potential impacts (or outcomes) and the possible representation of the BM, according to the model built on recent literature (George and Bock 2011). At business level, the implementation of this NBM is characterised by a decoupling of product and service dimensions, highlighting the passage from a product- to a service-centred strategy. Technologies are normally considered as a cornerstone of SMEs competitiveness, are here considered as enabling factors. Moreover, the exploitation of "on the shelf" technologies implies the introduction of new products' architectural solutions. This can be achieved only by an enhanced modularity structure underpinned by an increased components' standardisation. Standardisation and modularity imply the definition of a new appropriability strategy based on a mix of contractual, relational and resource dependency elements. The strategic outcome here is the shift from a product- to a service-centred rationale, from which innovation can be distinguished according to its application (and not technological contents), evaluated according to the benefit or value generated by the client during the use and finally is reproducible (Toivonen and Tuominen 2009).

		BM REPRESENTATION	
		OBJECT	PROCESS
IMPACT	BUSINESS	•DECOUPLING SERVICES FROM PRODUCT •TECHNOLOGIES AS FACILITATORS •RE-DEFINITION OF PRODUCT ARCHITECTURE •SERVICE INNOVATION	•FROM PRODUCT CENTRIC TO CLIENT CENTRIC •ROLE OF ACADEMIA IS LIMITED (AS A PEER) •COLLABORATIVE ENTREPRENEURSHIP
	SYSTEM	•IS A SYSTEMIC INSTRUMENT •REALISATION OF PURPOSEFUL ENACTMENT	•INTERACTIVE/REFLEXIVE DIALOGUE •FOCUS IS ENDOGENOUS POTENTIAL •SOURCE OF SYSTEMIC INTELLIGENCE

Fig. 15.9 New business model: possible impacts

The impact at business level is however related to the learning process implied in the design, formulation and structuration of this final idea. We here focus on the activities and time-dependant process related to the NBM generation. Firstly, we have a shift from a product to a client-centred perspective, an element already well discussed in the document. However, the role of research institutions here is only ancillary as the discourse on technological contents fades, introducing the issue of bundling of already available solutions (e.g. on the shelf technologies). What we want to highlight here is that the effect is not only in the organisation of the technology transfer or development processes, as the role of universities (and related research centres) loses its technical/functional neutrality. An issue already discussed in introducing the emerging role of innovation intermediaries and that here can be appreciated at first hand. What we observed in this process was the development of a collaborative network between different actors (i.e. universities and research centres, employer associations, consultants, banks and other institutions) in order to explore, test and address the feasibility of this idea. On the basis of this newly established common understanding, the project has been carried on under the coordination of the research laboratory (championing the idea). This kind of behaviour can be defined as collaborative entrepreneurship. Collaborative entrepreneurship relies on the development of specific strategic orientation, defined as entrepreneurial orientation (Lumpkin and Dess 1996).[1]

Collaborative entrepreneurship, defined as "the creation of something of economic value based on new, jointly generated ideas that emerge from the sharing of information and knowledge" (Miles et al. 2006:2), can be conceived as a way to organise a steady pace for innovation performances (continuous innovation). The

[1] "An EO refers to the processes, practices, and decision-making activities that lead to new entry. It emerges from a strategic-choice perspective (Child 1972), which asserts that new-entry opportunities can be successfully undertaken by 'purposeful enactment'" (Lumpkin and Dess 1996:136).

authors define collaboration as "a process where two or more parties work closely with each other to achieve mutually beneficial outcomes" (Miles et al. 2006). However, the terms collaboration here is extended to organisations pertaining to different sectors, which decide to merge their effort with the aim to explore, source and manage in the best way their knowledge base (Ribeiro-Soriano and Urbano 2009; Miles et al. 2005). From this observation, we introduce the idea of a BM as a systemic instrument with a potential role to play in the evolution of traditional clusters. We justify this position according to the literature exploring the BM as a market device, defined as "the material and discursive assemblage that intervene in a construction of markets" (Muniesa et al. 2007). The term "assemblage" refers to the process of voluntary agreement over a common point done by different and independent actors. To note how this process and time-dependent perspective highlights the systemic nature of the BM. It becomes an instrument to realise what has been called a "purposeful enactment (Van de Ven and Poole 1995). The outcome of this process is the proposition of novel products/service to the market, and the evolution of agents' internal organisaiton, capabilities and routines.

Of course, the process relies on an interactive and reflexive dialogue between different components of the system in the exploration and establishment of a common understanding, a typical feature of market devices (Buenza and Garud 2007) and institutionalisation processes (Jensen et al. 2010). On the other hand, the focus on the realisation of this purposeful enactment highlights the dynamic role played by BM as market device in helping local actors to think out of the box, in experimenting new avenues and idea, and, to summarise, to enhance the innovativeness of the cluster. While innovation scholars appreciate this kind of dynamics as one important aspect of the innovation process, the perspective for technological agencies and other governmental organisation is still superficial. Surely the adoption of restrictive normative models for the evaluation of public policies' deployment plays an important part here, inhibiting the experimentation and consequent learning dynamics of public officers and institutions (Potts 2009). Others observe how the influence of the so-called development industry enhanced the development normative and prescriptive features for policy strategies (Uyarra and Flanagan 2010). In this perspective, an important systemic outcome for the development of NBM is the constitution of an intelligence system able to expand the understanding of public institutions according to the evolution of local systems. To conclude this discussion, in Table 15.1, we try to summarise the opportunities arising from the experimentation of this NBM, according to the characteristics of the specific PSS characterising the new offering. We limit our analysis to the business side of the impact as the project is still in its prime and effects at a different governance level cannot be appreciated.

The pivotal role of the research laboratory (MUSP), as promoter, pivot and animateur of the project, testifies its passage from a functional to a proactive behaviour. This observation seems to be in line with the evolution of public or semipublic research institutes presented by recent literature (Jain and George 2007; Hagedoorn et al. 2003), along with the emergence of the intermediation functions (Winch and Courtney 2007; Howells 2006). Characteristics of this phenomenon are the non-neutrality of these infrastructures and the adoption of specific strategies aiming at

Table 15.1 NBM components: characteristics and opportunities

Components	Characteristics		Opportunities
	Use-oriented services (UOS)	Results-oriented services (ROS)	
Customer segments	Low initial investments	No initial investments	Change relationship with traditional markets
	Property of the machinery not strategic	High flexibility in demand and productions	Access new, dynamic niches
Value proposition	Ownership with the supplier or intermediary	Delivery of ad hoc solutions (product and/or services)	Creation/destruction of specific capabilities
	Modular payment options		Extend the network of critical partners
	Deliver of specific capabilities		
Channels	Easy and quick transactions	Interface with multiple clients	Possible tensions with intermediary organisations
	Management of risk according to personalised contracts	Rapid detection of trends and critical aspects of the demand	Balanced with value of information and variety of potential market
Customer relationship	Blend of transactional (contract) and relational (contact)	Definition of ad hoc interfaces with clients	Creation of a specialised agent in charge for the management of some critical aspects of the transaction
Revenue streams	Blend of pay per use, availability	Pay per unit (or time)	Definition of specific price strategies
	Possible demand shaping and price discrimination	Definition of payment plans along all the life of the good	
		Design of services' bundling strategies	
Key resources	Skilled workers are critical	Skilled workers are critical	Shift from a product to knowledge-intensive components
		Information and knowledge are critical	
Key activities	Design of specific providers' structure and strategy	Service providers are critical partners in the design and deployment activities	Passage form a reactive to a proactive stance. The time to market
	Contracts and agreements are critical	Strong focus on scouting and analysis of customers' needs	Development of real time analysis capabilities on markets' need and trends
	Development of a service-oriented managerial culture		
Key partnerships	Establishment of long-time relationship based on cooperation (not more ownership)	Need to manage a network of highly skilled and potentially independent actors	Development of specific services
Cost structure	Capital intensive	Risk intensive	Definition of innovative contractual. Relational and organisational structures to manage the life-cycle costs and deployment of the machinery

Our elaboration from Barquet et al. (2011), Biege et al. (2009), Kobler et al. (2009)

influence or someway direct the institutionalisation of socio-technical networks (e.g. partaking) (Garud and Karnøe 2003). Contorted by the experience accrued by the direct observation of the process, we assumed the development, by the intermediary, of a specific entrepreneurial orientation, contextualised in a collaborative entrepreneurial effort.

6 Conclusions

The aim of this chapter was to explore the potential role of innovation intermediaries in the evolution of a traditional cluster in developing a service-oriented attitude. After a critical review of the available literature on business models and innovation intermediaries, we introduced the case in object. A region, recently empowered by new responsibilities and characterised by an industrial base devoted to traditional productions, began to question the structure and remits of its actual system of innovation. Following a specific RTI programmes for its requalification, the need to engage the regional research system induced the creation of a specific network of institutes (research laboratories) meant to organise, match and steer the regional R&D activities. The case study, profiting from the analysis of a specific project promoted by one of these laboratories, tries to unravel the potential and unintended outcomes of this programmes.

The preliminary results for this case study suggest that the adoption of business models from a service-centred perspective can stimulate the innovation process of firms in two ways. Firstly, we have the different approach to the market, not more based on the level of personalisation of products (in this case, machine tool) but according to a market and client perspective. Secondly, this kind of business model affects the way in which machine tool producers approach the sourcing of technologies and knowledge from the third parties. Based on this first, limited observation, the impact of a service-centred perspective on machine tool producers suggests a standardisation of the product architecture and features. Moreover, the effects on technology acquisition can be appreciated adopting a more heterogeneous perception on available knowledge, technologies and practices. In other words, the prominence of scientific knowledge is counterbalanced by the observation and adoption of business practices already in use in other sectors. The specific case refers to the adoption of renting and leasing practices, as well as the integration of the value proposition with other kinds of services.

On the other hand, if we consider a business model as a marked device, its adoption influences each actor involved: firms, intermediaries and, possibly, regional and sectoral institutions. In particular, the role of innovation intermediaries (in this case, a contract research technology organisation – C-RTO) shifts from a pure functionalistic perspective to a more entrepreneurial one. By the role played in the process, the nature of inputs and knowledge mediated, and by the active involvement of the organisation, we started to think about the possible emergence of a collaborative entrepreneurial solution between core SMEs in the cluster (leaders), intermediary and possibly the regional innovation agency. The exchange of information and experiences, the elaboration of practices, the analysis of emerging problems and relative solutions diverge in typologies and contents for the usual (dyadic) relationships between users and suppliers of technological knowledge. So conceptualising a business model as a process, it could be compared to a systemic instrument for the effective governance of innovative processes.

We tried to justify our considerations profiting from the available materials and literature at the best of our ability. However, results and conclusions should be taken with great caution given the initial stage of the project and the limited scope of the observation.

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References

AAVV (2011) High level group on Key Enabling Technologies (KETs) – Thematic report by the working team on advanced manufacturing systems. DG Enterprise and Industry Thematic reports, European Commission – DG Enterprise and Industry, Bruxelles

Baden-Fuller C, Morgan MS (2010) Business models as models. Long Range Plan 43:156–171

Balconi M, Brusoni S, Orsenigo L (2010) In defence of the linear model: an essay. Res Policy 39:1–13

Barquet A, Cunha V, Oliveira M, Rozenfeld H (2011) Business model elements for product-service system. In: Hesselbach H (ed) Functional thinking for value creation. Proceedings of the 3rd CIRP international conference on industrial product service systems, Springer, Berlin/Heidelberg

Bessant J, Davies A (2007) Managing service innovation. In: Innovation in services. DTi, London

Bianchi P, Bellini N (1991) Public policies for local networks of innovators. Res Policy 20:487–497

Bianchi P, Labory S (2011) Industrial policy after the crisis: the case of the Emilia-Romagna Region in Italy. Policy Stud 32:429–445

Biege S, Copani G, Lay G, Marvulli S, Schroeter M, (2009) "Innovative service-based business concepts for the machine tool building industry", Proceedings of the 1st CIRP IPS2 Conference, Cranfield University, UK.

Biege S, Schröter M, Weissenberger-Eibl M (2011) Product adaptation for industrial product-service systems – characteristics, motives and challenges. In: Hesselbach H, Herrmann C (eds) Functional thinking for value creation. Proceedings of the 3rd CIRP international conference on industrial product service systems, Springer, Berlin/Heidelberg

Breslin D (2008) A review of the evolutionary approach to the study of entrepreneurship. Int J Manage Rev 10:399–423

Buenza D, Garud R (2007) Calculators, lemmings or frame-makers? The intermediary role of securities analysts. In: Callon M, Millo Y, Muniesa F (eds) Market devices. Blackwell Publishing, Oxford, UK

Callon M (1989) Four models of the dynamics of science. In: Janasoff S (ed) Handbook of science and technology studies. Sage, Thousand Oaks
Casadesus-Masanell R, Ricart JE (2010) From strategy to business models and onto tactics. Long Range Plan 43:195–215
Chesbrough H, Rosenbloom RS (2002) The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. Ind Corp Change 11:529–555
Chesbrough H, Schwartz K (2007) Innovating business models with co-development partnerships. Res Technol Manage 50(1):55–59
COCCHI A. (2011) Innovation by Intermediation. The case of New Business Model for the Machine Tool Sector in Emilia-Romagna (Italy). Proceedings of the SSMENet UK Conference "Case Studies in Service Innovation" 7 June. Manchester, Manchester University, UK
Consoli D, Mina A (2009) An evolutionary perspective on health innovation systems. J Evol Econ 19:297–319
Conte T (2008) A framework for business models in business value networks. FZI Research Centre for Information Technology, Institute of Information Systems and Management (IISM), Karlsruhe
Conti JP (2007) Smart talk [M2M – Machine-to-machine communications]. Manufac Eng 86:20–23
Cuervo A, Ribeiro D, Roig S (2007) Entrepreneurship: concepts, theory and perspective. Springer, Heidelberg
David P, Metcalfe JS (2008) "Only connect": academic-business research collaborations and the formation of ecologies of innovation. Discussion papers. Stanford Institute for Economic Policy Research, Stanford
Demil B, Lecocq X (2010) Business model evolution: in search of dynamic consistency. Long Range Plan 43:227–246
Doganova L, Eyquem-Renault M (2009) What do business models do? Innovation devices in technology entrepreneurship. Res Policy 38(10):1559–1570
Dopfer K, Potts J (2008) The general theory of economic evolution. Routledge, Abingdon
Dopfer K, Foster J, Potts J (2004) Micro meso macro. J Evol Econ 14:269–286
Eliadis P, Hill M, Howlett M (2005) Introduction. In: Eliadis P, Hill M, Howlett M (eds) Designing government. McGill-Queen's University Press, Monreal
Elsner W (2008) Why meso? On "aggregation" and "emergence", and why and how the meso level is essential in social economics. Forum Soc Econ 36:1–16
Elsner W (2010) The process and a simple logic of 'meso'. Emergence and the co-evolution of institutions and group size. J Evol Econ 20:445–477
ERA (2009) European Rental Association. Annual report 2009
Gambardella A, McGahan AM (2010) Business-model innovation: general purpose technologies and their implications for industry structure. Long Range Plan 43:262–271
Garud R, Karnøe P (2003) Bricolage versus breakthrough: distributed and embedded agency in technology entrepreneurship. Res Policy 32:277–300
George G, Bock AJ (2011) The business model in practice and its implications for entrepreneurship research. Entrep Theory Pract 35:83–111
Georghiou L (1998) Issues in the evaluation of innovation and technology policy. Evaluation 4:37–51
Georghiou L, Roessner D (2000) Evaluating technology programs: tools and methods. Res Policy 29:657–678
Godin B (2006) The linear model of innovation: the historical construction of an analytical framework. Sci Technol Hum Values 31:639
Godin B (2010) National Innovation System: A Note on the Origins of a Concept, Working Paper, Project on the Intellectual History of Innovation. Montreal: INRS
Goedkoop Mark J, van Halen, Cees JG, te Riele, Harry RM, Peter JM, Rommens (1999) "Product Service Systems, Ecological and Economic Basis." The report No. 1999/36 submitted to Ministerje van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. March pp. 22–25
Greenough RM, Grubic T (2011) Modelling condition-based maintenance to deliver a service to machine tool users. Int J Adv Manuf Technol 52:1117–1132

Hagedoorn J, Link AN, Vonortas NS (2003) Introduction: strategic research partnerships – economic, managerial and policy implications. Technol Anal Strateg Manage 15:155–157

Hesselbach JR, Herrmann C (eds) (2011) Functional thinking for value creation. Proceedings of the 3rd CIRP international conference on industrial product service systems, Springer, Berlin/Heidelberg

Howells J (2004) Innovation, consumption and services: encapsulation and the combinatorial role of services. Serv Ind J 24:19–36

Howells J (2006) Intermediation and the role of intermediaries in innovation. Res Policy 35:715–728

Howlett M (2000) Managing the "hollow state": procedural policy instruments and modern governance. Can Public Adm 43:412–431

Howlett M (2009) Governance modes, policy regimes and operational plans: a multi-level nested model of policy instrument choice and policy design. Policy Sci 42:73–89

Isaksson O, Larsson T, Johnsson P (2001) Towards a framework for developing product/service systems. In: Hesselbach H, Herrmann C (eds) Functional thinking for value creation. Proceedings of the 3rd CIRP international conference on industrial product service systems, Springer, Berlin/Heidelberg

Jacob F, Ulaga W (2008) The transition form product to service in business markets: an agenda for academic inquiry. Ind Mark Manage 37:247–253

Jain S, George G (2007) Technology transfer offices as institutional entrepreneurs: the case of Wisconsin Alumni Research Foundation and human embryonic stem cells. Ind Corp Change 16:535–567

Jensen SRH, Poulfelt F, Kraus S (2010) Managerial routines in professional service firms: transforming knowledge into competitive advantages. Serv Ind J 30(12):2045–2062

Kang M-J, Wimmer R (2008) Product service systems as systemic cures for obese consumption and production. J Clean Prod 16:1146–1152

Kirkels Y, Duysters G (2010) Brokerage in SME networks. Res Policy 39:375–385

Kobler F, Fahling J, Vattai A, Leimeister JM, Krcmar H (2009) Analysis of value creation through product-service-systems in the German Medical Engineering Industry. In: Fahnrich K-P, Franczyk B (eds) International symposium on service sciences ISSS'09. Logos-Verlag, Berlin

Kuhlmann S (2001) Future governance of innovation policy in Europe – three scenarios. Res Policy 30:953–976

Kuhlmann S, Boekholt P, Georghiou L, Guy K, Héraud J-A, Laredo P, Lemola T, Loveridge D, Luukkonen T, Polt W, Rip A, Sanz-Menendez L, Smits R (1999) Improving distributed intelligence in complex innovation systems. Final report of the advanced science and technology policy planning network. Karlsruhe, Germany

Kwan S, Soe-Tsyr Y (2011) Customer-driven value co-creation in service networks. In: Demirkan H, Spohrer JC, Krishna V (eds) The science of service systems. Springer, New York

Lanza G, Werner P, Behmann B, Appel D (2011) Warranty cost improvement of machine tool during the bidding process and operation. In: IEEE (ed) Reliability and maintainability symposium (RAMS), 2011 proceedings, IEEE, Lake Buena Vista

Lay G, Schroeder M, Biege S (2009) Service-based business concepts: a typology for business-to-business markets. Eur Manage J 27:442–455

Lumpkin GT, Dess GG (1996) Clarifying the entrepreneurial orientation construct and linking it to performance. Acad Manage Rev 21:135–172

Magretta J (2002) Why business models matter. Harv Bus Rev 80:86–92

Makinen S, Seppanen M (2007) Assessing business models concepts with taxonomical research criteria. Manage Res News 30:735–748

Mason K, Spring M (2011) The sites and practices of business models. Ind Mark Manage 40:1032–1041

Mcdonald RA (2005) The Swiss army knife of governance. In: Elidas P, Hill M, Howlett M (eds) Designing government: from instruments to governance. McGill-Queen's University Press, Montreal/Kingston

Mcgrath RG (2010) Business models: a discovery driven approach. Long Range Plan 43:247–261

Meier H, Völker O (2008) Industrial product-service-systems – typology of service supply chain for IPS2 providing. In: Mitsuishi M, Ueda K, Kimura F (eds) Manufacturing systems and technologies for the new frontier. Springer, London
Metcalfe J, Ramlogan R (2005) Limits to the economy of knowledge and the knowledge of the economy. Futures 37:655–674
Metcalfe JS, James A, Mina A (2005) Emergent innovation systems and the delivery of clinical services: the case of intra-ocular lenses. Res Policy 34:1283–1304
Metcalfe S, De Liso N, Gagliardi D, Ramlogan (2012) ROPENLOC Working Paper Series, Univeristy of Trento. Italy: the University of Trento. Working Paper No. 3/12
Meyer-Kramer F (1996) Fraunhofer 2000: strategies of applied research. In: Krull W, Meyer-Kramer F (eds) Science and technology in Germany. Cartermillm, Harlow
Miles I (2009) Web Blog: Knowledge-intensive business services. In: Miles I (ed) A long-needed definition, Manchester. http://knowledgeintensiveservices.blogspot.com/2009_12_01_archive.html
Miles R, Miles G, Snow C (2005) Collaborative innovation. How communities of networked firms use continuous innovation to create wealth. Stanford University Press, Stanford
Miles RE, Miles G, Snow CC (2006) Collaborative entrepreneurship: a business model for continuous innovation. Organ Dyn 35:1–11
Morris MH, Lewis PS (1994) Reconceptualizing entrepreneurship: an input–output perspective. SAM Adv Manage J (07497075) 59:21
Morris M, Schindehutte M, Allen J (2005) The entrepreneur's business model: toward a unified perspective. J Bus Res 58:726–735
Muniesa F, Millo Y, Callon M (2007) An introduction to market devices. In: Callon M, Millo Y, Muniesa F (eds) Market devices. Blackwell Publishing, Oxford
Niosi J (2002) National systems of innovations are "x-efficient" (and x-effective): why some are slow learners. Res Policy 31:291–302
Nordin F, Kowalkowski C (2010) Solutions offerings: a critical review and reconceptualisation. J Serv Manage 21:441–459
Osterwalder A, Pigneur Y, Tucci CL (2005) Clarifying business models: origins, present, and future of the concept. Commun Assoc Inf Syst 16:1–25
Polanyi M (1958) Personal knowledge: towards a post-critical philosophy. University of Chicago Press, Chicago
Polanyi M (2000) The republic of science: its political and economic theory. Minerva 38:1–21
Potts J (2009) The innovation deficit in public services: the curious problem of too much efficiency and not enough waste and failure. Innov Manage Policy Pract 11:34–43
Ribeiro-Soriano D, Urbano D (2009) Overview of collaborative entrepreneurship: an integrated approach between business decisions and negotiations. Group Decis Negot 18:419–430
Schmiedeberg C (2011) Evaluation of cluster policy: a methodological overview. Evaluation 16:389
Smits R, Kuhlmann S (2004) The rise of systemic instruments in innovation policy. Int J Foresight Innov Policy 1:4–32
Sphorer JC, Maglio PP (2010) Toward a science of service systems. Value and symbols. In: Maglio PP, Kieliszwski CC, Sphorer JC (eds) Handbook of service science. Springer, London
Talbot C (2005) Consilience and performance in the "art of the state". Public Policy Adm 20:20–51
Teece DJ (2010) Business models, business strategy and innovation. Long Range Plan 43:172–194
Toivonen M, Tuominen T (2009) Emergence of innovation in services. Serv Ind J 29:887–902
Tukker A (2004) Eight types of product-service system: eight ways to sustainability? Experiences from suspronet. Bus Strateg Environ 13:246–260
Uyarra E, Flanagan K (2010) From regional systems of innovation to regions as innovation policy spaces. Environ Plan Gov Policy 28:681–695
van de Ven AH, Poole S (1995) Explaining development and change in organizations. Acad Manage Rev 20:510–540
Vargo SL, Lusch RF (2004) The four service marketing myths. Remnants of the goods-based, manufacturing model. J Serv Manage 6:324–335

Vargo SL, Lusch RF (2008) From goods to service(s): divergences and convergences of logics. Ind Mark Manage 37:254–259

Veciana JM (2007) Entrepreneurship as a scientific research programme. In: Cuervo A, Ribeiro D, Roig S (eds) Entrepreneurship: concepts, theory and perspectives. Springer, Heidelberg

Velamuri V, Neyer A-K, Möslein K (2011) Hybrid value creation: a systematic review of an evolving research area. J für Betriebswirtschaft 61:3–35

Vladimirova D, Evans S, Martinez V, Kingston J (2011) Elements of change in the transformation towards product service systems. In: Hesselbach H (ed) Functional thinking for value creation. Proceedings of the 3rd CIRP international conference on industrial product service systems, Springer, Berlin-Heidelberg

Wieczorek AJ, Hekkert M, Smits R (2010) Systemic policy instruments and their role in addressing sustainability challenges. In: 8th Globelics conference, Kuala Lumpur. Globelics, Indonesia

Winch GM, Courtney R (2007) The organization of innovation brokers: an international review. Technol Anal Strateg Manage 19:747–763

Winter SG, Szulanski G (2001) Replication as strategy. Organ Sci 12:730–743

Xu X, Wang Z (2011) State of the art: business services and its impact on manufacturing. J Intell Manuf 22:622–653

Zott C, Amit R (2008) The fit between product market strategy and business model: implications for firm performance. Strateg Manage J 29:1–26

Chapter 16
Technology Transfer in the Global Automotive Value Chain: Lessons from the Turkish Automotive Industry

Mehmet Teoman Pamukçu and Alper Sönmez

Abstract The automotive industry is one of the main contributors to value added, employment and exports of the Turkish economy and it has undergone major changes since the mid-nineties. Most automotive manufacturers in Turkey are either joint ventures or wholly-owned affiliates of multinational companies. Literature on global value chains point to the possibility of technology transfer occurring through backward linkages from automotive manufacturers to their suppliers. Here we analyze the existence and the importance of different types of knowledge and technology transfer mechanisms in the Turkish automotive industry. In addition, characteristics of local suppliers impacting on these transfers and their impact on firm performance are analyzed. To this end, a survey including a detailed questionnaire was administered to production/R&D managers of 158 automotive suppliers operating in Turkey in 2010. Findings confirm the existence of transfers from customers to their local suppliers on co-design and co-development activities, designing of production tools, development/improvement of quality control methods, cost reduction and design of materials. In addition, econometric analysis indicates that these transfers exert a positive effect on the performance of supplier firms.

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1 Introduction

The acceleration of the globalization of the world economy in the new millennium makes all the more important industrial upgrading and acquisition of advanced technological capabilities by nations in order to enhance competitiveness of their economies on world markets and improve the welfare of their populations. A major characteristic of the globalization era is the ever-increasing role of multinational companies (MNCs) in the world economy through their increased implications in foreign direct investment (FDI) flows and global value chains. The implications of the enhanced role of MNCs in the world economy are intensively debated as far as the industrial upgrading and related technological catch-up processes in developing nations are concerned. Indeed, even today only a limited number of developed countries control the conception, development, and production of new technologies in the world. Although technological activities of MNCs were pointed out as being the least globalized activity of MNCs, things seem to have changed by now.[1] Although developing nations do not benefit directly from advantages possessed by MNCs, they attempt to access some of the proprietary intangible assets possessed by MNCs, at least indirectly through technology transfer.

FDI by MNCs is currently considered to be a major channel for developing countries in order to access the advanced technologies of the developed world. A number of studies adopting quantitative as well as qualitative research methodologies addressed the issue of whether technology transfers from MNC affiliates to domestic firms occur in developing nations and, if so, through which channels and under which conditions.[2] Their findings point to the importance of the absorptive capacity of firms, the level of physical and human infrastructure in the country, the degree of competition at the sector level, and the technology gap existing between foreign and local enterprises. Another major lesson is that the likelihood of knowledge transfers increases significantly when enterprises operating in vertically linked industries, rather than those operating in the same sector, are involved in the technology transfer:[3] indeed, deliberate linkages formed between domestic and foreign firms operating in sectors characterized by intense backward or forward linkages are much more promising for knowledge transfers than spillovers occurring between competitors in a given sector.[4]

An increasing number of studies focus on buyer–suppliers relationships in the automotive industry since the rapid pace of technological change, the extent of the globalization process, and the intensified international competition are taking place

[1] Patel and Pavitt (1991) and UNCTAD (2005).

[2] Teece (1977). See also Eden et al. (1996), Blomstrom and Kokko (1998), Borensztein et al. (1998), Gorg and Greenaway (2004), Saggi (2005), and Smeets (2008).

[3] In other terms, technology transfer potential of *intraindustry* FDI-related knowledge spillovers seems to be much less than those associated with *interindustry* spillovers. On this issue, see Javorcik (2004), Saggi (2005), and Saliola and Zanfei (2009).

[4] Dicken (2007).

more intensively in this sector than in any other one. Indeed, partly in response to the intensified competition arising from Asian automotive manufacturers, many US and European MNCs delocalized their manufacturing activities to emerging economies from 1980s onward and gradually increased their presence on these markets. This period coincided with the reconsolidation of the automotive industry, which led to a drastic fall in the number of producers.

As a result, three major transformations exerted a fundamental impact on buyer–supplier relationships in the automotive industry. First, many suppliers were granted the responsibility to design entire products on their own. Second, supply of complete system components or products (modules) rather than supply of individual parts was required from suppliers, and third, as a result buyers became much more involved with their suppliers in order to increase the quality of their products, reduce defect rates, and ensure timely delivery of inputs to be used in the production process so as to minimize problems on the production line.[5] This process was accompanied by the emergence of various groups of suppliers possessing very different design and manufacturing capabilities and led manufacturers to impose stringent criteria for a supplier to work closely with them and finally become – and remain – their "direct supplier." Due to the existence of mutual interests between the two parties, these transformations in buyer–supplier relationships made auto manufacturers more willing to transfer part of their knowledge about manufacturing, design, and R&D activities to their direct suppliers. These transfers occurred under different forms, involved knowledge and technology flows of different quality and quantity, and impacted differently on the competencies of suppliers. A host of factors including absorptive capacity of suppliers, their production capabilities, ownership structure, degree of proximity to automotive manufacturers, type of components manufactured, and governance relations in supply chains impacted on the outcome. Hence, similar to intraindustry FDI-related knowledge spillovers, spillovers accruing through backward linkages do not occur automatically, and studies should be conducted in order to identify those factors that influence their occurrence.

Our objective in this chapter is to analyze aforementioned issues for the automotive sector in Turkey through a survey conducted among suppliers of parts and components in 2010. MNCs started investing in the automotive sector in Turkey in the late 1960s and have increased significantly their presence since the 1990s. This sector has contributed positively to economic growth, employment creation, and export performance and is therefore considered as one of the most strategic industries in Turkey. Moreover, automotive manufacturers, mostly joint ventures formed by foreign and domestic agents, have acquired extensive production capabilities over time and transformed Turkey into a production platform, as indicated by the evolution of Turkey's position among world producers.[6] However, the aforementioned consolida-

[5] Humphrey and Memedovic (2003).

[6] This development has had significant effects on the emergence of automotive suppliers in Turkey as well as on the acquisition of manufacturing and design capabilities by them: see Wasti et al. (2006).

tion process of the world automotive industry led automotive manufacturers in Turkey to go one step ahead and attempt to transform her from being solely a production base toward a design and R&D platform.[7] Efforts in this direction by manufacturers will depend strongly on the capacity of suppliers to play their role by carrying out a number of design-related activities previously conducted by manufacturers. This, in turn, will depend on whether automotive manufacturers are ready to transfer knowledge and technology to their suppliers and also on the extent, nature, and modalities of these transfers. To analyze this question, we prepared a questionnaire and used it to collect detailed data and information from auto suppliers in Turkey. The survey was conducted with the CEOs, R&D, production, and product directors of 165 supplier firms in order to investigate the existence, nature, and extent of technology transfers from buyers to suppliers.

The remainder of this chapter is organized as follows. Section 2 contains a brief overview of the evolution of the automotive industry in Turkey, our research methodology, and characteristics of the data collection process. In Sect. 3, first, the profile of suppliers in our sample is examined, then knowledge and technology transfers (KTTs in the sequel) accruing from MNCs to their suppliers are analyzed, and finally, determinants of various modes of KTTs are analyzed through ordinal logistic regression models. We conclude our study in Sect. 4.

2 Automotive Industry in Turkey, Research Methodology, and Data

2.1 Automotive Industry in Turkey

Automotive industry was established in Turkey in the mid-1950s as an assembly industry. A number of MNCs formed majority-owned joint ventures with Turkish partners and entered into the market in the late 1960s. Until the 1980s, the share of the automotive industry in Turkey's total exports was almost nil due to the import substitution development strategy pursued until the year 1980. Following a switch to much more outward-oriented economic policies in 1980, the share of automotive products in exports started to increase and reached 1% on average for 1980–1990. After the signature of the Customs Union Agreement between Turkey and the EU in 1996, which eliminated custom duties levied on industrial products, three additional global automotive manufacturers from Japan and South Korea launched production in Turkey. Data from United Nation's COMTRADE database suggests that the share of automotive products in total exports continued to rise continually from 2000 onward and is now only second behind textile products with a share of 13% in 2009. Turkish automotive industry has experienced significant output and productivity growth during the last decade and enhanced its competitiveness on global markets,

[7] SPO (2005).

which helped transforming it into one of the most dynamic and important sectors in Turkey.[8]

Available data from annual manufacturing surveys conducted by the Turkish Institute of Statistics points to the automotive sector as being the sector with the most important foreign presence. Indeed, over the period 2003–2006, foreign firms constituted in this sector 17% of all firms, employed nearly 55% of total labor, produced almost 80% of the gross output and 73% of the value added. It was followed by the electrical machinery sector and the radio, television, and communication sector. The major place occupied by MNC affiliates in the automotive sector points to possible flows of KTT accruing from buyers to suppliers in this sector.

According to data from the International Organization of Motor Vehicle Manufacturers website (www.oica.net) concerning number of units produced, Turkey was ranked 24th in world with total amount of nearly 300,000 vehicle production (222,000 cars and 76,000 commercial) corresponding to a total share of 5‰ in 1999. Moreover, Turkey was ranked 10th among European countries for the same year. In the last decade, Turkey managed to triple her share (15‰) and rose to 16th place with nearly 1.1 million units produced (600,000 cars and 490,000 commercial vehicles) in 2010. Turkey is now the 5th largest producer among European countries after Germany, Spain, France, and UK, respectively. Besides, Turkey's share has risen to a larger extent in commercial vehicles than in cars. In the world ranking, Turkey is at the 9th position in car production and 17th rank in commercial vehicles production with the shares being equal to 1% and 2.5%, respectively, in 2010.

2.2 *Research Methodology and Data*

There is no dataset available to investigate KTT-related issues examined in Sect. 2 for the Turkish economy. Two different research methods can be used to collect data and information required for our analysis and each of them involves dealing, to a different degree, with a selected sample of supplier firms operating in the Turkish automotive sector. The first one involves conducting in-depth semi-structured interviews with a selected sample of firms while the second one aims at collecting data through a survey questionnaire to be filled in by the respondents. Each method has its advantages and shortcomings, but the second one will be adopted here since it will enable us to conduct an econometric exercise in the next section in order to examine determinants of KTTs in Turkey. Indeed, by its nature, the first method – case study research – is applicable only to a limited number of firms, and although it may bring valuable information about the issues analyzed, it is not suitable for quantitative analysis.[9]

[8] See SPO (2005) for more information about the automotive sector in Turkey.

[9] Ekmekci (2009) uses the first method – case study – to analyze knowledge and technology transfer in the Turkish automotive industry.

We proceeded in the following manner in order to determine the target population to be analyzed in our study.

First, we examined the list of members of the Association of Automotive Parts and Components of Turkey (TAYSAD), which is the most important representative body of automotive supplier firms in Turkey. In 2010, this association had 286 members which are responsible for 65% of total production of this sector and 70% of its exports. At the same time, 29 affiliated companies are among the top 500 industrial companies list compiled each year by the Istanbul Chamber of Industry whereas 41 members are among the top 1,000 exporters in Turkey. Moreover, among the 286 firms affiliated with TAYSAD 58 (20%) have foreign partners. Therefore, an analysis based on TAYSAD members will enable us to carry out an analysis distinguishing between local and foreign firms operating in the part and components sector in Turkey, which is seldom done in studies concerning automotive suppliers in Turkey.

Note that TAYSAD members are in general *direct suppliers* of the automotive manufacturer companies operating in Turkey. By "direct supplier," we refer to first-tier suppliers that work directly with automotive manufacturers and produce systems, modules, or other nontrivial parts and components. In contrast, the second- and third-tier suppliers do not produce directly for manufacturers but for first-tier suppliers and their products are technologically simple commodity-type parts and components.

Second, information on the geographical distribution of TAYSAD firms indicates that most of them are located in the cities of Bursa, Istanbul, Kocaeli at the Marmara region, and in Izmir at the Aegean region. TAYSAD provided us with the names and addresses of 219 affiliated companies operating in these four cities. However, some of them refused to take part to the survey, and others indicated that their main activity was not anymore supply of part and components to automotive manufacturers. Therefore, an additional data source was required to compensate for the reduction in the sample size. The lists of firms affiliated with Bursa Chamber of Trade and Industry and with several organized industrial districts were checked to identify those automotive suppliers which are not members of TAYSAD. Finally, another 82 supplier firms were identified and added to the initial list, and we ended up with a sample frame including 290 firms. However, some firms declared they did not operate anymore in the automotive sector, and others refused to take part to the survey, leaving us with a sample of 158 firms who completed the survey questionnaire. With data collected from 7 firms during a pilot survey conducted to test the survey questionnaire, we have finally a sample of 165 firms, indicating a response rate of 57%. The survey was administered to the CEOs, R&D, production, and product directors of supplier firms.

Our survey questionnaire comprises eight main sections, each dealing with a different aspect of the KTT process: (1) general information on the characteristics of suppliers; (2) information on knowledge and technology transfers (related to product and production process), financial assistance, and training assistance from buyers to their suppliers; (3) market structure of suppliers; (4) production, technological, and design capabilities of suppliers; (5) input sources of suppliers; (6) collaboration of customer firms[10] with their suppliers; (7) R&D and innovations activities of suppliers; and (8) factors in the evolution of the performance of suppliers. Besides variables measured in monetary terms, responses were provided to the survey questionnaire in the form of binary variables (yes/no) and ordinal variables measuring the strength of the answer on a 5-point Likert scale. The nature of variables used will determine the type of econometric estimation techniques used in this chapter.

3 Knowledge and Technology Transfers from Customers to Suppliers in the Turkish Automotive Industry

In this chapter we will first conduct a non quantitative analysis of the data collected through the survey. Second, based on the variables constructed from raw data, we will attempt to analyze determinants of knowledge and technology transfers with appropriate econometric techniques.

3.1 Main Characteristics of Suppliers

In Table 16.1, three groups of firms are distinguished: local firms, foreign firms, and direct supplier firms.[11] This distinction will be maintained in all the tables that will be analyzed in this section. Data presented in Table 16.1 aims at providing an insight to the reader about the main characteristics of our sample.

Information on firm size, measured by the number of employees or by total sales, confirms our expectations that a large majority of firms in the sample are direct suppliers of the automotive manufacturers – that is, first- or second-tier suppliers. Moreover, foreign firms are larger than domestic firms, and they are also younger – most of them were established after 2000. On average, foreign suppliers are more export oriented, spend more on R&D activities, and are also more R&D intensive than local firms. However, local firms seem to have, on average, more patents – grants or applications – than foreign firms. When we look at the last two indicators concerning the duration of the work for the most important customer (*work together*) and the share of subcontracting agreement in total production (*subcontracting*), local suppliers are better placed than foreign ones.

Six alternative indicators used to measure the absorptive capacity of surveyed firms are presented in Table 16.2. These indicators are respectively the share of engineers in total employment, the share of white-collar personnel in

[10] The two terms "buyers" and "customers or customer firms" will be used interchangeably in the sequel.

[11] Data pertaining to the number of employees, sales, export share in sales, and R&D expenditures refer to the year 2008.

Table 16.1 Summary statistics

	Local firms			Foreign firms			Direct supplier firms			All firms		
	Obs.	Mean	St. dev.	Obs.	Mean	St. dev.	Obs.	Mean	St. dev.	Obs.	Mean	St. dev.
Age (year)	120	28.84	13.78	45	18.56	13.85	132	26.38	14.31	165	26.04	14.50
Turnover (1,000 euros)	105	24,636	34,028	38	48,658	56,000	114	33,284	41,375	143	31,019	42,176
Employment	119	255.33	280.48	42	404.36	551.20	129	325.08	403.91	161	294.20	374.41
Engineer	119	16.38	21.25	42	27.50	26.93	130	22.24	25.06	161	19.42	23.39
White-Collar	119	36.92	33.84	42	67.24	103.87	129	49.05	65.42	161	44.70	61.16
Blue-Collar	118	204.01	245.70	41	318.27	501.69	127	258.24	361.75	159	233.47	333.07
Foreign share (%)	120	0	0	45	76.00	29.10	132	22.00	38.00	165	20.68	37.07
Export intensity (%)	120	34.53	27.50	45	44.00	33.20	133	35.00	28.30	165	36.83	29.41
R&D exp. (1,000 euros)	100	456	1,814	33	1,282	2,166	107	770	2,131	133	661	1,932
R&D intensity (%)	104	2.55	4.83	35	2.91	3.50	111	2.77	4.87	139	2.64	4.52
NPAT	114	3.75	12.59	40	1.62	4.12	125	3.58	12.12	154	3.20	11.05
NOPAT	114	1.56	4.63	40	0.82	2.02	125	1.51	4.48	154	1.37	4.12
NAPAT	112	2.23	8.15	39	0.82	2.22	123	2.10	7.82	151	1.87	7.13
Worktogether (year)	118	18.12	10.29	45	1.80	11.36	131	18.59	10.85	163	17.48	10.61
Subcontracting agr. (%)	113	13.17	27.55	42	9.00	24.00	125	12.00	27.30	155	12.16	26.61

NOPAT number of owned patents, *NAPAT* number of applied patents, *NPAT* number of owned or applied patents, *WORKTOGETHER* number of years worked for the most important customer

Table 16.2 Alternative indicators of absorptive capacity

	Local	Foreign	DSF	All
Share of engineers in total employment (%)	6.79***	11.33***	8.41	7.98
Share of white-collar personnel in total employment (%)	16.6**	20.9**	17.35	17.72
R&D intensity (%)	2.55	2.91	2.77	2.64
Export intensity (%)	34.53*	43.78*	35.30	36.83
No. of patents granted	1.56	0.83	1.51	1.37
Sales per employee (euros)	89,159**	159,240**	99,884	107,548

DSF direct supplier firms
*, **, and *** denote significance at the 10%, 5%, and 1%, respectively

total employment, the share of R&D expenditures in turnover (R&D intensity), the share of export in turnover (export intensity), the number of patents granted, and sales per employee.

A significant number of high-skilled employees is an important indicator of advanced technological capabilities. Besides, the most important requirement for being able to operate effectively complex production technologies and for performing R&D and innovation activities is an advanced absorptive capacity at the firm level. Data on the human capital level of foreign and local suppliers show that the proportion of skilled personnel is higher in foreign firms compared to local suppliers, and the difference is statistically significant for both indicators of human capital.

Another argument in favor of a more advanced absorptive capacity for foreign firms is the R&D intensity of foreign firms which is higher than that corresponding to local suppliers although the difference is not statistically significant.

Foreign firms are more export oriented than their local counterparts – the difference between export intensities corresponding to each category significant at the 10% level. On average, around 45% of the sales of foreign firms are sent to the overseas markets. International markets are more competitive than the domestic market, and they require the capability to deal with stringent demands of consumers and more advanced technological production capabilities pertaining to the products and production processes (aimed at quality control, low defect rate, high quality, tests, design, etc.). Therefore, our data suggests that more export-oriented foreign suppliers are in possession of these qualities, and to a larger extent than local suppliers.

Highly qualified workforce and significant R&D activities are indicators of inputs to the innovation process of suppliers whereas patents are output indicators related to this process. Although the average number of patents granted to local firms is very low (1.6), they are higher than the number corresponding to foreign suppliers (0.83) – but the difference is not statistically significant at 10%. Yet this doesn't mean that the local firms are more successful than the foreign firms at converting their technology expenditures into patents because most of advanced R&D activities leading to patent applications are conducted at headquarters by parent company. Or it may be that foreign suppliers make use of patents granted to their parent company at the home country for their production activities in Turkey.

Average total sales per person of foreign suppliers is almost twice as much larger than local firms (significant at 5% level). In other terms, foreign suppliers are more productive than local ones. Intangible proprietary assets of the parent company transferred to its affiliate in Turkey materialize in the quality of human capital and the amount of R&D activities, that is, in technological capabilities, and exert a positive effect on the productivity level.

In sum, almost all the indicators in Table 16.2 point in the direction of a higher absorptive capacity in foreign than local firms.

120 over 165 supplier firms (73%) in our sample are owned entirely by national agents while the rest, that is, 25 firms (27%), are owned by foreigners to different degrees: almost half of these 25 foreign firms are fully owned by foreign agents while 16 of them are partly owned with the share of foreign capital in firm equity being between 40% and 69%. Minority- and majority-owned foreign firms are very limited in number. Most of foreign firms are from Germany (29%), USA (13%), France (11%), Japan (9%), Italy (9%), and Spain (7%). These companies are owned by foreign agents to different degrees, except for Japanese firms which are entirely owned by Japanese capital.

Size distribution of supplier firms is evaluated with respect to the usual classification that distinguishes between small (10–49 employees), medium (50–249 employees), and large (more than 250 employees) enterprises. Data indicates that our sample comprises mostly medium (53%) and large (38%) firms while only about 9% are small firms. This confirms remarks made in the previous section concerning the fact that our sample is mostly about the first- and possibly some second-tier part and component suppliers. A chi-square test points to a significant difference at the 10% level between the size distribution of direct and nondirect suppliers in the Turkish automotive industry in the year 2008.

Firms were asked to name their main product or products with a maximum number of three and their respective shares in their sales. The number of firms that specified only one, two, or three products is 26, 17, and 122, respectively. In order to identify the technological complexity of the products(s) manufactured by suppliers, we proceeded in the following manner. First, we analyzed the characteristics of the main product(s) manufactured by these firms to establish a technological complexity classification. For those firms which declared having more than one main product, the shares of the second and third products in sales were examined as well as the extent to which these products were technologically related. Our analysis indicates that on the one hand the share of the second and third products in total sales was much lower than that of the first product and that all these products were part of the same product group, that is, with a similar degree of technological complexity. Second, engineers affiliated with several automotive manufacturers as well as those affiliated with automotive parts and components manufacturers were consulted to establish the aforementioned technology complexity classification. Factors such as the knowledge and technology content of the products, whether it is a commodity-type product, the complexity of the manufacturing process, and its position in the value chain (primary or secondary product or raw material) were all taken into account in order to construct such a classification.[12]

Data indicate that 52% of all firms are manufacturing technologically complex or high-tech products while medium-tech and low-tech products constitute, respectively, 31% and 17% of their sales. 69% of foreign-owned firms are involved in high-tech production while the corresponding share for local firms is 45%. A two-sided Mann–Whitney U test shows that the difference is significant at the 1% significance level. Therefore, it seems that foreign supplier firms are technologically more advanced than local firms, which deal with somewhat technologically lower level production processes and products. The sources of this "technology gap" should be analyzed and policy proposals designed to mitigate it. A similar statistical difference is observed between direct and nondirect supplier firms as well.

3.2 Analysis of the Main Channels of Knowledge and Technology Transfers from Customers to Automotive Suppliers

In this section, we will examine various types of knowledge and technology transfers (KTTs) accruing from customer companies to their suppliers in Turkey, especially those (1) related to production processes and products, (2) implemented through trainings provided to suppliers by their customers, and (3) achieved – albeit in an indirect manner – through financial assistance. A thorough analysis of these various channels of KTT and their relative importance will shed a light on the importance and the nature of linkages occurring in the Turkish automotive industry between manufacturers and suppliers.

3.2.1 Knowledge and Technology Transfers (KTTs) Related to the Production Processes

Thirteen different types of production process-related KTTs occurring in direction of suppliers and originating from their customers are presented below in Table 16.3. Note that initially, respondents were asked to choose among five different types of KTT and indicate the frequency of the type of KTT involved.[13] Respondents were also asked to add any other production process-related KTT not mentioned in the survey questionnaire. The five KTT channels proposed initially in the questionnaire are

[12] For instance, parts or components as motor, gear box, suspension, braking system, safety systems, and so on (in primary product class) were classified in the *high-technology category*; the parts as various automotive fasteners, headlight, ventilation ducts, damper, seat, internal trim materials, and such in the *medium-technology category* and the parts as mudguard, seat cover, indicator, signal arms, mirror, and exhaust silencer in the *low-technology category*.

[13] The alternatives offered were (i) *often,* (ii) *sometimes,* and (iii) *never*.

(i) assistance for design, (ii) assistance for R&D activities (iii), providing know-how (iv), assistance for logistic management, and (v) providing documentation. We expect the quantity of the knowledge transferred, and its strategic importance for the supplier, to decrease from (i) to (iv).

When the "often" responses given by all the firms are examined, it is observed that providing documentations (33%), assistance for logistic management (15%), and quality control (14%) are the most frequently selected items by at least 10% of respondents. They are followed by two channels of KTT involving transfer of know-how (10.4%) and assistance for R&D activities (10.3%) from customers to suppliers. The proportion of local firms which receive documentation (36%) and assistance for logistic management (16%) is larger than the corresponding share for foreign firms, respectively, 24% and 9%. Furthermore, the observed difference between local and foreign firms is statistically significant at the 10% level. A contrary situation is observed for KTT accruing to suppliers through know-how transfers.

Data in Table 16.3 point out that, compared to foreign firms, local suppliers tend to be involved in those production-related KTTs which are less knowledge intensive and of a lesser quality. Only 9% of local suppliers receive assistance from their customers for their R&D activities and even a lower proportion for their design activities (7%). Although there are no statistically significant differences between foreign and local for these aforementioned high-level KTTs, the absence of these transfers may not have the same implications for both group of firms; indeed, the low figures for foreign firms may indicate that they have advanced design and R&D capabilities and therefore do not need to interact with their customers in order to benefits from KTTs. On the other hand, figures concerning local firms may point to the absence of much needed production-related KTTs, with negative implications for their production and innovation capabilities.

When suppliers that selected the "sometimes" category are analyzed, although the proportion of all firms that indicated this category is significantly higher than those selecting the category "often" for all the items, the remark made above about the low knowledge intensity of KTTs accruing to local firms remains valid: 58% of local and 56 of foreign firms receive assistance from their customers on logistics while 62% of foreign firms benefit from know-how flows originating from their customers versus only 50% for local firms (the difference is statistically significant for both items). The only case that contrasts with the above judgment concerns the transfer of codified knowledge in the form of documentations related to the production process (the first item in Table 16.3).

In addition, KTTs aiming at production processes and which occur the least are identified by the proportion of suppliers that choose the "never" category: granting of patent/license rights to suppliers (73%), assistance for business management (68%), and involvement of customer's staff in launching the operations of the plant (64%). The figures for the five items initially included in the questionnaire are (1) providing documentations (11%), (2) assistance for logistic management (37%), (3) providing know-how (31%), (4) assistance for R&D activities (36%), and (5) assistance for design (35%). A tendency seems to exist for this proportion to increase with the quality and strategic importance of knowledge provided to supplier firms by their customers.

Table 16.3 Types of knowledge and technology transfers related to the production process (%)

	Often				Sometimes			
	Local	Foreign	DSF	All	Local	Foreign	DSF	All
1. *Provided various documentations*	35.8*	24.4*	32.6	*32.7*	55.3*	57.7*	57.6	*56.4*
2. *Assistance for logistic management*	17.5*	8.9*	15.9*	*15.2*	58.3*	55.5*	59.8*	*57.6*
3. Assistance for quality control methods	14.2	13.3	13.6	*13.9*	65.0	53.3	64.4	*61.8*
4. *Provided know-how*	9.3*	13.3*	12.3	*10.4*	50*	62.2*	50.0	*53.4*
5. *Assistance for R&D activities*	9.2	13.3	11.4	*10.3*	53.3	53.3	54.5	*53.3*
6. Supply of raw material	10.0	8.9	10.6	*9.7*	29.2	37.8	32.6	*31.5*
7. Customer sent its staff for assistance in solving problems in the production process	5.8	8.9	7.6	*6.7*	50.0	51.1	50.8	*50.3*
8. *Assistance for design*	6.7	6.7	8.3**	*6.7*	51.7	62.2	56.8**	*54.5*
9. Supply of machinery, tools, and equipment	4.2	8.9	6.8	*5.5*	40.0	40.0	40.2	*40.0*
10. Assistance for productivity-related problems	4.2	8.9	6.8	*5.5*	50.8	42.2	49.2	*48.5*
11. Customer's staff involved in the establishment of production processes of the plant	5.8	4.4	6.8**	*5.5*	29.2	31.1	31.8**	*29.7*
12. Patent and/or license rights granted	2.5	4.4	3.8**	*3.0*	14.3	13.3	16.7**	*14.0*
13. Assistance for business management	1.7	4.4	2.2*	*2.4*	30.8	35.6	35.6*	*32.1*

Table 16.3 does not include information for the "never" category but this information can be obtained readily for each item by summing the proportions of answers given to two other categories (*often and sometimes*) and subtracting it from 100
***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided) Items are sorted according to "all firms" and "often" category. Items denoted in bold are the questions included explicitly in the survey questionnaire. Remaining items were added by the respondents themselves

3.2.2 Knowledge and Technology Transfers Related to Products

Table 16.4 shows the proportion of suppliers involved in product-related KTTs to different degrees (i.e., often and sometimes).

49% of respondents declared that they benefited from KTTs in the form of technical specifications, original design, or technical drawings (SDDs) originating from their customers while this figure falls to 26% for both transfers related to joint operations and product specifications. Two last items included in Table 16.4 require an important level of absorptive capacity on the part of suppliers but also present the most important potential for product-related KTTs. They are the KTT-related activities that occur least frequently, hence pointing to their difficulty or strategic issues

Table 16.4 Types of knowledge and technology transfers related to products (%)

	Often				Sometimes			
	Local	Foreign	DSF	All	Local	Foreign	DSF	All
Technical specifications, original design, or technical drawings related to products	55.5***	31.1***	47.0	48.8	31.9***	40***	36.4	34.1
Joint operations related to product	25.2	28.9	27.3	26.2	53.8	57.8	54.5	54.9
Product specifications	27.7	22.2	25.8	26.2	38.7	55.6	43.2	43.3
Joint design activity related to product	15.1	13.3	16.7**	14.6	54.6	60.0	57.6**	56.1
Assistance related to product designs	10.2	15.6	12.2*	11.7	52.5	51.1	55.0*	52.1

***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided) Items are sorted according to "all firms" and "often" category

involved. Besides, the first product-related KTT activity, which probably provides basic codified information to suppliers and does not require an advanced absorptive capacity on their part to make use of the knowledge transferred, concerns 56% of local versus 31% of foreign firms – and the difference is statistically significant at 1% level. In other words, as far the "often" category is concerned, local firms tend to benefit mostly from the low-tech kind of product-related KTTs. On the other hand, while there is no statistical difference at the 10% level for the last two knowledge-intensive KTT items between foreign and local firms, such a significant difference exists between direct and nondirect suppliers firms at the 1% level. Hence, being a direct supplier of automotive manufacturers operating in Turkey and therefore being more close to customers in the supply chain exerts a positive effect on this type of KTT.

When respondents which opted for the "sometimes" category are analyzed, a different picture arises. Indeed, the last two product-related KTT channels are now among the most frequently used ones with more than 50% of suppliers involved in each of them. This last finding indicates that customers desire ensuring critical characteristics of inputs such defect rates, quality, and delivery on time so as not to encounter any major problems later on the production lines. As such, these KTTs about product design are a prime example of deliberate technology transfer from customers to their suppliers through backward linkages. On the contrary, the previously most frequent KTT item (SDDs) is now experienced only by 34% of suppliers, which is the lowest proportion for the "sometimes" category. Moreover, 40% of foreign suppliers declare they are involved in this kind of product-related KTT activity while the corresponding figure for local firms is only 32%, and the difference is statistically significant at the 1% level. Figures concerning direct suppliers for the last two KTT items confirm the advantages of the proximity in the value chain to automotive manufacturers pertaining to the nature of the transfers realized – and the difference between direct and nondirect suppliers is statistically significant.

Table 16.5 Knowledge and technology transfers through training: types of training (%)

	Often				Sometimes			
Types of trainings	Local	Foreign	DSF	All	Local	Foreign	DSF	All
Training on technologies used in production	9.2	15.6	13.0*	11.0	37.0	37.8	38.2*	37.2
Training of production/ operation staff (engineers, technicians, etc.)	7.6	17.8	13.0**	10.4	53.8	46.7	52.7**	51.8
Training of management staff	5.8	11.1	9.1*	7.3	47.5	53.3	50*	49.1

***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided) Items are sorted according to "all firms" and "often" category

3.2.3 Knowledge and Technology Transfers Occurring Through Training

Many of the previously examined KTT activities, whether related to production processes or products, entail the transfer of codified knowledge form customers to their suppliers. However, as is well known, some strategic knowledge exists only in tacit form and is embodied mainly in individuals and organizations. Therefore, its transfer requires face-to-face contacts between employees of manufacturers and supplier firms in the automotive sector. One major way to achieve transfer of tacit knowledge from manufacturers to suppliers is by organizing trainings sessions that targets employees of supplier firms. These training sessions can be of different types and be provided via different modalities. Responses of suppliers to the questions on KTTs occurring through training are presented below in Table 16.5 for different types and modalities of trainings.

Information on three different types of trainings is presented in Table 16.5, that is, trainings on production technologies, trainings targeting production, and management staff of suppliers. Data is provided for both the "often" and the "sometimes" categories. One first notices that the proportion of all firms that declared being subject to at least one of these three types of trainings, 11%, is much lower than the corresponding shares of product- or process-related KTTs (see Tables 16.3 and 16.4). In other words, transfer of tacit knowledge occurs relatively less frequently than transfer of mainly codified knowledge. This might be due to the more difficult and costly nature transferring knowledge embodied in people and organizations since face-to-face contacts between employees of manufacturers and suppliers are required for an effective KTT through training to occur. In addition, the more strategic nature of tacit knowledge may dissuade some automotive manufacturers from transferring it to their suppliers in order to conserve their bargaining power in supply value chain, especially if trust between the two parties is not strong enough.

Whatever the factors behind these low proportions, data indicate that 11% of suppliers receive training on production technologies, while training provided to production workers and managers concern 10% and 7% of suppliers, respectively. The proportion of foreign firms subject to all three kinds of training is higher than for local firms, pointing to the advantages of foreign ownership in the transfer of tacit knowledge – the difference, however, is not statistically significant at 10%. On the other hand, a significant difference exists between the proportion of direct and nondirect supplier firms benefiting from these three types of tacit KTTs. When responses with the "sometimes" option are examined, the difference between the foreign and local firms observed earlier is reduced – for instance, 54% of local firms declare their engineers and technicians receive training from their customers while the corresponding proportion is 47% for foreign firms. In any case, 52% of all firms did never benefit from KTT occurring through the first type of training, 38% from the second type of training, and 43% from the third type of training. These proportions are higher than those related to production and especially product-related KTTs discussed earlier, pointing once again to the less frequent character of this type of knowledge transfer.

Trainings provided by customers can be classified according to the modalities used, as well. In Table 16.6, we distinguish between three main modes of training. The first one consists in visits of supplier's staff to customers' plants, which is mainly a kind of visual inspection with low potential of tacit knowledge transfer.[14] The remaining two channels of trainings are: (1) on-the-job training focusing on theoretical or applied issues and (2) off-the-job training organized through seminars and courses.

Off-the-job training activities are classified in three groups according to their location: (1) supplier's own plant, (2) specialized institutes, and (3) customer's plant. 46% of all respondents declared that they received trainings in their own plant on a frequent basis while 22% and 7% pointed to specialized institutes and customers' plants, respectively, as locations of this type of frequent training. 27% of foreign firms benefit from trainings taking place in specialized institutes while the corresponding figure for local firms is 20%, with the difference being statistically significant at the 1% level. When responses given to the *sometimes* category are analyzed, it is observed that respondents declaring benefiting from trainings in specialized institutes and customers' plants increase significantly to 67% and 66%, respectively. Compared to local firms, foreign suppliers are more intensively involved in these two types of tacit knowledge transfers. The statistically significant difference for trainings received at customers' plants may point to more close relationship between foreign suppliers and their customers as well as to their higher level of absorptive capacity – required for the knowledge transfer through trainings to be effective. At the end, only 8%, 11%, and 32% of all firms declare they were never involved in these three respective tacit KTT channels.

As for the *on-the-job training channel*, it turns out that the frequency of this type of KTT channel is lower than that of off-the-job training activities: 5% of all firms declare being involved with this type of KTT at customers' plants – in Turkey or abroad – on a frequent basis while 7% are involved in this activity in their own plant. It can be pointed out that 1.7% of local firms attend frequently this type of

[14] This channel of tacit KTT may simply reflect the existence of close relationships between the supplier and the customer. By itself, it is probably of low significance as a channel of tacit knowledge transfer.

Table 16.6 Knowledge and technology transfers through training: modes of training (%)

	Often				Sometimes			
	Local	Foreign	DSF	All	Local	Foreign	DSF	All
A) Visits to customers' plants	20.8	13.3	18.9	18.8	60.8	71.1	63.6	63.6
B) Off-the-job training (seminars and courses)								
At supplier's plant	47.1	42.2	47.3	45.7	44.5	51.1	46.6	46.3
At other private-specialized institutes	20.2^{**}	26.7^{**}	22.1	22.0	64.7^{**}	73.3^{**}	69.5	67.1
At customers' plants	6.7^{*}	6.7^{*}	6.8^{*}	6.7	61.7^{*}	77.7^{*}	68.9^{*}	66.1
C) On-the-job training (theoretical and/or applied training)								
At costumer's plant								
In Turkey	4.2	4.4	4.5	4.,2	35.0	44.4	39.4	37.6
Abroad	1.7^{**}	0^{**}	1.5	1.2	22.0^{**}	40^{**}	29.2	27.0
At supplier's plant	5.9	11.4	8.5	7.4	42.0	38.6	40.8	41.1

***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided) Items are sorted according to "all firms" and "often" category training *abroad* at their customer's plant while none of the foreign supplier firms do – and the difference is significant at the 5% level. When figures about on-the-job trainings occurring on an occasional basis (*sometimes*) are examined, the frequency of this mode of training rises enormously: 65% of all firms declare being involved in this type of KTT, with the frequency observed for foreign firms (84%) being larger than the one for local firms (57%). Furthermore, 40% of foreign supplier firms do attend trainings organized at their customer's plant abroad while the corresponding figure for local firms is only 22%, and the difference is statistically significant at the 5% level. In a similar vein, the share of all suppliers involved in organizing in-house on-the-job training activities is 41%. At the end, only 30% and 52%, respectively, of all firms declare they were never involved in these two KTT activities occurring via on-the-job training.

Finally, as far as the last modality of KTT through training – that is, *visits by suppliers to their customers' plants* – is concerned, 29% of all firms declare attending these visits on a frequent basis, while 64% do it on an occasional basis. In other terms, only 9% of firms have never visited their customers' plants for KKT-related purposes. Note that these visits take place in accordance to a predetermined program, and suppliers' staff visits their customer's plants in order to receive a kind of visual and verbal education/training about customers' products and production processes by entering directly in contact with specialized personnel. According to data presented in Table 16.4, 21% of local firms attended these visits on a frequent basis versus 13% of foreign firms while the corresponding figures for the "sometimes" category are 61% and 71%.

In summary, data in Table 16.5 shows that customer firms – mainly automotive manufacturers – do transfer tacit knowledge to their suppliers through different types of training involving especially production personnel. The main motivation of customers in organizing these trainings[15] is to enhance their suppliers' production-design, and R&D-related capabilities so that they can deliver on time better quality, low-cost parts and components and that the manufacturing process goes on smoothly. It is remarkable that KTT activities involving transfer of tacit knowledge from customers to suppliers in the automotive industry concern such a high proportion of suppliers – foreign or local – and are carried out via such diverse modalities. According to us, this points to the vitality of KTT activities occurring within the automotive industry in Turkey, especially when the transfer of tacit knowledge embodied in agents – hence more difficult to transfer – is concerned.

3.2.4 Financial Assistance Carried Out by Customers

Information on financial assistance provided by customers to their suppliers is presented in Table 16.7. Except the first type of financial transfer bearing on prefinance

[15] Note that these activities are costly in terms of direct expenses as well as opportunity costs incurred by customers, especially when on-the-job training is concerned.

Table 16.7 Financial transfers by customers (%)

	Often				Sometimes			
	Local	Foreign	DSF	All	Local	Foreign	DSF	All
Pre-financing of machinery, equipment, and tools	8.6*	17.8*	13.2***	11.1	39.3*	42.2*	44.2***	40.1
Prepayment for orders before delivery	7.6	6.7	7.6	7.3	36.1	31.1	32.1	34.8
Loans with low interest rates	1.7	0.0	1.5	1.2	6.8	2.2	4.6	5.5
Risk capital	0.8	0.0	0.8	0.6	4.2	0.0	3.8	3.1
Unilateral financial aid	0.0	0.0	0.0	0.0	7.7	4.4	7.8	6.8

***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided) Items are sorted according to "all firms" and "often" category

of machinery, equipment, and tools acquisition, the remaining modalities do not directly contribute to KTT in direction of supplier firms but may exert a positive – and sometimes critical – impact on their survival rates by ensuring a timely flow of financial resources.

Data in Table 16.7 shows clearly that transfers involving financial resources occur much less frequently compared to KTT-related transfers. Only 11% of all firms declare benefiting on a frequent basis from financial aids granted by their customers in order to acquire technologies embodied in hardware. These aids concern 9% of local firms and 18% of foreign firms with the difference between these two groups being statistically significant at the 10% level. As for the pre-payments made before delivery of orders, 7% of all firms do benefit from this practice frequently. This proportion falls to 1.2% and 0.6% for loans with low interest rates and contribution to risk capital by customers, respectively. None of the suppliers are involved frequently in unilateral financial aid provided by their customers.

When responses in the "sometimes" category are analyzed, the proportion of firms involved in pre-financing of codified knowledge embodied in hardware increases substantially and attains 40%. The difference between foreign and local firms remains statistically significant. Prepayments for orders concern now 35% of all firms while the corresponding figures for the remaining three financial aid channels are never over 7%. In other words, 93% of firms have never benefited from unilateral financial aid nor from low-interest loans provided by their customers, 96% of firms did not experience any contribution of customers to risk capital, and 57% have never experienced any prepayments made before deliver of orders. Therefore, we can conclude that customers, mainly automotive manufacturers, in the Turkish automotive industry do not prefer to assist their suppliers through financial assistance. However, for those customers who are involved in such transfers, the preferred means turn out to be pre-financing of machinery and prepayments made before deliver of orders.

Table 16.8 Why do automotive suppliers collaborate with other firms? (%)

	Local	Foreign	DSF	All
1. Improving product quality	79.2	77.8	79.5	78.8
2. Learning about new technologies	75.0**	60.0**	72.0	70.9
3. Opening up to global markets	73.3*	64.4*	72.0	70.9
4. Entering new technology fields	74.2*	53.3*	67.4	68.5
5. Reducing/sharing production costs/risks	65.8	53.3	63.6	62.4
6. Carrying out R&D activities	60.8	46.7	56.8	57.0
7. Establishing long-term strategic partnership	52.5	62.2	54.5	55.2
8. Replacing technologically phased out products with new ones	54.2	44.4	53.0	51.5
9. Know-how transfer	50.8	42.2	50.8	48.5

Only responses indicating a given motivation as being *important* or *very important* are presented here

***, **, and * denote significance level at 1%, 5%, and *10%, respectively (Mann–Whitney U test, two-sided)

3.2.5 Motivations for Collaboration of Automotive Suppliers with Other Firms

One precondition for the occurrence of KTTs toward automotive suppliers is that they collaborate with other firms to this end. One question is included in the survey questionnaire in order to determine the motivations of suppliers for establishing interfirm collaborations and the importance attached to each of them. The five factors included in the survey initially are (1) conducting R&D activities, (2) transferring know-how, (3) establishing long-term strategic partnerships, (4) improving product quality, and (5) being informed about the new technologies. An option was left for respondent firms to mention other factors not included in the list. They were asked to determine the importance attached to each motivation on a 5-point Likert scale (1 = very unimportant and 5 = very important). Data on factors conducive to collaboration and estimated to be important or very important – values 4 or 5 on the Likert scale – by supplier firms are presented in Table 16.8 below.

More than 70% of suppliers attribute a high degree of importance to the first three items in Table 16.8 for establishing collaborations with other firms while 69% consider opening up to global markets a valuable reason for collaborating with other firms. 80% of suppliers, foreign or local, consider product quality improvement as a critical factor for collaborating with other firms. This may point to the existence of advanced design capabilities in supplier firms since such competencies are required to conduct product quality-improving activities. Compared to foreign firms, a higher proportion of local firms emphasize the critical role of the following factors in establishing interfirm relationships: *learning about new technologies* (75% vs. 60%), *opening up to global markets* (73% vs. 64%), and *entering new* *technology fields* (74% vs. 53%). In all three cases, differences between local and foreign suppliers are statistically significant. In contrast to the first motivation (*improving product quality*), these last three ones do not aim – at least directly – at acquiring KTTs to be used in the production or innovation process but rather at accessing new markets abroad or with new technologies.

Findings related to new technologies may indicate that suppliers collaborate with their customers to learn about the existence and the workings of new technologies available on the world or domestic markets – in which case customers play the role of technology gatekeeper for suppliers as well as the locus of learning-by-doing activities involving new technologies. The statistically significant difference between local and foreign firms also confirms that absorptive capacities[16] of local firms are weaker than those of foreign firms, and hence, they need to cooperate with other firms – especially their customers – to compensate for this lesser absorptive capacity. Besides obtaining information on the existence, size and peculiar characteristics of new markets abroad, collaboration aimed at *opening up to new markets* and *sharing production costs or risks* may well reduce risks associated with operating in new markets abroad (unchartered territories for many local suppliers) and provide suppliers with the benefits of scale economies.

57% of all firms cooperate with other firms – most probably, their customers – in order to carry out R&D activities, with this proportion being larger for local (61%) than for foreign firms (47%). Cooperating with other firms is a major way to benefit from their competencies in the R&D process and share technical and commercial risks as well as development costs. Another reason for collaborating with the customers may be the prospect of finding a ready market for the product developed by the time R&D project ends. Establishing long-term strategic partnership – pointed to by 55% firms – may be explained by similar factors.

One unexpected finding is that the least important motivation for cooperation pointed to by firms is know-how transfer: only 49% of suppliers find it important or very important for collaborating with other firms. Indeed, one may expect that such knowledge flows to be an important factor for collaboration between suppliers and automotive manufacturers. The relatively low figure for this item may be due to two factors: (1) respondents pointing to collaborations launched for know-how transfer and aimed at improving product quality may be included in the first item indicated in Table 16.8 (*improving product quality*) and hence excluded from the responses given to the last item or (2) if the know-how transfer mentioned in the last item relates to the production process or is perceived as such by respondents; the low response rate for this item may simply reflect the fact that production capabilities of (local) automotive suppliers in Turkey are relatively more developed than their design and innovation capabilities.

[16] Defined as firms competencies required to identify, acquire, use, adapt, assimilate, and modify embodied and disembodied technologies related to products and production processes. See Cohen and Levinthal (1990).

3.3 Econometric Analysis of the Determinants of Knowledge and Technology Transfers from Customers to Suppliers in the Turkish Automotive Industry

In this section, an econometric analysis will be conducted in an attempt to identify factors impacting on different types of KTTs discussed in the previous section. First, the econometric estimation method used will be examined below with an emphasis on the interpretation of the coefficients estimated. Second, explanatory variables introduced in the regressions will be examined, and finally, findings will be presented and analyzed.

3.3.1 Ordinal Logistic Regression Model and Explanatory Variables

Since all KTT-related indicators constructed from the survey questionnaire are categorical but ordered variables – categorical variables with a sense of ordering – *ordinal logistic regression model* will be used to examine determinants of KTTs accruing to automotive suppliers in Turkey. Surprisingly, there seem to be very few studies investigating factors that influence KTTs from customers to their suppliers in the automotive industry of emerging economies.[17] The quantitative study conducted in this chapter aims at filling the gap in this domain.

Two points about the ordinal logistic regression model are worth mentioning.[18] First, the estimated coefficient of an explanatory variable in this model does not necessarily inform us about its marginal effect – that is, change in the probability of observing a category associated with a unit change in the explanatory variable – but rather about the change in the log of odds of being in a higher level of the dependent variable, given that all the other variables in the model are held constant. The sign of a coefficient associated with a variable is not necessarily the same as the sign of its marginal effect. For instance, Verbeek (2008) points out that for an ordinal-dependent variable comprised of three categories with increasing intensity, a positive coefficient associated with an explanatory variable indicates that if this variable increases, the probability that the most intense category occurs will increase while the probability of the least intense category will decrease. The impact on the probability of the occurrence of the intermediate category is ambiguous since it might increase or decrease.[19] Second, when using this regression model, the parallel regression assumption is maintained, meaning that the relationship between each pair of categories associated with an explanatory variable does not change. This last

[17] Berger (2005), Giroud (2003), Techakanont (2002), Techakanont and Terdudomtham (2004), and Wasti et al. (2006).

[18] On the ordinal logistic models, see Maddala (1983), Liao (1994), Long (2001), and Verbeek (2008).

[19] The probability of occurrence of the intermediate category may increase for some values of an explanatory variable and decrease for others: see Long (2001).

point will be illustrated below while examining the results of our econometric analysis.

Based on the collected survey data, a number of indicators have been constructed to be used as explanatory variables in the regressions. Eight potential determinants of KTT-related activities have been constructed from survey data.

The first variable is the *age of a supplier* and has been constructed by subtracting the establishment year of the supplier from 2010, which is the year when the survey was conducted. Age of a supplier may indicate its experience in the automotive sector and proxy the extent to which it might have trust-based relationships with its customers. The higher the trust between both partners, the lesser the transactions costs incurred and the higher will be the probability to experience KTT-related activities with customers. On the other hand, more recently established suppliers may act more aggressively in contradiction to older suppliers, which may show signs of rigidity and cannot adapt to a changing environment (*Age*).

The second explanatory variable is *firm size* measured as the logarithm of the number of employees. Firm size may proxy a host of variables potentially affecting KTTs: (1) scale and scope economies in the production process, (2) cost and availability of financial resources, and (3) extent of the labor division within the firm. It may affect negatively KTT-related activities of suppliers since large suppliers may be self-sufficient and less in need of KTT from their customers. However, increasingly, even human and financial resources of the largest firms cannot be sufficient for conducting R&D and innovation activities, leading them to collaborate with other firms. In addition, it is also admitted that firm size may act as a proxy for production capabilities since it is related to the production capacity or scale of the firm. Empirical studies show that automotive manufacturers tend to consider strong production capability as a necessary condition for the establishment of KTT-related activities with suppliers (*Firm size*).

The third variable introduced in the regressions is the *export intensity* of supplier firms, measured as the ratio of exports to their sales. Following the economic crisis of the year 2001, automotive manufacturers as well as suppliers in Turkey increased the proportion of their sales sold on world markets. The intense competition prevailing abroad may oblige supplier firms to cooperate with their customers in order to improve the quality of their products, receive know-how pertaining to the production process in order to increase its efficiency, and to carry out design-related activities. In some instances, these KTT-related activities may be conducted with the help of customers abroad. Therefore, the impact of this variable depends also on the position of supplier firms in the supply chain of multinational companies (*Export*).

The fourth explanatory variable is a binary one and takes the value of 1 if a firm declares being the *direct supplier* of at least one automotive manufacturer established in Turkey, 0 otherwise. By direct supplier, we refer to the first-tier suppliers working directly with the main automotive manufacturers. This close relationship may be associated by the production of the relatively sophisticated of parts and components for customers and hence more prone to KTTs. By definition, the likelihood of second- and third-tier suppliers to benefit from such an advantage is rather low. Having a good reputation in the sector, benefiting from a stable demand, and being part of design activities in its early stages are other – potential – advantages of being a direct supplier which may exert a positive influence on KTT-related activities[20] (*Direct supplier*).

The fifth explanatory variable informs us whether a supplier firm is owned by foreign agents. It is a dummy variable that takes the value of 1 if the share of firm equity owned by foreigners equals at least to 10%, 0 otherwise. *Foreign suppliers* may possess a number of intangible proprietary assets that enable them to compete with domestic suppliers without any need of KTTs. On the other hand, these same proprietary assets may enable them to pursue advanced design-related KTTs with their customers, which may operate in Turkey or abroad, especially if they are asked by their customers to manufacture technologically sophisticated parts and components. If it is an affiliate of a foreign MNC, it might transfer knowledge and technology from its parent firm. Hence, the effect of this variable on KTTs remains an empirical issue (*Foreign capital*).

The sixth variable is a binary one as well and it informs us whether a supplier firm is part of a larger group, a parent company, or a conglomerate. Such membership may be conducive to KTTs in case the supplier firm works for a manufacturer itself part of the larger group, since this can reduce transaction costs and build trust between both firms. On the other hand, such a status may exert a negative effect on KTTs since the role attributed to the supplier within its group may not be conducive to such relationships. This negative effect may also be the result of the formal technology transfer channels used within the group – for instance, technology licenses – which reduce the need of KTTs (*Local group*).

The seventh variable is also a binary variable indicating whether a supplier firm has a multinational company (MNC) among its customers. If this is the case, then MNCs can impact positively on KTTs of suppliers by being more stringent on issues such as delivery time, quality, and costs and also by selecting among its suppliers those capable ones to act as codesigner for it. Of course, the position of suppliers in the supply chain of MNCs is also important for the final outcome. This assumption has been tested by introducing this binary variable in the regressions (*MNC among customers*).

Finally, the last explanatory variable introduced in the regression is a binary variable indicating whether a supplier conducts or not R&D activity. This variable is an indicator of the level of the absorptive capacity of suppliers. A higher absorptive capacity may signal to automotive manufacturers the higher potential of a supplier in such innovative activities as codesign, product quality improvement, and product development and therefore foster cooperation between the two parties (*R&D activities*).

3.3.2 Findings of the Econometric Analysis

Table 16.9 below is a recapitulative table for econometric findings obtained in this study. It contains signs of coefficients statistically significant at least at the 10%

[20] Pamukçu and Sönmez (2011).

Table 16.9 Determinants of different types of KTTs: recapitulative table[a]

	Transfers related to production process	Transfers related to product	Training	Financial transfers	Cooperation activities
Age	– Know-how			+ Prepay for orders before delivery	– Long-term strategic partnership – Improve product quality – Learn about new technologies
Firm size		+ Joint design activities	+ Training of production staff	+ Low-interest loans + Prepay for orders before delivery	+ Long-term strategic partnership + Improve product quality
Export		+ Joint design act. + Technical specifications, original design, or technical drawings	– Training of management staff		– Long-term strategic partnership
Direct supplier	+ Design + Logistic	+ Design + Joint design activities	+ Training of production staff	+ Pre-finance of machine, equipment, and tools	– Long-term strategic partnership
Foreign capital	– Document – Logistic	– Technical specifications, original design, or technical drawings			– Know-how transfer – Improve product quality – Learn about new technologies
Local group	– Logistic	– Design		– Low-interest loans	
MNC among customers				– Prepay for orders before delivery	– Know-how transfer
R&D activities		+ Joint design activities			+ R&D cooperation + Long-term strategic partnership + Improving product quality + Learn about new technologies

[a](+) positive effect and (–) negative effect, statistically significant at least at the 10% level

level and are associated with explanatory variables that impact on different types of KTTs – production process, product, training, financial transfers, and cooperation activities.[21]

Knowledge and Technology Transfers Related to the Production Processes: Production-related KTTs may take the form of assistance for design, R&D activities, or logistics management or occur through providing know-how and various documentations. Three degrees of importance are associated with each type of KTT: (1) *never,* (2) *sometimes,* and (3) *often*.

A significant and negative association exists between *firm age* and the frequency of KTTs occurring through know-how on production-related issues. A 1-year increase in the age of a supplier reduces by 0.03 points the log of odds of being in a higher level of the know-how transfer variable, that is, in the "often" category compared to the combined "sometimes and never" category or in the combined "often and sometimes" categories compared to the "never" category.[22] Alternatively, by taking the exponential of the estimated coefficient not reported here, one can calculate the impact of the firm age on the *odds* of being in a higher level of the know-how transfer variable, that is, more frequent use of this type of KTT. The calculated coefficient for firm age equals 0.97, indicating that a 1-year increase in firm age reduces by 0.97 times the odds of often (combined *often and sometimes*) category with respect to the combined *sometimes and never* (never) category.

In other words, the importance attributed by suppliers to KTTs in the form of know-how related to production processes decreases with the level of experience of the suppliers. This may simply indicate that many experienced suppliers in the Turkish automotive industry do possess a high level of production capabilities which makes unnecessary the frequent know-how transfers from their customers.

The coefficient associated with *being a direct supplier* is positive and significant at the 5% level. The odds of using *often* (often and sometimes) KTTs in form of production-related design assistance versus the combined *sometimes and never* category (never) is 2.73 times greater for direct than nondirect suppliers. A similar effect is observed for assistance about logistics management. Although there is no obvious explanation as to why being a direct supplier is associated with more frequent use of these two types of production related KTTs, it nevertheless shows that working closely with customers bears some advantages when it comes to more intense use of some KTTs.

As for the coefficients associated with the *foreign ownership* variable, they are negative and statistically significant for assistance given to logistic management and for receiving documentations from customers. The odds of *less* versus *more* frequent logistic assistance is 2.19 times higher for foreign than local firms. Similarly, odds of *less* versus *more* frequent reception of documentations is 2.30

[21] More details on the findings of the econometric analysis are available from the authors upon request.

[22] As mentioned earlier, the value of the estimated coefficient implies that being a more experienced firm reduces the probability of more frequent know-how transfers (*often*) while it increases the probability of non use (*never*) of this type of KTT.

times higher for foreign than local firms. An explanation for the negative association between foreign ownership and the frequency of two types of KTT is that these are the two least knowledge-intensive KTT activities and hence are not needed by foreign firms who possess a significant level of technological capabilities.

Finally, being part of a *local group or conglomerate* increases by 2.06 times the odds of *less* versus *more* frequent assistance on logistic by customers with respect to these suppliers that do not have such an affiliation. The explanation of such a finding is not obvious.

Knowledge and Technology Transfers Related to Products: Product-related KTTs may take the form of joint design activities, SDDs, or design. Three degrees of importance are associated with each type of KTT: (1) *never,* (2) *sometimes,* and (3) *often*.

A positive and significant association exists between *firm size* and the frequency of product-related KTTs occurring through joint design activities involving suppliers and their customers. A 1% increase in firm size increases the odds of being involved *often* (often and sometimes) in product-related joint design activities versus the combined *sometimes and never* category (never) by 1.53 times. As discussed previously, firm size may proxy production capabilities of supplier firms, and such capabilities may be necessary for automotive manufacturers to be willing to enter in joint design activities with suppliers.

An increase in *export intensity* increases the probability of frequent occurrence (*often*) of joint design activities while it decreases the probability of non-occurrence (*never*). A similar result is obtained for the occurrence of assistance in the form of technical specifications, original design, or technical drawings (SDDs). Both findings are likely to be caused by the peculiar requirements of foreign markets as to the characteristics, nature, quality, or performance of products which tend to be different from the ones sold on the domestic market.

Being a *direct supplier* firm increases the likelihood of occurrence of KKTs in the form of assistance provided by customers for product design and joint design activities by both parties. These two product-related KTTs are the most sophisticated ones among the five KTT categories included in the survey questionnaire. Hence, being a direct supplier is indeed associated with a number of advantages leading to an intense transfer of advanced KTT aimed at products.

The only statistically significant impact of *foreign ownership* is on the SDD form of KTT. It is negative and decreases the probability of frequent use of this type of product-related KTT for foreign firms compared to local firms. Since SDDs are considered to be a relatively simple type of KTT, this finding may suggest that higher technological capabilities of foreign firms reduce the need for this type of KTT. Note that a similar result was obtained while analyzing the impact of foreign ownership on production-related KTTs since being a foreign variable reduces the probability of frequent use of the least sophisticated type of transfer, that is, provision of various documentations by customers.

Being *part of a local group* exerts a negative impact on the probability of frequent occurrence of assistance aimed at product design, which may suggest that this group of suppliers either possesses already sufficient knowledge on product design-related issues or obtain this knowledge through other means – for instance thanks to its privileged relationships with its parent company.

Finally, those suppliers which carry out *R&D activities* are more likely to conduct more frequent design activities in collaboration with their customers. This also suggests that automotive manufacturers prefer engaging in such advanced activities with those suppliers who possess a highly developed absorptive capacity.

Knowledge and Technology Transfers Through Trainings Provided by Customers: Only *firm size* exerts a positive and significant effect on the probability of frequent use of trainings on production technologies while it also influences positively training activities given to the production staff of suppliers. This suggests that customers choose among their suppliers those firms with advanced production capabilities in order to provide the aforementioned training activities. Being a direct supplier is another variable that impacts positively on the second type of training, suggesting that close relationships of these firms with their customers increase the probability of frequent trainings given to their production personnel. Finally, more export-intensive firms seem to feel less the need of frequent training targeting their managers.

Financial Assistance: Firm size exerts a statistically significant and positive impact on the frequency of provision of low-interest loans by customers to their suppliers. This may be due to the fact that being a larger supplier with significant production capabilities may reduce risks associated with the reimbursement of the loan granted. Being part of a *local group*, however, increases the probability of low frequency associated with the occurrence of such financial assistance to suppliers by their customers. Being a *direct supplier* is the only variable that has a significant and positive effect on the probability of occurrence of financial assistance via pre-financing, which is likely to reflect the advantages of being close partners of automotive manufacturers. Two variables impact significantly and positively on frequency of prepayment before delivery: (1) firm age, suggesting that firms that have been able to establish trust-based relationship with their customers benefit from this type of financial assistance and (2) firm size which again points to the advantages of possessing advanced production capabilities. On the other hand, having MNCs among customers impacts negatively on the probability of occurrence of this financial aid method by suppliers.

Why Do Suppliers Cooperate with Other Firms? Estimation results concerning determinants of suppliers' motives for establishing interfirm collaborations show that *firm age* – proxy for the extent of firm experience and maturity – exerts a negative impact on the degree of importance attached by suppliers to the following motives for interfirm collaboration: (1) establishment of long-term strategic partnership, (2) improvement of product quality, and (3) learning about new technologies. These three motives for interfirm collaboration are also recognized as signs of vitality and dynamism for a firm. Therefore, our findings indicate that these signs of dynamism tend to play a lesser role for older suppliers as motives for entering in interfirm collaboration, given that all the other variables in the model are held constant.

Firm size exerts a significant and positive impact on the degree of importance attached to the establishment of strategic partnership and improvement of product quality as motives for establishing interfirm relationships. This might suggest that once suppliers reach some kind of threshold in their production capabilities, they move on to cooperate with their customers in order to improve quality or their products – an important requirement for becoming and remaining the supplier of automotive manufacturers – and for establishing relationship on a long-term basis. The positive but insignificant impact of firm size on know-how transfer as a motive for interfirm collaboration points to the already advanced production capabilities of suppliers.

Both export intensity and being a direct supplier have a significant and negative influence on the degree of importance attached to the establishment of strategic partnerships for collaboration, given that all the other variables in the model are held constant. These findings are no obvious to interpret.

Foreign ownership impacts negatively and significantly on the degree of importance attached to three motives of interfirm collaboration: (1) know-how transfer, (2) product quality improvement, and (3) learning about new technologies. Rather than considering these results as a sign of lack of technological dynamism on the part of foreign firms – as was the case for older firms – we believe that they point to the fact that foreign suppliers possess a number of intangible proprietary assets which renders such motives for collaboration less pertinent.

Finally, conducting R&D activity affects positively and significantly the degree of importance attached to all collaboration motives except know-how transfer. Although the positive effect of this variable on R&D motive for collaboration is easily understandable, its positive effect on strategic partnership and quality improvement shows the importance of innovation capabilities beyond production capabilities for interfirm collaborations to occur, while the positive effect on learning about new technologies motive points to the role played by the absorptive capacity in this process.

4 Conclusion

The main objective of this chapter is to evaluate whether interactions with automotive manufacturers in the Turkish automotive industry enable suppliers to upgrade their technological capabilities. One important issue addressed is the extent to which these interactions lead to knowledge and technology transfers from customers to their suppliers through backward linkages. To this end, a questionnaire was designed and used to collect detailed data and information about auto suppliers present in Turkey. The survey was conducted with the CEOs, R&D, production, and product directors of 165 supplier firms in order to investigate the existence, nature, and extent of technology transfers from buyers to suppliers. Our main findings can be summarized as follows.

KTTs accrue from customers (mainly MNCs) to their local suppliers mainly through provision of information on documentations, logistic management, quality control, codevelopment activities, designing, and on cost reduction. Compared to foreign suppliers, local suppliers tend to be more frequently involved in those production- and product-related KTTs that are less knowledge intensive and of a lesser quality. On the other hand, being a direct supplier of automotive manufacturers in Turkey and therefore being more close to customers in the supply chain exerts a positive effect on the number of KTTs. Moreover, various types of training have been provided to suppliers by customers. These trainings aim mostly at production staff and occur via off-the-job training activities. However, it seems that foreign suppliers are more involved in training activities than local supplier firms. This finding probably indicates that customers prefer to work mostly with foreign suppliers because of their advanced technological capabilities and absorptive capacity level. These types of KTT activities provided by customers aim, in general, at triggering new product developments. Therefore, it confirms that strategic relationships between foreign suppliers and customers are very strong, indicating that it is necessary to have highly qualified personnel to be able to from these activities. Besides, it seems that customers do not generally prefer providing financial assistance to their suppliers; but if they do so, these assistances mainly take the form of prefinancing of machinery and prepayments for orders before delivery.

The only variable that affects positively the *KTTs aimed at the production process* is *being the direct supplier* of an automotive main manufacturer. Other variables such as age, foreign capital, and being part of a group affect negatively these transfers.

A larger number of variables influence positively *product-related KTTs* than the transfers related to production process. Firm size, export, being a direct supplier, and R&D activities increase the possibility of product-related transfers; on the contrary, *foreign capital* and *being part of a group* exert a negative effect on such transfers.

Training activities provided by customers to supplier firms may be an important channel for KTTs. Our findings show that trainings are provided mainly to *production personnel* (engineers, technicians) rather than to *managers*. Firm size and being a direct supplier impacts positively on transfers provided to production personnel, whereas export intensity influences negatively the transfers provided to management personnel of supplier firms.

The main finding related to factors affecting the establishment of collaboration activities with other firms is that independent variables other than *firm size* and *R&D activities* reduce the probability of frequent occurrence of these activities. An increase in firm size increases the possibility of establishing long-term strategic partnership (LTSP) and improving product quality. In addition, conducting R&D activities – an important indicator of competence – also increases the possibility of collaboration in the fields of R&D, long-term strategic partnership, improving product quality, and learning about new technologies.

If we look at the findings in Table 16.9 in terms of independent variables used in the regression models, we can make the following observations: *Being a direct supplier* of automotive manufacturers is the most important feature that affects the frequency of terms of transfers for production process, product, training, and financial aids. *Foreign ownership* has a negative impact on transfers for product and production process and cooperation activities, a finding probably related to the already developed R&D capabilities of foreign suppliers. *To be part of a local group* has a negative effect on production process, product, and financial transfers. Finally, engaging in *R&D activities* affects positively joint design activities (products), which points to the importance of R&D capabilities for those suppliers which desire to become a codesigner.

The survey conducted among suppliers in the Turkish automotive industry and the econometric analysis based on the data collected via the survey is one of the first study of its kind for the Turkish industry. Similar studies using a different target group or different research methodologies should be undertaken to address the issues Turkish automotive industry will have to tackle in the next decades.

References

Berger M (2005) Upgrading the system of innovation in late-industrializing countries – the role of transnational corporations in Thailand's Manufacturing Sector. Ph.D. thesis, Christian-Albrechts-Universität, Mathematisch-Naturwissenschaftlichen Fakultät

Blomstrom M, Kokko A (1998) Multinational corporations and spillovers. J Econ Surv 12:1–31

Borensztein E, Gregorio JD, Lee J-W (1998) How does foreign direct investment affect economic growth? J Int Econ 45:115–135

Cohen W, Levinthal DA (1990) Absorptive capacity: a new perspective on learning and innovation. Adm Sci Q 35:128–152

Dicken P (2007) Global shift: mapping the changing contours of the world economy, 5th edn. Routledge, London.

Eden L, Levitas E, Martinez RJ (1996) The production, transfer and spillover of technology: comparing large and small multinationals as technology producers. Small Bus Econ 9:53–66

Ekmekci U (2009) Determinants of knowledge transfer from foreign direct investments to local supplier firms: the case of Turkish Automotive Industry. Unpublished Ph.D. thesis, Department of Management Engineering, Institute of Science and Technology, stanbul Technical University, Istanbul

Giroud A (2003) Transnational corporations, technology, and economic development: backward linkages and knowledge transfer in South-East Asia. Edward Elgar, Cheltenham/Northampton

Gorg H, Greenaway D (2004) Much ado about nothing? Do domestic firms really benefit from foreign direct investment? IZA discussion paper series, no. 944

Humphrey J, Memedovic O (2003) The global automotive industry value chain: what prospects for upgrading by developing countries. UNIDO, Vienna

Javorcik BS (2004) Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. Am Econ Rev 94:605–627

Liao TF (1994) Interpreting probability models: logit, probit, and other generalized linear models. Sage University papers series, Quantitative applications in the social sciences. Sage, California

Long JS (2001) Regression models for categorical and limited dependent variables. Advanced quantitative techniques in the social science series. Sage, California

Maddala GS (1983) Limited-dependent and qualitative variables in econometrics, Econometric society monographs. Cambridge University Press, New York

Pamukçu M, Sönmez A (2011) Analysis of knowledge and technology transfer by multinational companies to local suppliers in the Turkish Automotive Industry, scientific project funded by The Scientific and Technological Research Council of Turkey (TUBITAK), project no. 109K587. Middle East Technical University, Ankara, 140 pp

Patel P, Pavitt K (1991) Large firms in the production of the world's technology: an important case of non-globalization. J Int Bus Stud 22:1–21
Saggi K (2005) Foreign direct investment, linkages, and technology spillovers. In: Hoekman B, Javorcik BS (eds) Global integration and technology transfer (içinde). Palgrave Macmillan/World Bank, Basingstoke/New York/Washington, DC, pp 51–66
Saliola F, Zanfei A (2009) Multinational firms, global value chains and the organisation of knowledge transfer. Res Policy 38:369–381
Smeets R (2008) Collecting the pieces of the FDI knowledge spillovers puzzle. World Bank Res Obs 23:107–138
State Planning Organization (SPO) (2005) Ninth plan for economic development (2007–2013). Report of the special expert committee on automotive industry (in Turkish), SPO, Ankara
Techakanont K (2002) A study on inter-firm technology transfer in the Thai Automobile Industry. Unpublished Ph.D. thesis, Graduate School for International Development and Cooperation, Hiroshima University, Japan
Techakanont K, Terdudomtham T (2004) Evolution of inter-firm technology transfer and technological capability formation of local parts firms in the Thai Automobile Industry. J Technol Innov 12:2–20
Teece DJ (1977) Technology transfer by multinational firms: the resource cost of transferring technological know-how. Econ J 87:242–261
UNCTAD (2005) World investment report 2005: transnational corporations and the internationalization of R&D. United Nations, New York/Geneva
Verbeek M (2008) A guide to modern econometrics, 3rd edn. Wiley, Sussex
Wasti NS, Kozan MK, Kuman A (2006) Buyer–supplier relationships in the Turkish automotive industry. Int J Oper Prod Manage 26:947–970

Chapter 17
Investigating the Lateral Migration of Technology in a Resource-Based Economy: Conceptual and Methodological Issues from a Study of the Australian Mining Sector

Tim Turpin, Hao Tan, Phil Toner, and Sam Garrett-Jones

Abstract 'Lateral migration' refers to the application of technologies in a different sector and context from that in which they were originally developed (Pogue and Rampa, 2006). Lorentzen and Pogue (2009) and Jourdan (2010) have proposed that this is most likely to occur when there is: a significant market demand from local producers; local opportunity to test and commission new technologies; a cluster of firms that can support each other and cross fertilize ideas; and a strong base of R&D. In order to investigate these propositions a robust methodology is needed to identify the pathways along which such technology migration occurs and the ways it is facilitated or inhibited. This paper reports on a conceptual and methodological approach to

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investigate lateral migration of technology from the mining and energy sector in Australia. First, an econometric analysis is used to measure the extent of lateral migration of mining and energy technologies using patent, trade and input-output data sets to provide a quantitative account of which technologies are more successful than others in migrating into other sectors. Second we use a case study approach to investigate the processes that inhibit or facilitate lateral migration

1 Introduction

In 2008 one of Australia's leading international air freight handling centres introduced a neutron gamma scanning technique for analysing the content of incoming international cargo containers (CSIRO personnel communication, 2010). Until then 99% of air cargo containers entering Australia was not scanned for an analysis of the contents. The new technology and process trialled at the Australian freight handling centre introduced a new technology to the security industry. As a consequence of the trial, an Australian R&D organisation and local firm have established a global venture in partnership with a Chinese firm to produce and market large-scale capital goods for security scanning with three-dimensional images for container-based sea and land freight. The partnership has estimated that they will capture 60% of a lucrative global market for the equipment.

The technology was originally developed for the mining sector in the late 1970s for the on-line screening of coal seams. The same technology was later adapted for monitoring flows in oil wells. After further development the technology was adapted for the moisture-based analysis of a variety of conveyer belt products. All of these applications were one way or another associated directly with mining, extraction or processing of minerals and fuels. The application of the technology to air freight scanning and analysis represented adaptation in a sector well removed from mineral resource extraction or processing. An interesting feature of this story concerns the process through which the technology migrated into the security sector and the time it took (some 40 years) to make the journey.

The Australian mining sector contributes the second largest component of real GDP (after services) to the Australian economy. It accounts for more than double the total investment recorded by manufacturing and is by far the largest sector contributor to exports (41% for 2009–2010). Mining also accounts for over 25% of business sector R&D. There is, however, concern at the high level of import content, especially capital goods and advanced services, entering into the Australian resource sector. That is to say, there are limited linkages between the domestic manufacturing and advanced services industries and resource production. For example, according to the Australian Bureau of Agricultural and Resource Economics (Tedesco and Haseltine 2010), annual sales of innovative equipment and consulting and software services to the local and overseas mining industry is around $9 billion. This is equivalent to just 2.2% of total annual manufacturing sales. A recent Reserve Bank of Australia conference suggested the massive growth of investment in liquefied natural gas (LNG) will exacerbate this lack of local content (Gregory and Sheehan 2011). LNG processing plants are classic ‘turn key projects’ that will be floated into position in a fully operational state from Korea with other major structural steel elements coming from countries such as the Philippines. Most of the local content in the Australia resource sector is construction-related activity – for every one dollar spent on machinery and equipment, three are spent on ‘non dwelling construction activity’ (ABS 2011). Being 80% foreign owned also means most resource profits are repatriated offshore (Reserve Bank of Australia 2009). Under current policy settings, the resources boom is unlikely to generate a robust manufacturing sector. Moreover, we know from our preliminary analyses of patent citations for mining and energy technology that Australia compares well in global terms. Yet we know very little about the extent, direction and *processes* through which mining technologies and skills migrate into other sectors of the economy.

This chapter presents a methodology developed to investigate and document the socio-economic processes underpinning the lateral migration of technologies from the mining sector. The objective is to consider some policy options that might promote the lateral migration of technologies into and across other sectors of the economy. Studies based on such a methodology could also help address policy concerns about the about the so-called resource curse from mining, and in particular the risks in the economy becoming too narrowly based (Commonwealth of Australia 2010). Identifying technology flows from mining to other industries and responding to impediments to such flows will assist in promoting a more diversified economy.

2 Conceptualising the Lateral Migration of Technology

The concept of lateral migration of technology was introduced by Jourdan from the South African Mineral Technology Research Council and Altman from the South African Humanities and Social Science Research Council (Lorentzen 2006). Their lateral migration thesis proposes that when the knowledge base of a resource sector and its associated capital goods and services are applied in other sectors not linked to resource exploitation, ‘additional development trajectories open up’ (Lorentzen and Pogue 2009:7; Kuramato and Sagosti 2006); Walker and Farisani 2006). In South Africa Jourdan (2010) found that the development of relevant *capital goods and services* was fundamental to the lateral migration of technologies. From this perspective lateral migration is most likely to occur when there is a significant market demand from local producers, local opportunity to test and commission new technologies, a cluster of firms that can support each other and cross-fertilise ideas and utilise mining technologies, and a strong base of R&D organisations (Jourdan 2010). Policy implications for promoting lateral migration of technologies in South Africa included support to enable diversification of a firm’s export base, support for suppliers to key sectors, human resource development, and linkages to government innovation incentive programmes and tertiary institutions (Jourdan 2010: 17). Such policy considerations may be country specific.

Lateral migration refers to the application of technologies in a different sector and context from that in which they were originally developed (Pogue and Rampa 2006). A large body of literature has focused on the closely related concept of 'spillovers' (see Griliches 1979; Glaser et al. 1992 and Jaffe et al. 1993). Two types of spillover are generally identified: (1) 'rent spillovers' and (2) 'knowledge spillovers' (Coe and Hoffmaister 1999; Jojo 2006). The former refers to competitive market conditions that prevent a producer of an innovation from charging a price that reflects the productivity and other benefits gained by the user of the innovation. The latter concerns the public good character of technology, which enables relevant knowledge to be transferred from one firm to another while the receiving firm does not necessarily have to pay for it.

Knowledge spillovers imply that firms engaged in developing innovative products may fail to undertake R&D because of the difficulty in protecting the resultant intellectual property. Addressing this problem is a purpose of the recent bill of Commonwealth of Australia for a new R&D tax credit law (Swan 2010: 5–6) which has passed the lower house. Mining groups have objected to the reference to spillovers claiming this could require them to demonstrate potential spillover *before* becoming eligible for the credit and that spillover is too imprecise a concept for use in tax law (AusIMM 2011: 4).

Support for the industry's contention is given by the Australian Productivity Commission (2007) which cites evidence from aggregate time series data that suggests positive spillover rates of return to business research and development (R&D) as a whole (and by extension, research embodied in technologies). But the Commission also notes that 'none of these quantitative methods can realistically measure rates of return with precision' (Productivity Commission 2007: xix–xx). This is due to the 'complex causal pathways' linking R&D to productivity grown, long time lags in effects and shortcomings in the data (Topp et al. 2008). In the policy context, claims are made of larger spillovers from agricultural and energy R&D than in other industry sectors, even in the absence of 'unequivocal data' (DPIE 1995: 6).

The current study will provide much needed baseline data and a more robust methodology to inform this policy debate. Knowledge spillovers, in particular those of an interindustry nature, are of interest in the present study. However, while the study will lead to some general conclusions about flows of knowledge between basic research and industry sectors, we are more concerned with the *lateral* migration of specific technologies embodied in (1) mining capital goods and (2) technological services developed in, or specifically for, the mining sector.

We see the notion of lateral migration from the resource sector as an application and extension of the more general concept of technology spillovers to the resource sector. A theoretical development of the notion of lateral migration and empirical investigations of the phenomenon would potentially help to answer some most intractable questions facing resource-intensive economies in the world. These broader questions include:

- Does resource intensity hamper growth?
- Is it possible to reconcile resource intensity with the knowledge economy?
- What lessons do theory and history hold for economic policy in resource-based economies? see Lorentzen (2008, p. 1)

The methodology discussed in this chapter enables an investigation of both the *assumptions* behind the lateral migration thesis and the *policy implication* for Australia's resource-based economy. While lateral migration can be understood as a product of knowledge spillovers, we do not presume that it only occurs among firms that are *geographically* concentrated or locally bound. The knowledge embedded in technology and skills associated with trade in mining-related capital goods and technical services are important channels that enable the lateral migration, well beyond geographic boundaries. By focusing directly on the *migration of specific technologies and associated knowledge and skills*, we propose to identify inhibiting or facilitating factors and contribute more usefully to policy debates. The classic 'Hindsight' and 'TRACES' case studies of the antecedents of particular technologies offer some useful methodological insights for revealing these actors. These are discussed in more detail in the methodology section later in this chapter.

3 A Methodology for Researching Lateral Migration of Technology from the Australian Mining Sector

In this chapter, we propose three types of analyses in order to establish a quantitative account of lateral migration of technology in the Australian resource sector and to use the results from the analyses as basis for a further qualitative investigation. These analyses are based on input–output data, patent data and trade data, respectively.

Many mining technologies are embedded in capital goods. The export of mining-related capital goods from Australia has grown considerably from about AU$ 3 billion in 1995 to AU$ 6.8 billion in 2009 (Fig. 17.1). An analysis of the production and export of mining-related capital goods introduces further insight into the potential for lateral migration. Preliminary analysis by the project team in collaboration with our international collaborator in South Africa has produced a classification of mining-related capital goods. There is currently no internationally accepted definition of mining capital goods. However, the South African Capital Equipment Council (SACEC) has assessed, at a six-digit HS level, which capital equipment products are most likely to be destined for the mining sector. We have added to the development of the classification using Australian data based on the same six-digit HS product classification.[1] Our analysis shows that there has been a steady growth in production and export of these goods (from 15% of all Australian capital goods exports in 2003 to 23% in 2009). This does not take into account the domestic

[1] HS refers to the Harmonised System (HS) Classification. It is a six-digit standardised international numerical method of classifying traded products.

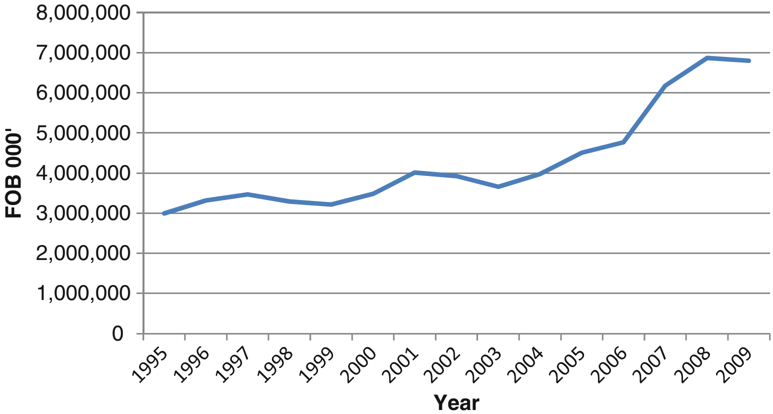

Fig. 17.1 Exports of mining-related capital goods: 1995–2009 (Source of primary data: Australian Bureau of Statistics (2010) special table on merchandise exports prepared by ABS from Table 5368.0 International Trade in Goods and Services, Australia)

inputs of these capital goods to the Australian economy. The recent increase in mining investment suggests it is likely to be reflected in a similar rise in domestic inputs. This part of the methodology will identify, more specifically, the nature of capital goods destined for mining and their inputs to other sectors. It will be possible to make a further distinction between those products primarily produced for mining (*core mining*) and those used more generally by mining and other sectors (*mining related*). This task could be undertaken after some detailed case study analyses (see Sect. 3.2 below).

Using the SAEEC definition, it is possible to identify the nature of mining-related capital goods and their *export destination* for the years 1995–2009. This information sheds light on the rates of growth of specific technologies and the destinations. Such data can guide a more detailed case study analysis of selected technologies and the firms that produce them (Yin 2003). Among the largest exports of mining-related capital goods from Australia are machinery for sorting, screening, separating or washing earth, stone, ores or other mineral substances and pumps for liquids. Figure 17.2 shows the ten largest exports of mining-related commodities from Australia in 2009.

We propose to relate various mining-related manufacturing goods, such as 'self-propelled bulldozers', to mining goods, such as iron ore, by determining the extent of usage of the former in mining activities for the latter. This can be determined from an analysis of input–output data that provides detailed product category by domestic industry sector destination. This measure can then be factored into the export tables in order to provide a tentative estimate of their mining/non-mining application. The assumption being that the domestic inter-sectoral flows evident from input–output tables would potentially match the same products exported.

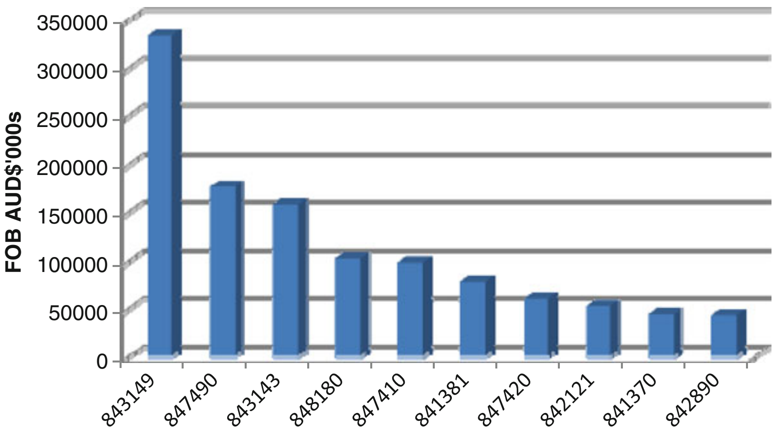

Fig. 17.2 The ten largest exports of mining-related capital goods from Australia: 2009 (Source of primary data: Australian Bureau of Statistics (2010) special table on merchandise exports prepared by ABS from Table 5368.0 International Trade in Goods and Services, Australia)
Note: 843149: Parts for machines of 8428, 8429 or 8430 (excl. buckets, shovels, grabs, grips, bulldozer or angledozer blades or boring or sinking machinery of 8430.41 or 8430.49); 8428: Other lifting, handling, loading or unloading machinery (e.g. lifts, escalators, conveyors, telefer-ics); 8429 Self-propelled bulldozers, angledozers, graders, levellers, scrapers, mechanical shovels, excavators, shovel loaders, tamping machines and road rollers; 8430: Other moving, grading, levelling, scraping, excavating, tamping, compacting, extracting or boring machinery, for earth, minerals or ores; pile-drivers and pile-extractors; snowploughs and snowblowers
847490: Parts of the machinery of 8474; 8474: Machinery for sorting, screening, separating, washing, crushing, grinding, mixing or kneading earth, stone, ores or other mineral substances, in solid (including powder or paste) form; machinery for agglomerating shaping or moulding solid mineral fuels, ceramic paste, unhardened cements, plastering materials or other mineral products in powder or paste form; machines for forming foundry moulds of sand
843143: Parts for boring or sinking machinery of 8430.41 or 8430.49
848180: Valves nes, taps, cocks and similar appliances for pipes, boiler shells, tanks, vats or the like (incl. thermostatically controlled valves)
847410: Machinery for sorting, screening, separating or washing earth, stone, ores or other mineral substances, in solid (incl. powder or paste) form
841381: Pumps for liquids, whether or not fitted with a measuring device, nes (incl. pumps for swimming pools)
847420: Machinery for crushing or grinding earth, stone, ores or other mineral substances, in solid (incl. powder or paste) form
842121: Machinery and apparatus for filtering or purifying water (incl. swimming pool filters)
841370: Centrifugal pumps, nes for liquids (incl. pumps for swimming pools)
842890: Lifting, handling, loading or unloading machinery nes (excl. machines and apparatus specified in Heading 8486).

An analysis of exported mining-related capital goods also offers some insight into the global spread of Australian export of mining-related technologies. China, Japan and India are the major destination for mined commodities. However, they are far less significant as destinations for Australian mining-related capital goods, with only China remaining in the top ten destinations for Australian exported mining-related capital goods. The ASEAN countries comprise over 50% of the top ten

Table 17.1 Australian mining capital goods product exports: top ten destinations, 1999–2009

Destination	AUD 000 s	% of all exports
USA	1,551,892.3	9.7
New Zealand	1,198,162.3	7.5
China	1,179,266.0	7.4
Indonesia	1,176,348.1	7.4
PNG	1,134,429.8	7.1
Singapore	1,070,190.6	6.7
South Africa	501,746.5	3.1
Malaysia	420,018.7	2.6
Thailand	368,844.9	2.3
UK	337,608.8	2.1
Total top 10	*8,938,508.1*	*55.9*
All ASEAN	3,376,274.0	21.1
All exports	15,998,622.1	
Asia Pacific share in top ten destinations	6,547,260.4	73.2

Source: Australian Bureau of Statistics special table on merchandise exports prepared by ABS from Table 5368.0 International Trade in Goods and Services, Australia

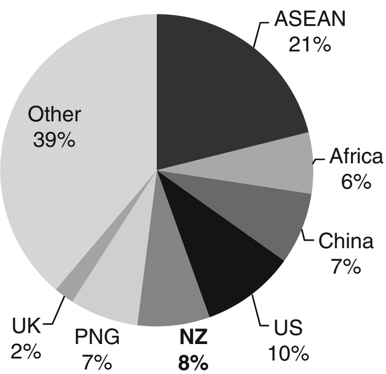

Fig. 17.3 ASEAN and selected other mining product destinations, 1999–2009 (Source: Australian Bureau of Statistics special table on merchandise exports prepared by ABS from Table 5368.0 International Trade in Goods and Services, Australia)

destination countries (see Table 17.1 and Fig. 17.3) reflecting a very different trade pattern than for mineral and energy commodities. While PNG and Indonesia are likely destinations for mining equipment, Singapore, New Zealand and the USA may be either applying these goods in other sectors or serving as an export forwarding process into other unknown countries or sectors.

Analyses such as discussed above provide some overview of the context in which mining-related technologies are moving internationally and inter-sectorally. They have less to offer in terms of revealing the lateral migration of technologies or technical knowledge, developed through R&D in unanticipated ways such as illustrated by the neutron gamma sensor technology introduced earlier in this chapter. This lack of empirical data is acknowledged by policy agencies in Australia. To reveal more about that migration path, it is necessary to turn to the process of knowledge production and application embedded in activities such as provision of mining technical services and R&D investments made by mining companies or by intermediaries such as universities, product suppliers and research institutes.

The methodology consists of two research components: (1) an econometric analysis and (2) a multiple case study approach. The purpose of component one is to measure the extent of lateral migration of mining and energy technologies using patent, trade and input–output data sets to provide a quantitative account of which technologies are more successful than others in migrating into other industrial sectors. This component will serve to identify technologies and firms on which to focus in component two. Component two will select several mining and energy technologies for in-depth comparative case studies in order to gain detailed insights into the paths and mechanisms along which technologies migrate into other sectors.

3.1 An Econometric Analysis

The econometric analysis will first build an index for measuring the extent of lateral migration of technologies from the mining sector, based on patent citation data, trade data and input–output data. Subsequently, a number of variables suggested by the literature will be examined for their roles in explaining the extent of lateral migration as measured by the index.

The lateral migration index will be built primarily on patent citations. It is acknowledged that patents do have limitations in terms of tracking interindustry flows of technology as they are only one form, among many, of identifying and protecting intellectual property. We will collect and analyse not just the simple patent counts but also patent *citations* data, especially *forward citations*. Forward citations are citations to the patent by subsequent patents. Forward citations are regarded as a good indicator of the economic value of the invention (Trajtenberg 1990). Patent citations, including backward and forward citations, have been intensively used for tracing and analysing knowledge flows and technology spillovers both within and across industries (see Jaffe et al. 1993; Fung and Chow 2002). Our preliminary analysis of patent data for mining technologies identified two broad clusters of patents: *mining technologies* and *energy technologies*. It is also acknowledged that the term 'energy' technologies potentially cover a very diverse set of industries and technologies, some of which may be only marginally related to the resource sector. This includes, for example, electricity generation from solar, wind and tidal sources. A comparison of patents belonging to these two clusters for Australia, South Africa, Canada and the United States revealed that Australia ranks lowest of the four with respect to citations for mining technology patents, but second highest for energy technologies. This finding suggests that a comparison of the migration of mining technologies and energy technologies is a productive starting point for the selection of case studies.

Patent and patent citations data can be collected from the main patent organisations including the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO) and the World Intellectual Property Organization

(WIPO) of the UN, all of which provide access to patent information including description, inventor country, patent classification, references and so on. In addition, the US National Bureau of Economic Research (NBER) maintains a large database comprising detailed information of over three million US patents and more than 16 million citations (see www.nber.org/patents/). The database provides forward citation counts for individual patents and citation-based measures including generality, originality, mean forward citation lag, mean backward citation lag and so on (Hall et al. 2001). The current database includes patents granted by 1999, and a major update of the database, which has been partially released and is anticipated to be fully released in 2011, will bring existing data up to date through December 2004. We shall also approach companies such as the World Intellectual Property Search (WIPS), Matheo Patent and Patent Guider that provide commercial service for computerised patent databases.

The purpose of this component is to establish a sample of technologies that originated from the Australian mining and energy sectors. A key task in this exercise is to search patents that have been granted to Australian firms or individuals associated with the production of mining capital goods identified using the South African mining capital goods classification.

Once the patent forward citations of the technologies under study are collected, the classification codes of the patents that cite each mining- and energy-related technology can be examined. For example, a citation sharing a three-digit code with the technology is considered 'closer' than a citation sharing only a two-digit code. The 'technological breadth' of citations received by each technology can then be identified, which will be the primary input for calculating the extent of lateral immigration of the technology.

Besides the patent citations data, two other types of data can be further used as complementary indicators in building the *lateral migration index*, namely, trade data and input–output data. Both data help examine the economic significance of mining-related goods and their underlying technologies. Trade data for mining-related capital goods indicate intensity and diversity of exports of the goods, thus providing useful information of competitiveness of Australian mining technologies in the global market. The more competitive the technologies, the more likely lateral migration, if it occurs, will carry a significant economic impact. Similarly, input–output data can help understand the significance of mining-related goods and their underlying technologies for other sectors in the domestic economy. It is acknowledged that input–output data has limitations in that they only record flows of intermediate goods, not capital goods. We therefore assume that there is a close correspondence in the two types of flows.

The two types of technology spillovers tend to be studied using different measures due to their distinct natures (Los 2000). For example, coefficients derived from input–output tables have been long utilised to capture rent spillovers (Terleckyj 1980), based on the notion that 'the "statistical benefit" industries obtain through R&D embodied in intermediate goods is proportional to the parts of output of the innovating industry they buy' (Los 2000, p. 4). On the other hand, patent data have been predominantly employed to measure knowledge spillovers.

For example, early studies have traced the spillovers flows based on the so-called user–producer method, by determining sectors that produce and use individual patents (Scherer 1982). Other studies have utilised patent citations to analyse knowledge flows and technology spillovers both within and across industries (Jaffe et al. 1993).

The *lateral migration index* will be built by analytic methods such as factor analysis, which will 'ground' the data as discussed above with different weights onto the index. We will then seek to develop explanatory variables for the lateral migration of technologies. Explanatory variables employed in the context of resource-based developing countries include absorptive capacities or firm learning, the role of foreign technology, knowledge infrastructure, and interactions among various players and industry policy (Lorentzen and Pogue 2009). In the Australian context, it will be necessary to undertake a series of detailed case studies in order to understand something of the impact of these factors on the process of lateral migration.

3.2 A Case Study Analyses: Rethinking the Hindsight and TRACES Studies

Much of the earlier work on knowledge and technology 'spillovers' concerns the contribution of fundamental research (undertaken mostly by universities and government) to subsequent industrial innovation and technologies (see Garrett-Jones et al. 1995). The seminal TRACES (Technology in Retrospect and Critical Events in Science) case studies by the US NSF demonstrated the importance of government-funded research to five key industrial innovations including the electron microscope and the oral contraceptive pill (National Science Foundation 1969). Project Hindsight, a 1965 US Department of Defense study, identified novel applications of science and technology and traced these back to critical research and development events.

Critique of these studies by Irvine and Martin, Kostoff, Gibbons and others (see Garrett-Jones et al. 1995) illustrates several of the factors to consider in tracking the lateral transfer of knowledge and technologies. Such factors include the timescale and cut-off points chosen for examination, how 'key events' are defined and identified, the weighting given to particular 'key events', the underlying model of technology creation and transfer assumed (e.g. linear model, pool model), the range of direct or indirect benefits measured or captured, cumulative or additive effects and the pathways through which indirect impact occurs.

The methodology for the current study draws insights from this earlier work but seeks to complement retrospective insights with the regularly available empirical data, discussed above. Case study interviews will be sought with MTSE producers, research intermediaries such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia and universities. The selection will be informed by the econometric analysis (1) and a mining research 'expert panel'. For example, we have previously conducted interviews with 26 firms and research agencies in Australia and South Africa and found that lateral migration was often an indirect process depending very much on intermediary organisation. An expert panel comprising people who have previously been engaged in this process is likely to lead quite directly toward insightful observations about barriers and facilitating factors. Based on the econometric analysis in component (1), certain technologies can be targeted that have been successful in lateral immigration. To ensure the validity, reliability and replicability of the case studies, multiple data sources will be utilised, including archival records, observations and data collected from semi-structured interviews. Whenever possible, for each technology, both the technology 'provider' and 'receivers' will be approached. Approximately 200 interviews will be undertaken, representing paired producers and adopters engaged with 50 technology/service sets. The case study information will focus in particular on the relationship between the production of capital goods and technical services, linkages with public research institutions and universities, the role of mining sector clients/collaborators in the original technology/technical service development, international links and the role of IPR in the process. Interviews will be recorded, transcribed and processed using a qualitative data management software program such as NVivo.

Findings from the TRACES and PACE (Arundel et al. 1995), studies show the influence both of the *type of knowledge* or technology (cutting edge or in more widespread use) and the *appropriation regime* on their subsequent development and application. In pharmaceuticals, new technology is a source of proprietary value, whereas in the utilities sector, there may be more value in common standards and interoperability. Salter and Martin's key conclusion is that the relative importance of different forms of economic benefit varies with scientific field, technology and industrial sector (Salter and Martin 2001: 527). A similar observation applies to lateral transfer of knowledge and technology between firms and industry sectors. There are multiple *forms* in which the knowledge can be embodied and *transferred*: in publications, graduates, instruments and through networks, personnel exchange and formation of new firms. The current study of the mining sector will focus on *two ways* through which embodied knowledge can migrate into other sectors: (1) through the production and application (perhaps with adaptation) of *capital good* and (2) through the provision of *technical services*. The case study approach for component (2) will build on lessons learned from the case study methodologies adopted by these earlier studies.

4 Conclusion

Our working proposition in applying the methodology to the lateral migration question in the Australian mining sector is that the adoption, diffusion and long-term acceptance of technologies in sectors different from their original source is influenced by a variety of *socio-economic and institutional factors*. The objective of this type of study is to understand how to better facilitate this process. Our preliminary analysis suggests that the lateral migration of technologies out of the mining sector can be best understood in terms of the complementary co-evolution of knowledge embedded in the manufacture of mining-based capital goods, the skills and experience of personnel and firms engaged in the provision of mining technical services and a strong national manufacturing base to absorb, adapt and draw out the potential value of the technological development. The study will explore our proposition in the Australian context and seek to identify barriers and/or facilitating factors in the process.

Our objective is to map the lateral migration of technologies and skills, produced initially in or for the Australian mining sector, into other industry sectors. Specifically, the task is to investigate the lateral migration through capital goods (including software) as well as technical services. It has the potential to offer insights into where lateral migration is more likely to occur, how it can more effectively be underpinned through supportive policy and how capital goods and technical services can provide pathways for the lateral migration of technologies.

The task requires a 'mixed' methodology. On the one hand, we are seeking to identify the technologies that are currently finding their way from the mining and minerals sector into new applications in other sectors. We are also seeking to generate some indicators from data resources such as patent databases, input–output tables and export data with the capacity to assess levels of export for mining-related capital goods. Finally, we are seeking to use retrospective case study analyses to reveal the social processes through which technologies and associated technical knowledge have made the journey across sectoral and organisational boundaries. By combining these quantitative and qualitative analytical approaches, we hope to have overcome the difficulties that limited the Hindsight and TRACES studies. At the same time, we hope to generate some more robust indices to underpin policy initiatives such as government-funded R&D taxation incentives, targeted export incentives and cross sector R&D programmes and to describe the nature of specific 'spillovers' from Australia's mining and energy sectors.

References

ABS (2011) Table 8104 Research and experimental development business Australia 2008–9, and Table 8112.0 Research and Development, All sector summary available at ABS.gov.au

Arundel A, Van de Paal G, Soete L (1995) PACE report: innovation strategies of Europe's largest firms: results of the PACE survey for information sources. Public research, protection of innovations, and government programmes, final report. MERIT, University of Limburg, Maastricht

AusIMM (2011) Submission on the exposure draft of the tax laws amendment (Research and Development) Bill 2010, AusIMM, Carlton, Australia

Australian Bureau of Statistics (2010) Special table on merchandise exports prepared by ABS from Table 5368.0 International Trade in Goods and Services, Australia

Australian Bureau of Statistics (2011) Australian System of National Accounts, cat no. 5204.0, Table 64. Gross Fixed Capital Formation, by industry by type of asset

Coe DT, Hoffmaister AW (1999) Are there international R&D spillovers among randomly matched trading partners? A response to Keller. IMF working paper 99/18, Washington, DC

Commonwealth of Australia (2010) Benefitting from our mineral resources: opportunities, challenges and policy settings, statement 4, budget 2010–11, Canberra

Department of Primary Industries and Energy (1995) DPIE response to the industry commission draft report on research and development, Canberra, March 1995

Fung KM, Chow WW (2002) Measuring the intensity of knowledge flow with patent statistics. Econ Lett 74:353–358

Garrett-Jones S, Turpin T, Bellavista J, Hill S (1995) Using basic research – assessing connections between basic research and socioeconomic objectives. Part 1: review of current theory and international practices. AGPS, Canberra

Glaser EL, Kallal HD, Scheinkman JA, Shleifer A (1992) Growth of cities. J Polit Econ 100(6):1126–1152

Gregory Bob and Peter Sheehan (2011) The resources boom and macroeconomic policy in Australia, Australian Economic Report: Number 1, Centre for Strategic Economic Studies Victoria University, Melbourne

Griliches Z (1979) Issues in assessing the contribution of research and development to productivity growth. Bell J Econ 10(1):92–116

Hall BH, Jaffe AB, Tratjenberg M (2001) The NBER patent citation data file

Jaffe AB, Trajtenberg M, Henderson R (1993) Geographic localization of knowledge spillovers as evidenced by patent citations. Q J Econ 108(3):577–598

Jojo J (2006) International technology spillovers and manufacturing performance in Indonesia. Technische Universiteit Eindhoven, – Proefschrift, Eindhoven

Jourdan (2010) Links with domestic industry, downstream processing and the provision of inputs: resource based industrialisation in South Africa, 2010, Mintek, South Africa. unctad.org/infocomm/diversification/cape/word/Jourdan.doc. Accessed 24 Feb 2011

Kuramato J, Sagosti F (2006) Cleaning pollution: from mining to environmental remediation. In: Lorentzen J et al (eds) Lateral migration in resource intensive economies: technological learning and industrial policy. HSRC, pp 93–128, Pretoria

Lorentzen J (2006) Innovation in resource-based technology clusters: investigating the lateral migration thesis. Human Science Research Council, South Africa

Lorentzen J (ed) (2008) Resource intensity, knowledge and development. HSRC Press, Cape Town

Lorentzen J, Pogue TE (2009) Knowledge intensification in resource-based developing economies: from technologies learning to lateral migration. Institute for Economic Research on Innovation working paper 2009-04, Pretoria

Los B (2000) The empirical performance of a new interindustry technology spillover measure. In: Saviotti PP, Nooteboom B (eds) Technology and knowledge: from the firm to innovation systems. Edward Elgar, Cheltenham, pp 118–151

National Science Foundation (1969) Technology in retrospect and critical events in science: TRACES. National Science Foundation, Washington, DC

Pogue TE, Rampa M (2006) Innovation in resource-based technology clusters: investigating the lateral migration thesis. An analysis of hydraulic technologies in South Africa's mining sector. Human Science Research Council RSA, Pretoria

Productivity Commission (2007) Public support for science and innovation. Productivity Commission, Canberra

Reserve Bank of Australia (2009) The level and distribution of recent mining sector revenue, Reserve Bank Bulletin – January 2009. http://www.rba.gov.au/publications/bulletin/2009/jan/2.html /Accessed 16 November 2012/

Salter AJ, Martin BR (2001) The economic benefits of publicly funded basic research: a critical review. Res Policy 30:509–532

Scherer FM (1982) Inter-industry technology flows and productivity growth. Rev Econ Stat 64(4):627–634

Swan W (2010) Exposure draft: tax laws amendment (research and development) bill 2010. Commonwealth of Australia, Canberra

Tedesco L, Haseltine C (2010) An economic survey of companies in the Australian mining technology services and equipment sector, 2006–07 to 2008–09. ABARE-BRS report 10.7, Canberra

Terleckyj N (1980) Direct and indirect effects of industrial research and development on the productivity growth of industries. In: Kendrick J, Vaccara B (eds) New developments in productivity measurement and analysis. University of Chicago Press, Chicago
Topp V, Soames L, Parham D, Bloch H (2008) Productivity in the mining sector: measurement and interpretation. Staff working paper, Productivity Commission, Dec 2008
Trajtenberg M (1990) A penny for your quotes: patent citations and the value of innovations. RAND J Econ 20(1):172–187
Walker M, Farisani L (2006) Innovation in resource-based technology clusters: investigating the lateral migration thesis: the manufacture of biodegradable plastics from maize starch, Employment-oriented industry studies. Human Science Research Council RSA, Pretoria
Yin RK (2003) Case study research: design and methods. Sage, Thousand Oaks

Part V
Tools and Best Practice Models

Chapter 18
The Demand Readiness Level Scale as New Proposed Tool to Hybridise Market Pull with Technology Push Approaches in Technology Transfer Practices

Florin Paun

Abstract The technology transfer process between a public laboratory and a company has been the subject of many publications and has been widely discussed in economic theory. This paper highlights several newly identified asymmetries occurring between the different agents taking part in the process.

The theoretical corpus of the article draws upon empirical sources, being based on the recent experience of one of the most dynamic Technology Transfer Offices (TTOs) in France: the case of ONERA (the National Office for Aerospace Studies and Research) and the SMEs.

In such a cooperative innovation process, we will show that certain collaborative tools or practices emerge, aimed at reducing information asymmetries or acting as compensation mechanisms for other types of asymmetries between the partners at a microeconomic level; especially in France where there is a gap between the public R&D laboratories and the SMEs in terms of Technology Readiness Levels (TRLs).

We finally showcase a new tool, the Demand Readiness Level scale (DRL), which combined with the TRL is providing a powerful tool, the Innovation (process) Readiness Diagram (IRD), dedicated to better manage the Technology Transfer relationship.

1 Introduction

The technology transfer process between a public laboratory and a company has been the subject of many publications and has been widely discussed in economic theory as well as in applied economics (e.g. the *Journal of Technology Transfer*). Here we will

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deal with the specificities related to the characteristics, capabilities and competencies of SMEs and public research laboratories in France. This chapter will be based mainly on feedback regarding the strategy implemented for the development of an economically 'healthy' relationship between ONERA (*Office National d'Etudes et Recherches Aérospatiales*, the National Office for Aerospace Studies and Research) and the SMEs. The choice and definition of collaborative tools will be explained together with the analysis of the initial results and the prospects envisaged.

We will contend that, in a cooperative process of innovation, these tools become mechanisms for reducing informational asymmetries (Stiglitz and Weiss 1992) or 'compensation mechanisms' (Paun 2009) for other asymmetries between the various players at a microeconomic level. These newly identified asymmetries, *institutional (culture) asymmetry* (regarding the institutionalist theory of Veblen 1914), *technological (information in the case of technology transfer) asymmetry, and risk and time scaling asymmetry*, often act as barriers to the technology transfer process while simultaneously being critical for the eventual high intensity of the innovations pursued. The greater the asymmetries, the stronger the impacts on the intensity of innovations, always supposing that the differently involved actors in the innovation process do succeed in working together. This involves the effective implementation of asymmetries reduction (or compensation mechanisms) bridging the various agents.

Some of these mechanisms, more related to the knowledge economy, could be adapted and reshaped for other agents in the R&D and innovation domain, and for evaluation or regulation authorities of this domain. Their implementation for these other players could induce an amplification effect on innovation and its direct effects on economic growth at the macroeconomic level within the framework of the 'national innovation system' (Freeman 1987; Lundvall 1992; Nelson 1993).

2 Context, Positioning, and Role of the Actors in Innovation

A brief description of ONERA's economic environment is necessary for a better understanding of the reasons for these tools and their operation, as well as a reminder of the fundamental principles of innovation and the role of technology transfer in this process.

ONERA is a scientific and technical public corporation with commercial and industrial characteristics (EPIC). Its mission is defined as follows: '… to develop and direct research in the aerospace field; to design, develop and implement the necessary technical tools and benches for carrying out this research; to ensure, in association with other R&D organisations, the circulation, at a national and international level, of the results of this research; to support their utilization by the aerospace industry; and possibly to facilitate their application outside the aerospace field'.

This nuance is very important, particularly in the 'ideological opposition' between those who prioritise a 'publication' strategy and those who prefer one that stresses a 'patent', because premature disclosure, in the form of articles or conferences, ensures the circulation of knowledge but also facilitates uncontrolled utilisation of the results of research by industry, including competitors of the national or European industry.

This quotation is also important for understanding ONERA's position in the TRL[1] chain (Mankins 1995), its role in technology transfer, and more generally its role in innovations generated on the basis of the technology that it has created.

It must also be observed that ONERA has to transfer the results of its research (in order to '… support utilization …') to the aerospace industry and also '… outside the aerospace field…'.

2.1 Specificities of the Aerospace and Defence Field

This brief description of ONERA's economic environment needs a complementary analysis of the players from the point of view of the utilisation of its research results by industry.

It must be admitted that an SME has less material means to establish a successful new product/service in the market than a Large Industrial Group. This is even more evident for a start-up partner.

The specificity of the aerospace and defence markets asserts itself very quickly because these sectors, which are generally 'complex systems', require a lot of time for the development and introduction of a new product on the market. We note that even large groups, beyond a certain limit, need institutional support at the national level, if not at the international level, to develop new technologies.

So in what circumstances would ONERA be able to respond well to its prospective mission of 'developing and directing research' and its transfer mission 'to support the utilization of its results by the national industry'?

The French and European aerospace and defence groups stand out as designated partners for successfully 'bearing' (i.e. acting as generator, carrier and user of) the new technologies suggested and/or developed by ONERA. This is particularly the case for the incremental or specialised innovation of the large groups. Such 'bearing' is however less obvious in the case of technological breakthroughs (see McCooe, quoted in Golob 2006), and this is even more the case in the civil aerospace sector where technologies used on board planes must be safe and tested technologies. For these aspects, since its creation, ONERA has developed and maintained effective strategic partnerships with the large national groups which have mostly become multinationals in recent years. This partnership policy will not be the subject of our analysis here.

The fundamental question raised during the development of ONERA's implementation strategy is that of access to markets for breakthrough technologies resulting from a specialised research sector such as aerospace. From empirical experience, it appears that, to put a 'breakthrough technology' on the market, thus challenging the existing products and/or business models, such as may be designed by a national skill centre, the best vectors are the SMEs.

Technological demonstrations that result in innovation will not necessarily take place in the aerospace market but can arise in any of the market sectors in which the

[1] Technology Readiness Levels.

SME receiving the technology can itself control the innovation process completely (until the successful introduction of the new product to the market). Some niche markets will be accessible, even in the aerospace sector (green aviation, small-scale drones, leisure, etc.). Once the technology is demonstrated, there are strong chances that the large aerospace groups will integrate this technology as a tested module into the systems they are designing (Mouchnino and Sautel 2007).

The strategic choice was taken at ONERA for the development of a partnership relationship with a national and European SME. If no SME is identified, the launching of a start-up partner could be studied, subject to the economic outlook and adequate financial support.

2.2 ONERA-SME Relationships

Like any healthy partnership relationship, that between ONERA and an SME must be a winning one for both parties. Both partners must have strong positions (Cowan et al. 2003) with each adopting its own role so that their collaboration generates significant added value. So ONERA develops its best technological solutions, possibly breakthrough technologies, and the SME implements its product development, industrialisation and marketing capabilities in order to reinforce its competitive advantage in its markets or to create new ones.

These complementary roles, based for one side on a 'craftsman instinct' and for the other on a 'predatory instinct', opposable in the sense given by the theory of Veblen (1899), generate significant *Institutional (mentally and behaviourally) Asymmetries* between the two partners.

Figure 18.1 (Paun 2010) presents the existing asymmetries between the public R&D laboratories and the SMEs in France by showcasing their respecting positions with regard to the TRLs (Mankins 1995). It should be stressed that the majority of the public R&D laboratories in France carry out their activities at the levels TRL 1 (basic research) and TRL 2 (applied research). The 33 Carnot Institutes, being responsible for 470 million of research carried on in partnership with industry, representing about a half of the yearly budget for French research undertaken in partnership with industry, are generally well involved in applied research (TRL 2). Very few of the Carnot Institutes could carry their research up to laboratory demonstration levels (TRL 3–4). Exceptionally and limited to particular programmes, some of the Carnot Institutes could bring their technology to the operational levels (TRL 6–7).

Beside these figures, the SMEs are currently running their business at TRL 9 (they are selling products, services or components). Fewer than 10% of French SMEs have Development Offices able to integrate (or absorb) operational prototypes (TRL 6–7) in order to structure production chains and introduce new products to the market. And even fewer have R&D capacities able to understand technologies available at Lab Demonstration Levels (TRL 3–4). Thus, the *Technological Asymmetry* existing between public R&D labs and the SMEs becomes obvious.

In addition, it is well known that between the same levels, an equity gap is evident in some European countries; hence, the European Investment Fund (EIF) and

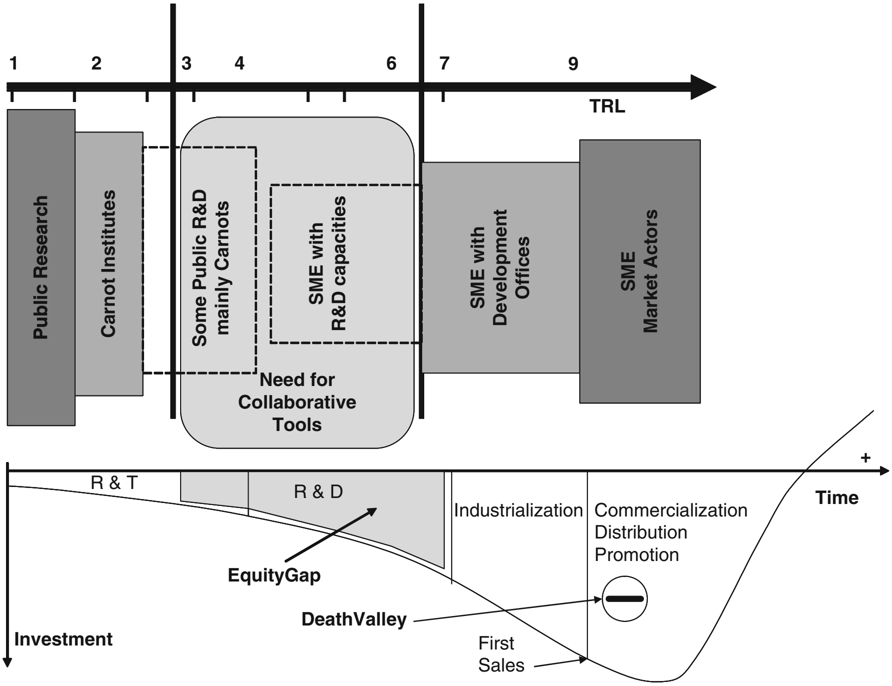

Fig. 18.1 Asymmetries between public R&D laboratories and SMEs by TRL scale

several publicly owned banks (like CDC in France) have dedicated important financing programmes to compensate for this Europe-specific 'amorcage' equity gap. This of itself will induce an important *Financial Risk Asymmetry* between the public R&D and the SMEs.

These asymmetries must be reduced (for the informational asymmetries) or compensated (for financial risk and institutional asymmetries) in order to support this new codevelopment relationship between the parties, as put forward in this analysis. The collaborative tools will thus be reduction and/or compensation mechanisms of the existing asymmetries between ONERA and its SME partners, with the aim of creating a 'Trust environment' between the two agents.

We will further highlight two of the collaborative tools specifically developed to better manage the ONERA-SMEs relationship.

3 Specific ONERA-SMEs Collaborative Tools

3.1 The Risk and Benefits Sharing Codevelopment Contract

A mechanism to try to solve the technological maturation asymmetry problem has been developed at ONERA: the shared risk development contract. This type of contract was developed and signed, for the first time in France, between an EPIC and a business firm.

For this phase of technology maturation ranging between TRL 2 and TRLs 3–4, the risk is still too great to be borne entirely by an SME as long as the technological proof, at least in the laboratory, as well as a complete comprehension of the technology have not been achieved. It seemed right to us that ONERA, as a creator of technology, should be able to join future industrial and commercial owners in order to reduce the risks and share the possible future benefits. The partnership is based on a technical and economic analysis of various phases of the development and on a *Business Plan* detailing the market prospects and investment returns on the new product. Based on this, ONERA can decide to assume part or all of the costs, within the framework of the codevelopment, the refunding of which, with profit-sharing based on business success, will take place or not, depending on the prospects for the use of the product.

The negotiation of the percentage allocated to sales, so as to cover ONERA's costs and its exposure to risk, is conducted according to criteria allowing the development of the company but also bearing in mind the fact that ONERA must make a positive return on all the operations of this kind. Thus, this contract is not a sort of licence nor a subsidy. The principles on which this contract is based are those of a service provided by ONERA on the basis of a determinable (though undetermined) price with payments deferred in time, negotiated between the parties on the basis of later sales and for a length of time agreed upon as part of the same negotiation.

This type of contract proves to be a very good tool, both financially but also technically, for collaboration with codesign in mind, for the development of a new product, a logic equivalent to that described by Cowan (2003). This tool means two parties can together cross, within the meaning of Aoki's theory (Aoki 2000), based on a Nash equilibrium (Nash 1950), a possible financial and technological comprehension barrier that may otherwise induce blocking.

In addition to compensating for risk and technological asymmetries between the two parties, this contract has also subsequently proved to be a good tool for reducing transactional information asymmetries (Akerlof 1970; Stiglitz and Weiss 1992) between the start-up partner and its investors. Indeed, at the time of the phase of 'due diligence' between the creators of the start-up partners and the Business Angels, the *shared risk development contract*, signed with ONERA, yields paramount information on both the product and the target market and on the technological developments and their costs.

These last years, at ONERA, several contracts of this type were signed with various commercial companies. Four of these companies have succeeded in raising significant funds from investors.

3.2 Hybridising Market Pull with Technology Push

Using the TRL scale provided, among the practitioner community, an efficient tool in measuring the abilities of an entrepreneurial team to face and collaborate with all

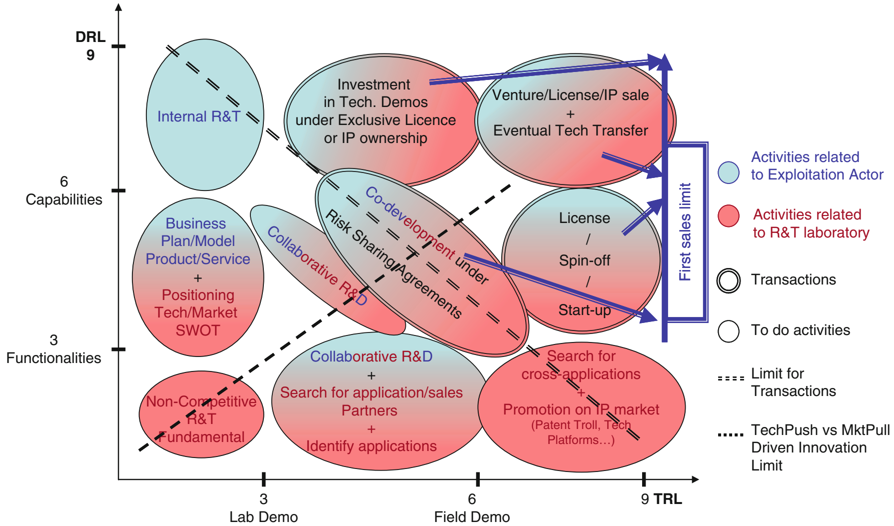

Fig. 18.2 Innovation process readiness diagram for technology-based innovation (© Paun and Richard 2011)

these actors. But, using only this reference, all the thinking patterns will be Technology Push oriented. Then, how is the entrepreneurial team ability measured to understand and identify a targeted market? By using market studies cross with technology acceptance studies? These types of tools completed by various others that the marketing profession has developed are not coming deep enough in the technology comprehension to be able to also measure and drive the technology development chain like the TRL scale is doing.

Pure Market Pull and pure Technology Push approaches are not existing. There is all the time a matching point between the two approaches. How to get this matching point? The successful exploitation of a new idea is always a result of a well-hybridised approach between the two of them. At ONERA, the 'Demand Readiness Level – DRL' scale (Paun 2011) completes the TRL scale as matching tool for the hybridisation between Technology Push and Market Pull.

This new scale, the Demand Readiness Level scale (Fig. 18.2), is able to measure the entrepreneurial team ability to understand and translate into needed capabilities the expressed need on a targeted market (Table 18.1).

The *Demand Readiness Level* is a new measure to assess the maturity of evolving demands identified by potential innovation actors towards an appropriate stage of conceptualisation of the need in the market allowing a matching point with scientific research teams capable to either propose as solution an existing scientific result through technology transfer process or translate the demand in new R&D projects. It actually means that it is the right timing to plot this additional scale, DRL, in a reverse manner related to the classic TRL scale in order to have the appropriate comprehension of the matching between the Market Pull and Technology

Table 18.1 Demand Readiness Level original definition (Paun 2011)

Level	Description for the Demand Readiness Level
1	Occurrence of a feeling 'something is missing'
2	Identification of a specific need
3	Identification of the expected functionalities for the new product/service
4	Quantification of the expected functionalities
5	Identification of the systemic capabilities (including the project leadership)
6	Translation of the expected functionalities into needed capabilities to build the response
7	Definition of the necessary and sufficient competencies and resources
8	Identification of the experts possessing the competencies
9	Building the adapted answer to the expressed need on the market

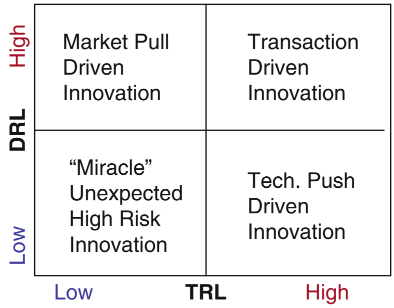

Fig. 18.3 Innovation typologies in DRL-TRL perspective (simplified IRD)

Push approaches. Following schematic (Paun 2011) is reminded in Fig. 18.3 for a better comprehension (Table 18.2).

For example, if an industrial partner have a DRL on 8, he will be able to identify and speak with the appropriate scientists to launch a collaborative R&D programme for developing a new product or service. Same type of matching between different levels could be observed at each level of the previous table. Looking in two references systems, one for the Technology Push approach and the other one for the Market Pull approach, the given particularly timing when an technology transfer agreement is ready for signature becomes predictable.

3.3 Innovation Process (Technological) Readiness Diagram: IRD Diagram

The author together with Philippe Richard (CEO, Venture Strategies Consulting) are proposing a first tool to manage technology transfer processes by combining the TRL scale with the DRL scale in the following diagram (Fig. 18.4). This Diagram is showcasing the possible activities or transactions occurring at the different DRL and TRL levels.

Table 18.2 Example of matching points between DRL and TRL allowing tech. transfer agreements

Level	Description for the *Demand Readiness Level*	Description TRL level	Level
1	Occurrence of a feeling 'something is missing'	–	–
2	Identification of a specific need in a given market	Certification and first sales	9
3	Identification of the expected functionalities for the new product/service	Product industrialisation	8
4	Quantification of the expected functionalities	Industrial prototype	7
5	Identification of the systemic capabilities (including the project leadership)	Field demonstration for the whole system	6
6	Translation of the expected functionalities into needed capabilities to build the response	Technology development	5
7	Definition of the necessary and sufficient competencies and resources	Laboratory demonstration	4
8	Identification of the experts	Proof of concept	3
9	Building the answer to the expressed need	Applied research	2
		Fundamental research	1

As an example, if a company is advancing very high on the DRL at 7th to 9th level, its executives will be able to identify the existing experts possessing the right competencies for developing the innovative proposed product.

– If the existing state of the art shows only TRL 1–3 for the required technology, the company has all the interest to hire the existing experts and promote an aggressive Internal Research and Technology Program in order to get decisive competitive advantages.
– If the existing state of the art demonstrates that the existing technology already succeeds the proof of concept and the laboratory demonstration, the company will face three possibilities. If the demonstration was made by someone else, the company will invest in further developments (reducing the technology development risk for the existing developers) but only on the basis of an exclusive licence relative to its domain. This could be made also on the basis of an IP acquisition. If the existing developer is one of the company's competitors, the company has all interest to consider the development of the intended new product on the basis of a concurrent technology starting with TRL 1–3 by hiring the right experts (return at the first described case). Finally, if by chance the existing laboratory demonstrated technology was obtained inside the company, this one will continue an investment programme with reduced risk due to the high level of DRL reached in parallel.
– If the required technology needed to develop the intended innovative product corresponding the high level of obtained DRL was already demonstrated in operational conditions, this was made definitely by someone else, outside the company. This external actor could be … or someone who is currently running an innovation programme in a Technology Push approach or someone who is already selling products or services with the needed technology in another market domain. Both cases will bring to a venture, a licence or acquisition of IP

rights. The type of transaction will mainly depend on the size of the external actor (a big industrial will prefer a venture if the business will be closed of its core competencies or a licence if it will be far from while a small will better prefer a licence or a IP acquisition).

These High-DRL possibilities were thus identified. Other 'hot spots' represented on the Innovation Readiness Diagram could be easily identified as well. On the diagram are also presented the various limits corresponding to Market Pull versus TechnoPush innovation projects, transaction-based innovation projects and obviously the limit for the First Sales.

The following diagram proposed a simplified IRD, in Fig. 18.5, by simply classifying the various innovation processes in four categories: the Market Pull, the Technology Push, the transaction-based innovations or by the not enough matured innovation process which could become eventually 'miracle' innovations by investing with very high risk.

4 Results

To date, 92 SME have signed a partnership with ONERA, and more than 40 licensing agreements, know-how communication agreements or shared risk development contracts are currently running, with various industrial partners in a variety of fields. Of these, 28 were signed over the past 4 years, corresponding to the new development policy, while the remainder (12) represent the historical 'heritage' of the old ONERA development policy. More than 200 high-skilled jobs were created by the ONERA's SMEs partners based on ONERA's technology.

Following the successful implementation of the new collaborative tools during this period, the number of collaboration agreements signed went from one to more than ten agreements per year. The number of spin-offs went from one spin-off every 5 years to one spin-off on average per year. Fifteen new proposals for common R&D contracts also came to light during this last period.

Table 18.3 provides a selection of the partnerships with SMEs, this selection having been made on the basis of their diversity.

5 Conclusions

The first results show a series of development successes for innovative products/services based on technologies created by ONERA, and this in very varied sectors, going from biomedical prostheses to the wind power market.

As for any form of transaction, in a technology transfer process, the parties involved are informationally asymmetric. The new SME policy at ONERA has highlighted other forms of asymmetries characterising the technology transfer and partnership research between a public research organisation and an SME in France: technological capacity asymmetries, institutional one time scaling asymmetries and those related to the financial risk.

Table 18.3 ONERA-linked SME partners (selection only)

Partner	Application	Type of collaboration
Leosphere	Wind lidar	Licence, common R&D and spin-off contract
Oktal-SE	Electromagnetic environment simulation	Software licences and common R&D contracts
Phasics	Laser interferometer	Licence and ONERA post-graduate student recruiting
Protip	Biomedical prosthesis containing porous Titanium	Licence and shared risk development contract
Ixsea	Inertial navigation	Licence
Sirehna	UAV	Common R&D contract and software licence in fluids
Satimo	Medical imagery	Common development contract and licence
Isitek	Medical supervision in residence	Licence on sensors
Microcertec	US machining of ceramics	Licence
Fogale-nanotech	Capacitive sensors	Licence
Andheo	Fluid mechanics and energetic	Software licence and common R&D contracts
Secapem	Real-time shot acquisition and validation system	R&D contract and software licence considered
Michalex	Micro-indentation at very high temperatures	Licence and shared risk development contract
Nheolis	New type of wind power station	Shared risk development contract
Keopsys	Laser	Licence

The collaborative tools deployed at ONERA within the framework of its new development policy, the shared risk development contract and the use of the DRL scale and of the IRD (among the others not described here but available at http://innovationhub.onera.fr like the *ONERA-SME Charter and the Spin-off Charter*) are mechanisms designed and implemented to ensure the reduction of the information asymmetries and compensation for other asymmetries between ONERA and its partners.

The relationship established between ONERA and an SME is perceived more as a cooperative relationship for a codevelopment rather than as a simple study service (i.e. transactional). This relationship imposes compensation for financial risk and technological capacity asymmetries in addition to institutional (mentality) asymmetries and the reduction of information asymmetries between the two parties. Attention is thus drawn to the importance of the 'issues of confidence and interest' (Cowan et al. 2003) in a technology transfer relationship with regard to the questions of opportunity and uncertainties in a product/service sales relationship.

Moreover, the *shared risk development contracts* have also proven to be very effective tools in the reduction of information asymmetries between the SME (or the start-up partners) and other socioeconomic players (investors, competitiveness centres).

This research work contributes to Stiglitz's 'information asymmetry theory' by acknowledging the need to reduce and/or compensate for different asymmetries while carrying on a cooperative process like technology transfer which has impacts on all levels: direct impact on the agents (micro), on the regulators (regions and sectors – meso) and on economic growth (macro).

Since many years, the TRL scale allowed various analysis of the technology transfer and technological innovation processes by positioning the various stakeholders along this scale including Entrepreneurs. This contribution, reminds a new reference system for better addressing the Market Pull approach while doing technological innovation. The DRL scale could also be the object of the same dynamic exchanges, modifications and analysis that the TRL scale induced among the academics or practitioners communities. The aim is that this new (only proposed in 2011) tool for a hybridised approach will significantly improve the entrepreneurship practices through a better understanding of the different factors and staging, allowing the agreements signatures to creating value.

For a TT Officer or a Strategy Industrial Director will be important to survey the matching of the levels on the two scales while placing the participating actors, identifying the existing asymmetries between them and activating compensation or reduction tools for dealing with these asymmetries. When the sum of the two indicators will equalise 10, the deal between the Industrial and the R&D laboratory becomes feasible and will interest all the stakeholders of the innovation project, including the investors (private or public). Further research are on the process (at ANRT & AI Carnot) to Postulate that the Technology Transfer or Development Agreements are only possible if the sum DRL + TRL is at least equal to 10 regardless to Market Pull or Technology Push Entrepreneurship. If the sum will be smaller, then ten specific actions could be envisaged in Market Pull or in Technology Push approaches types.

5.1 Impacts at the Microeconomic Level

At ONERA, the cultural change taking place among the researchers involved in a relationship with an SME can be noted. Their contractual liability is reinforced by a better awareness of what is at stake that the successful transfer of their know-how to the SME represents. They understand the ‘predatory instinct’ (Veblen 1914) of an entrepreneur, interested in transfer opportunities for their technology outside the aerospace field. The implemented tools operate as relational facilitators in the relationship between ONERA and the SME but also in the internal relationship with ONERA between the scientists and the support structures for utilisation.

5.2 Impacts at the Meso-economic Level

The first successes, with more than 90 SMEs partnering nowadays with ONERA, recognise and prove the significant role that ONERA can play as a source of innovations and also as a catalyst for a cluster of skills and multi-sector innovations. This is valid for all the regions where ONERA is represented, thus confirming the views of other authors (Etzkowitz 1999; Florida and Cohen 1999).

ONERA's change of strategy in the choice of its customers, because of its opening to the world of the SME, has had an effect on the diffusion of its technologies beyond the aerospace field and especially on its positioning in other market sectors as well as in its relationship with its customer. Having a study service relationship with a large industrial group, ONERA has now also given itself the opportunity of having a codevelopment relationship with the SME partners.

ONERA's new policy of development with SMEs offers a solution to the problem encountered in a general way by clusters of companies, of the competitiveness centre type, that are based on the effects of agglomeration and of specialisation (Weber 1909/1929). This cluster model has proved risky for long-term development due to exaggerated territorial specialisation and the lack of job diversification, skills and sectors in the region, which could thus become a 'small world' (Watts and Strogatz 1998).

The positive effects of this new policy at the territorial level have been confirmed for the effects of complementarity and the interactions thus generated between various SMEs (Zimmermann 2002), encouraging them to work in complementary sectors, not necessarily belonging to the region competitiveness centres.

One of the results of the practical application of the new ONERA-SME policy is that ONERA became a 'distant source' (Maskell et al. 2005) of new ideas and expertise for other competitiveness centres outside the aerospace field.

5.3 Impact at the Macro-economic Level

The relationships that the SME partners have developed with ONERA allow changes towards sector-based operating rules specific to the innovation assistance structures or to regional development, in relation to professional networks, in the sense of 'cumulative causality' (Veblen 1914) or of 'recursive causality' (Morin 1990). Thus, it has been observed that some of ONERA's SME partners, especially the decisional committees of this type of structure (competitiveness centres, trade associations), proselytise for this new type of tool for collaboration with public research with other members of the said committees.

Other national structures grouping various innovation players actively examine some of the collaborative tools developed within the framework of the new SME policy of ONERA. These tools are often the subject of analyses by think tanks made up of these national structures, in order to exchange ideas regarding good practices between their respective members.

References

AI Carnot, Carnot Institute Association. http://www.instituts-carnot.eu

Akerlof GA (1970) The market for 'lemons': quality uncertainty and the market mechanism. Q J Econ 84(3):488–500

ANRT, www.anrt.asso.fr

Aoki M (2000) Information, corporate governance and institutional diversity. competitiveness in Japan, the USA, and the transition economics. Oxford University Press, Oxford

Cowan R, Jonard N, Zimmermann J-B (2003) Complémentarités cognitives et production de connaissances nouvelles, une analyse en termes de réseaux (Cognitive complementarities and production of new knowledge, an analysis in terms of networks). Revue d'économie industrielle, La morphogenèse des réseaux, no.103

Etzkowitz H (1999) Bringing the gap: the evolution of industry-university links in the US. In: Branscomb L, Kodama F, Florida R (eds) Industrializing knowledge: university-industry linkages in Japan and United States. MIT Press, Cambridge

Florida R, Cohen W (1999) Engine or infrastructure? The university role in economic development. In: Branscomb L, Kodama F, Florida R (eds) Industrializing knowledge: university-industry linkages in Japan and United States. MIT Press, Cambridge

Freeman C (1987) Technology policy and economic performance: lessons from Japan. Pinter, London

Golob E (2006) Capturing the regional economic benefits of university technology transfer: a case study. J Technol Transfer 31(6):685–695

Lundvall B-A (1992) National systems of innovation: towards a theory of innovation and interactive learning. Pinter, London

Mankins JC (1995) Technology readiness levels, a white paper, 6 April, Advanced Concepts Office, Office of Space Access and Technology, NASA

Maskell P, Bathelt H, Malmberg A (2005) Building global knowledge pipelines: the role of temporary clusters. World Dev 27(9):1715–1734

Morin E (1990) Science avec conscience (science with a conscience). Fayard, Paris, 1982, new modified edition

Mouchnino N, Sautel O (2007) Coordination productive et enjeux concurrentiels au sein d'une industrie modulaire: l'exemple d'Airbus (Productive Coordination and competing stakes within a modular industry: the example of Airbus), Innovations, De Boeck, Université, 2007/1, no. 25, pp 135–153

Nash JF (1950) Equilibrium points in N-person games. In: Proceedings of NAS

Nelson RR (ed) (1993) National innovation systems: a comparative analysis. Oxford University Press, New York

Paun F (2010) This figure was first presented and generally accepted at the 'Rendez Vous Carnot', Lyon, France, June 2010, within the last Round Table dedicated to collaboration between Carnot Institutes and the SMEs

Paun F (2011) Demand Readiness Level as equilibrium tool for the hybridization between technology push et market pull approaches. In: ANR – ERANET workshop, Paris, 8 Feb 2011 (available on ssrn)

Paun F, Richard Ph (2009) Role des outils collaboratifs dans la réduction et la compensation des asymétries relatives au processus de transfert de technologie ; étude de cas sur la nouvelle politique ONERA –PME, "Le travail collaboratif. Une innovation générique", Marché et Organisation, vol 9, édition Harmattan

Stiglitz J, Weiss A (1992) Asymmetric information in credit markets and its implications for macroeconomics. Oxf Econ Pap 44:694–724

Veblen T (1899) The theory of the leisure class : an economic study in the evolution of institutions, tr. fr.: Théorie de la classe de loisir. Gallimard, Paris, 1970

Veblen T (1914) The instinct of workmanship, and the state of the industrial arts. Augustus Kelley, New York, 1963

Watts DJ, Strogatz SH (1998) Collective dynamics of 'small-world' networks. Nature 393(6684):440–442

Weber A (1909/1929) The theory of industrial location. University of Chicago Press, Chicago

Zimmermann J-B (2002) Grappes d'entreprises et petits mondes (Company clusters and small worlds). Revue Economique 53(3):517–524

Chapter 19
Fraunhofer's Discover Markets: Fostering Technology Transfer by Integrating the Layperson's Perspective

Martina Schraudner and Solveig Wehking

Abstract This article presents and discusses Discover Markets, an initiative by funded by the German Federal Ministry of Education and Research, that seeks to redefine the boundaries of research and development and promote technology transfer by including a wider range of people in the process.

Fraunhofer is Europe's largest applied research organization. Worldwide,[1] it employs more than 18,000 people, mostly engineers, mathematicians, and natural scientists, at more than 80 locations in Germany alone, including 60 Fraunhofer Institutes. In 2010, 1.40 of the 1.66 billion euro annual research budget was generated through contracts.[2]

Discover Markets, funded by the German Federal Ministry of Education and Research, BMBF, and set to run from August 2010 to July 2013, seeks to redefine the boundaries of research and development and to foster technology transfer by including a wider range of people in the process.

Technology transfer is defined here as the exchange of ideas, findings, and methods of production and management among research institutions, industry, and the public with the purpose of making scientific and technological advances accessible and appealing to a wider range of potential users such as consumers and licensees.

This article presents Discover Market's methods and current findings from approximately midway through the project.

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[1] Fraunhofer maintains research centers and representative offices in the USA, Europe, Asia, and the Middle East.

[2] Approximately two thirds of the funding is provided by the public, while approximately one third is provided by industry.

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International Studies in Entrepreneurship 28, DOI 10.1007/978-1-4614-6102-9_19,

1 Background

Traditionally, it has been the research institutions themselves, often with input from their industrial partners, which have determined the direction of research and development, based solely on the contemporary state of scientific and technological developments. The European Commission has, in fact, recently stressed the importance of industrial applicability for projects that wish to receive their funding, but only by generally emphasizing the growing importance of certain domains such as nutrition, ageing societies, and energy sources (European Commission 2011).

The perspectives of potential consumers as well as the specifics of potential markets, however, have barely been taken into consideration, if at all. Simultaneously, market opportunities for technological innovations arise from continuously changing societal, economical, and technological factors. According to Vogel et al., "[a]s these factors change over time, they generate gaps in the marketplace between products and services that exist and the potential for those that would better fulfill market needs, wants, and desires. These gaps, then, create new product and service opportunities." (Vogel et al. 2005, p. 168).

One such gap is created by the facts that the demand for high-quality technological innovations is greater in Germany than in most countries (BDI und Deutsche Telekom Stiftung 2009, p. 39), while at the same time, many promising ideas produced by German research institutions do not make the transition into commercially successful products.

In order to exploit the opportunities arising from these gaps in the market, Discover Markets supplements the traditional model of research and development, which is generally oriented toward producing findings and developing prototypes in isolation, with original methods that always keep an eye toward creating marketable products.

This new approach extends both the beginning of the process, when it assesses a multitude of possible markets and applications, and the end, when it produces a workable business model. Furthermore, the perspectives of relevant groups are incorporated into and enhance the entire process. When relevant and/or possible, attention is paid that both men and women are included in matching proportions.

Discover Markets addresses the domains of health, energy, and materials.

2 Modifying Research and Development and Incorporating the Lay Perspective

Research and development, as it takes place at many research institutions including Fraunhofer, can be split into distinct successive stages. Their boundaries are clearly defined and a specific set of methods is utilized within each stage. Still, the stages are "interdependent" and often "loop" – some might require multiple repetitions, based on the results of their successors.

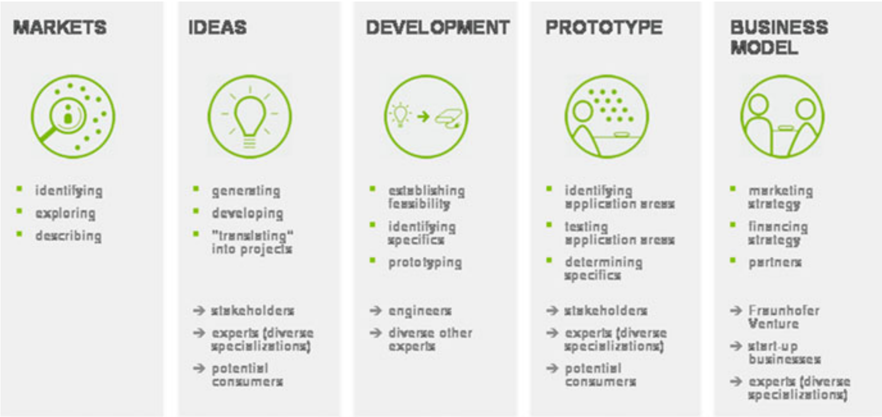

Fig. 19.1 Research and development at Fraunhofer as supplemented by Discover Markets

Discover Markets supplements this process by expanding its boundaries and the range of its methods, both as a whole and with regard to each stage, and by initiating and contributing to relevant projects such as fostering startups in cooperation with Fraunhofer Venture.

The following figure presents the process and its stages, as supplemented by Discover Markets (Fig. 19.1).

One key innovative aspect of Discover Markets' approach involves generating original ideas by including laypersons in the process. In pursuit of development of suitable methods, both in general and for stages two and three in particular, original *Ideation* workshops were designed.

Two such workshops with different yet connected purposes were held in succession in 2010, in order to jointly produce a great number and broad variety of original and feasible suggestions for potential innovations in preventive health care, physical rehabilitation, and ambient assisting living.

A proliferation of ideas for the given domains was the purpose of the first workshop. Participants, exclusively non-engineers, were split into small gender-balanced groups and asked to brainstorm possible innovations, deliberately focusing neither on technicalities nor on the potential feasibility or marketability of their ideas. Special techniques were applied to promote diversity of perspectives, to foster imagination and "thinking outside the box," and to create an encouraging working atmosphere.

The original method involved presenting a fictional story supplemented by a list of questions, both specifically designed to provide the framework and to guide the thinking process without giving direct instruction. The story and the questions also encouraged the participants to approach the three given health-care domains jointly and as they relate to everyday life, both their own and those of their friends and families.

The workshop was split into five successive sessions, within which the next part of the story was always presented and the next 45 min dedicated to brainstorming, guided by the questions. The workshop resulted in 320 original suggestions.

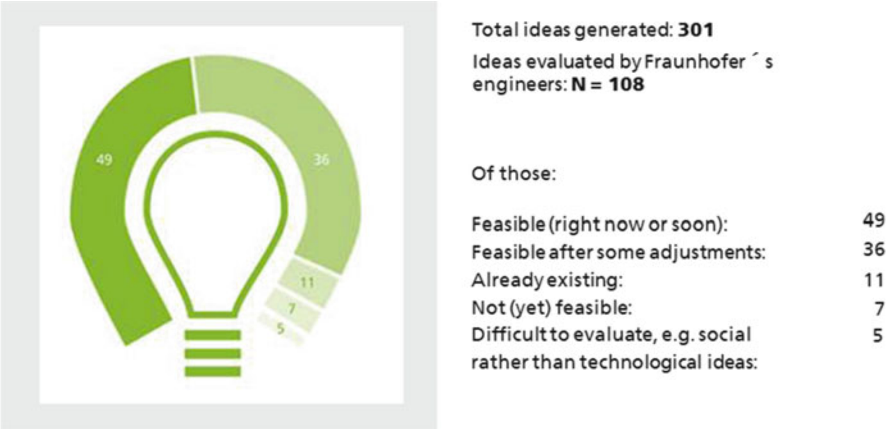

Fig. 19.2 Results of the *Ideation* workshops

Evaluation of the technical feasibility of as many of them as possible in the time provided was the purpose of the second workshop. In 1.5 days, a group of Fraunhofer engineers examined 108 ideas. The following figure summarizes the results of both workshops (Fig. 19.2).

In addition to their primary role of feasibility proving, engineers were also asked to brainstorm original ideas using methods similar to those of the first group. The engineers found the process more challenging than the first group and had less enthusiasm for it than for technical evaluation. This fact affirmed Discover Market's approach both in its initial decision to primarily involve engineers in their technical capacity and in its recognition of the value of including non-engineers in research and development.

One example of the creation of a viable technology by integrating the lay perspective is *My Rehab*, launched in October 2010 and currently one of Discover Markets' most advanced subprojects. At an actual physical rehabilitation facility, patients and employees have participated in the prototype development and testing of *Rehab@home*. This web-connected home trainer, which will fill an existing gap by providing patients with a post-clinical opportunity for consistent and interactive physical therapy, is nearly ready for licensing by a startup.

3 Laypersons and Technological Innovations: Social Media as Opportunity

The resistance by the European public to so-called green biotechnology, or "crop engineering," reveals the crucial role of public recognition for the viability of innovations. According to Weingart, "[t]he three-decade long public debates over biotechnology and biomedicine reveal controversies between existing social values and scientific and technological advances." Simultaneously, the public's opinions with regard to the technologies under debate were based on general assumptions rather than on specific knowledge or direct experience (Weingart 2002, p. 3).

Technological developments promise benefits to the everyday world, and thus dialogue-oriented methods that address lay perspectives are necessary to promote the social acceptance on which the viability of these developments depends. Internet-based social media provide an ideal opportunity. According to the PEW research center, the use of communication technologies "has become deeply embedded in group life and is affecting the way civic and social groups behave and the way they impact their communities" (PEW Research center 2011). In only a decade, virtual discourse has changed the ways in which societies approach vital topics; its impact continues to unfold, and only the future will reveal its limits.

However, researchers in Germany, unlike their counterparts in countries such as the USA, have yet to embrace social media as a legitimate means of scientific communication. As stated by experts in a related poll, the dissemination of research in Germany rarely extends beyond the boundaries of traditional publication to reach the general public. Among these Ulrich Schnabel, a former scientific editor at *Die Zeit,*[3] stated that many scientists neither adhere to dialogue-oriented methods nor recognize their value: "[m]any are still much attached to the traditional model of scientific communication; building of trust, however, requires more than just providing facts" (Gerber 2011, p. 14). Further studies support his assertion by indicating that merely increasing the amount of information about technological innovations does not necessarily improve their image or increase public interest (Zimmer 2002, Pfister et al. 1999; Peters 1999b).

The change from one-way "broadcasting" to open dialogue through multiple new forms of communication is due and would imply a paradigm shift toward open science.

4 *Forschungs* Blog

Recognizing the benefits of open science, Discover Markets tapped into the domain of social media in April 2011 by launching an original blog. Available in German at www.forschungs-blog.de, this resource introduces technological advances and is directed toward the general public.[4]

Some of its articles are presented in an innovative *dual blogging* format, where purely scientific texts are supplemented by "layperson-friendly" versions that

[3]A widely read German nationwide weekly newspaper that has a reputation for its quality journalism.

[4]The name of the blog translates as "research blog."

present the findings as they relate to the public, written in an appealing manner, for the most part by two German celebrity bloggers. Such a format allows a topic to be explored from different angles and gives the audience, technophiles in particular, the opportunity both to participate in entertaining scientific discussions and to contribute to technological innovations. In general, the creators pursue the following goals:

- Interesting the public in scientific and technological advances
- Initiating and moderating thematic discussions
- Presenting technological innovations and potential products and gathering feedback
- Including a wider range of people in research and development
- Expanding research directions and fostering innovative ideas through such inclusion
- Contributing to the paradigm shift in scientific communication

The blog is being developed in three stages as follows:

- Stage I – Launch and initial expansion – drawing the public's attention to the blog and technologies in general through, inter alia:
  - The novelty, within Germany, of blogging by a research institution
  - The innovation of Dual Blogging
  - The involvement of celebrity bloggers
  - The blog's presence on Facebook
- Stage II – Expansion – seeking a broader audience and expanding and diversifying the range of topics through, inter alia:
  - Expanding editorial staff
  - Utilizing innovative formats such as podcasts
  - Maintaining the blog's page on Facebook
  - Establishing its presence on Twitter
- Stage III – Inclusion – directly involving the audience in research and development and exploring the methods that allow for such involvement through, inter alia:
  - Presenting prototypes
  - Gathering feedback through, for example, voting
  - Holding thematic contests

At present, the first stage has been successfully completed, yielding the following results.

Both media and the public instantly embraced the original blog. Dpa, the German Press Agency, responded to the launch with two different articles. One or the other of those articles was immediately reproduced in over 140 print and online media including Focus.de, Welt.de, Sueddeutsche.de, and Zeit.de – Internet versions of the largest national magazine and newspapers. Some other media even published original articles. Given the blog's technical character, such instant recognition was rather unexpected and was probably due largely to the novelty of blogging by a research institution and the involvement of celebrity bloggers.

The response in the social media, continuing up to the present date, has been largely positive. As of December 2011, the blog has gained more than 1,100 fans on Facebook; the greatest proportion of the blog's viewers has linked to the blog through either Twitter or Facebook. Also as of this date, 58 articles have been uploaded, and have received, on average, 4.6 responses each, that is, 280 posts altogether, including those by the blog's editors.

5 Conclusions and Outlook

Discover Markets' current findings reveal the effectiveness of the explored approach and show in particular that technology transfer can be fostered by integrating the layperson's perspective into research and development.

During the subsequent stages of the project, methods that foster valuable input from relevant groups will be further explored and expanded. These methods will allow different degrees of the inclusion of laypersons, ranging from online voting to direct participation in research and development and the determination of applications of potential products.

One particular challenge lies in enabling all relevant parties such as potential consumers and licensees to accurately identify their needs and wants and in simultaneously utilizing technological innovations to accommodate them; suitable methods will also be explored.

References

10 Jahre ARD-ZDF Onlinestudie (2007) Internet zwischen Hype, Ernüchterung und Aufbruch. Baden-Baden. http://www.ard-zdf-onlinestudie.de/fileadmin/Fachtagung/ARD_ZDF_Onlinebrosch_re_040507.pdf. Accessed 10 Nov 2011

BDI und Deutsche Telekom Stiftung (Ed) (2009) Innovationsindikator Deutschland 2009. Politikberatung kompakt Nr. 51

Brussels, Com (2011) 808 Final communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Horizon 2020 – The Framework Program for Research and Innovation. http://ec.europa.eu/environment/enlarg/med/horizon_2020_en.htm. Accessed 14 Dec 2011

Gerber A (2011) Trendstudie Wissenschaftskommunikation – Vorhang auf für Phase 5. Berlin: edition innovare/innokomm Forschungszentrum, vol 1. http://www.stifterverband.info/publikationen_und_podcasts/positionen_dokumentationen/wissenschaftskommunikation_trendstudie/. Accessed 14 Dec 2011

Peters HP (2000) From information to attitudes? Thoughts on the relationship between knowledge about science and technology and attitudes toward technologies. In: Dierkes M, Grote Cv (eds) Between understanding and trust. The public, science and technology. Harwood Academic Publishers, Amsterdam, pp 265–286

Pfister HR, Böhm G, Jungermann H (1999) Die kognitive Repräsentation von Gentechnik: Wissen und Bewertungen. In: Hampel J, Renn O (eds) Gentechnik in der Öffentlichkeit: Wahrnehmung und Bewertung einer umstrittenen Technologie. Campus, Frankfurt/M./New York, pp 170–196

Purcell K, Rainie L, Smith A. PEW Research Center (2011) The social side of the Internet. http://www.pewinternet.org/~/media/Files/Reports/2011/PIP_Social_Side_of_the_Internet.pdf. Accessed 14 Dec 2011

Vogel CM, Cagan J, Boatwright P (2005) The design of things to come: how extraordinary people create extraordinary products. Wharton School Publishing, Upper Saddle River

Weingart P et al. (2002) Die gesellschaftliche Diskussion wissenschaftlichen Fortschritts in den Massenmedien Der Fall Biotechnologie und Biomedizin. EXPERTISE im Rahmen der “Ausschreibung von Expertisen im Themenfeld Politik, Wissenschaft und Gesellschaft.” http://www.sciencepolicystudies.de/dok/expertise-weingart.pdf. Accessed 10 Dec 2011

Appendix
The Impact of Collaborative Tools and Practices in Technology Transfer Process

Florin Paun and Dimitri Uzunidis

Abstract The aim of this session was to highlight the collaborative tools and practices, between R&D laboratories and industrial partners, developed, implemented and used by various technology transfer and R&D commercialisation offices. Constructive discussions between Technology Transfer Practitioners and Scholars provided at the end of the special session a suggested guide of best practices. These practices are briefly reminded hereby, and some of them are developed in the following papers.

The aim of this session was to highlight the collaborative tools and practices, between R&D laboratories and industrial partners, developed, implemented and used by various technology transfer and R&D commercialisation offices.

Various asymmetries related to information, financial risk, culture (behaviours and expectations) and time scaling were identified between the actors involved in technology transfer processes. These asymmetries, potentially source for value creation (in a collaborative work environment), could also become barriers (if ignored) in technology transfer process inducing thus important consequences on the innovation paths.

Innovative collaborative tools activating between R&D laboratories and their industrial partners (e.g. co-development contracts, co-innovation processes, IP co-ownership, risk sharing, R&D commercialisation favourable conditions, Market Pull and Technology Push hybridised approaches, TTOs networking and knowledge based clusters) were identified as reduction or compensation mechanisms playing an important role in managing these asymmetries and thus favouring innovations.

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Contributions related to these asymmetries or to successfully implemented or proposed collaborative tools and practices were presented by Executives of CURIE (French Network of the Research and Commercialisation Executives), Fraunhofer Headquarter (Germany), Carnot Institutes (France), Competitiveness Cluster Pegase (France), University Central Florida (USA), Onera—The French Aerospace Lab, CEA-LETI (France), and Institute Optics Graduate School (France) and commented by various practitioners and academics during the session.

Constructive discussions between Technology Transfer Practitioners and Scholars provided at the end of the special session a suggested guide of best practices. These practices are briefly reminded hereby, and some of them are developed in the following papers.

Suggested Guide for Practice in Tech Transfer

(Organisation/scholar especially highlighting and agreeing such an idea)

- Need to accurately identify and understand barriers which are mostly related to:
  - Asymmetries between actors; these asymmetries are related to information (in terms of technology understanding and targeted market) (*Stiglitz*) but also to different cultures, assumed risk and timescale (all).
  - Structural issues which call to the important role of the regulators and other authorities (University Central Florida—UCF, etc.).
- Need for cash to finance the proof of principle (apparently a general issue, AUTM, CURIE, Carnot, Fraunhofer, etc.) with a common agreed message for authorities:
  - Measure side effects; don't look only to the IP royalties' stream!
  - Measure the ratio of regional economic output for an invested dollar and balance the economic development versus direct financial IP return (CEA, UCF, Onera, etc.)
- Build "bridges" inter and intra of each of the three totalities (individuals, stakeholders and market/domains/times from the Total Innovation Management (*Xu*)).
- Favour the "good merits" and banish the "bad merits" (*Stiglitz, Scott*).
- Compensate or reduce the identified existing asymmetries (Onera).
- Develop SME's capabilities and manage asymmetries (*Paun, von Tunzelmann, Richard*) by the following:
  - Develop/use good practices and tools (Demand Readiness Level scale vs Technology Readiness Level scale, Innovation (Process) Readiness Diagram (*Paun*)) (all).
  - Use adapted tools for various stages of firms' development (UCF).

- Balance and hybridise Market Pull with Technology Push (Fraunhofer, Onera, etc.).
- Take care about your image (Fraunhofer, etc.).
  - Scientific blog in partnership with professional bloggers (Fraunhofer, etc.).
  - Highlight the creation of high-tech well-paid jobs (UCF, etc.).
  - Build strong patent portfolio (CEA, etc.).
- Respond to society needs (all):
  - Eco-innovation → measure the effects on the resources “good merit”.
  - To sustain the eco-innovation system → measure the social impact “good merit”.
- Some of the suggested tools/practices:
  - Not be alone while facing the market (Fraunhofer, CURIE, CARNOT, etc.).
  - Build a one-stop shop for entrepreneurial support (UCF, CURIE, CEA-Leti, etc.).
  - Build ecosystem of innovation (UCF, CEA-Leti, Onera, IOGS, Pegase, etc.).
  - Create clients by venture policy (CEA, etc.).
  - Take equity shares in start-up vs royalties (CEA, etc.) for a better financial return.
  - Build an economic pyramid with tech sourcing in the middle (*O'Neal*).
  - Build an ecosystem with entrepreneur in the middle of it (UCF, IOGS, etc.).
  - Adopt a politics of collaborative Technology Platforms (CEA, Onera, etc.).
  - Share risk and benefits with very small or small companies (Onera, Pegase, etc.).
  - Assign to the Technology Transfer Officers the role of “translators” between the two worlds (industry and science).
  - Protect IP (Fraunhofer, CEA, Onera, UCF, etc.) and patent before publication.
  - Promote politics of incentives for everybody to commit in Tech Transfer (all).
  - Measure the interest of very small/small enterprises for the Tech Transfer projects by their agreement to open their equity shares to the laboratory (Onera, etc.):
  - Involve students (IOGS, CEA-Leti, Onera, etc.).
  - Involve social science while Tech. Innovation expectancy (Fraunhofer, CEA, etc.).

References

Capmas F (2011) A full immersive and innovative entrepreneurial ecosystem for research idea valorization with master students. In: Institute Optics Graduate School, presentation at T2S annual conference, Augsburg

Haunold CH (2011) Tech transfer in France in CURIE network perspective: new approach, several new tools. In: Presentation at T2S annual conference, Augsburg

Paing B (2011) Technology transfer practices at CEA-LETI. In: Presentation at T2S annual conference, Augsburg

Piana L, Longère J-Y (2011) The contract for growth (proposed by pegase competitiveness cluster to their SME members). In: Presentation at T2S annual conference, Augsburg

Schraudner M, Wehking S (2011) Fraunhofer project "Discover Markets" (part 1) and "Forschungs-Blog" as part of social media efforts (part 2). In: Presentation at T2S annual conference, Augsburg

O'Neal TH (2008) Technology incubators as a tool for technology transfer. In: Presentation at T2S annual meeting, Albany

O'Neal TH, Schoen H, Ford C, Lasradp V (2011) Universities role as a catalyst for venture creation: a case study of the University of Central Florida role in the Greater Orlando area. In: Presentation at T2S annual conference, Augsburg

Paun F (2011) Demand readiness level: the DRL scale as new proposed tool to hybridize market pull with technology push approaches. In: Presentation at T2S annual meeting, Augsburg. Available at SSRN: http://ssrn.com/abstract=1948448

Paun F, von Tunzelmann N, Richard, PH (2011) Transferring new dynamic capabilities to SMEs: the role of ONERA—the french aerospace LabTM in promoting asymmetries management. Under printing at Journal of Innovation Management. Available at SSRN: http://ssrn.com/abstract=1763708

Scott JT (2009) Cost-benefit analysis for global public-private partnerships: an evaluation of the desirability of intergovernmental organizations entering into public-private partnerships. J Technol Trans 34:525–559. Springer, published online: 28 April 2009, Springer Science + Business Media, LLC 2009

Stiglitz J, Weiss A (1992) Asymmetric information in credit markets and its implications for macroeconomics. Oxford Economic Papers, vol 44, pp 694–724

Stiglitz J, Walsh C (2002) Principles of microeconomics (3rd ed.). W.W. Norton, New York

Xu Q, Chen J, Xie Z, Liu J, Zheng G, Wang Y (2007) Total innovation management: a novel paradigm of innovation management in the 21st century. J Technol Trans 32:9–25. Springer, Published online: 3 November 2006, Springer Science + Business Media, LLC 2006

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